

TECHNO-ECONOMIC EVALUATION OF RECONSTRUCTION PROJECTS FOR DAMAGED RESIDENTIAL STRUCTURES

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Abstract

As a result of the armed aggression of the Russian Federation, a significant portion of the housing stock in Ukraine has been damaged or destroyed. This has created an urgent need for the prompt determination of material costs for reconstruction or for providing compensation to owners of destroyed property. The process of obtaining compensation for reconstruction or the purchase of new property involves a clearly defined algorithm. This study analyzes the determination of the economic feasibility of restoring a residential building in the city of Dnipro, Ukraine, that has lost its operational suitability and, according to the technical inspection report, is classified as a damaged but not destroyed real estate property. The research included the determination of restoration costs, indirect development costs, land value, and the gross development value of the reconstructed property. These indicators were compared with the market value of the property prior to damage and with the compensation value calculated according to national legislation.

Keywords: *Economic feasibility; Damaged real estate; Destroyed real estate property; Gross development value; Market value*

Introduction

Large numbers of residential buildings in Ukraine have been damaged or destroyed as a result of military actions carried out by the Russian Federation. In many cases, residential structures have lost their operational suitability due to structural damage, making the issue of reconstruction and compensation particularly urgent. In study [1], the issue of the technical and economic feasibility of restoring a residential real estate object was examined using the example of destroyed apartments in a multi-story building.

In accordance with the Law of Ukraine and the Resolution [2], [3], the required compensation for the reconstruction of damaged or destroyed property is calculated.

Based on the results of technical inspections of a representative number (more than 200) of private low-rise residential buildings constructed between 1950 and 2000, whose structural elements were damaged as a result of off-design impacts, data on the condition of structures were collected, summarized, and analyzed. This made it possible to propose an algorithm for determining the technical and economic feasibility or infeasibility of restoring old low-rise residential buildings.

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During the inspection of damaged residential houses, numerous cases were identified where the building as a whole was assigned an emergency technical condition—category "4"—which requires the immediate evacuation of people from areas of possible collapse and/or the implementation of measures preventing such collapse until repair, strengthening, replacement of structural elements, or demolition of the building is carried out [4]. The assessment of the degree of damage of objects after explosions is complicated because it depends on many factors. It is particularly important to assess the degree of damage caused by dynamic impacts [5], [6], and fire [7]. The assessment of the effects of various harmful impacts also depends on the type of object, the technologies used, and the material from which the structural elements are made [8], [9], [10]. In this aspect, it is equally important to use modern construction materials in construction that have better mechanical properties and corrosion resistance [11], [12].

However, according to the classification of [13], the damage category in such cases corresponds to Category II (damage to load-bearing and enclosing structures, the degree and nature of which indicate the need to carry out works to strengthen certain load-bearing and enclosing structural elements of the facility). In this situation, the affected owner is entitled to receive compensation only for restoration through current or capital repair or reconstruction. Under current regulations, compensation for restoration works is limited to approximately 500,000 UAH for individuals. In many cases this amount is insufficient to cover the full cost of reconstruction.

Moreover, depending on the materials used in construction, the year of construction, and the technical condition of the structures, dismantling damaged sections may lead to the complete destruction of the building. At the time of inspection, however, from a technical standpoint, the building does not fall, in accordance with [13], under Category III—an object unfit for its intended use, with damage to load-bearing and enclosing structures of such degree and nature that indicates the risk of emergency collapse (destroyed objects)—because the estimated overall level of damage does not exceed 81%, at which urgent demolition (liquidation) of the facility is recommended.

In such cases, in addition to a technical inspection, it is necessary to perform a calculation of the economic feasibility of restoration in order to recognize the property as a destroyed real estate object that has completely lost its economic value.

The purpose of the study is to determine, using the example of a single-story private residential building damaged as a result of the military aggression of the Russian Federation in the city of Dnipro, the economic feasibility or infeasibility of its restoration.

Methodology of research

The research methodology is based on a combination of engineering inspection data, cost estimation procedures, and real estate valuation methods.

The object of study is a residential property located at 2B Boryslava Brondukova Street in the Sobornyi district of Dnipro, Ukraine (Figs. 1 and 2). The property is situated on a privatized land plot with cadastral number 12101000000:03:190:0015 and is classified as private ownership (Fig. 3).

On March 28, 2025, the building sustained severe structural damage due to a munition strike during the armed aggression of the Russian Federation. Engineering inspection identified extensive deformation of load-bearing elements and roofing structures.

The territory (land plot) is fully located within the territorial community. The development and use of the land are entirely regulated by local zoning provisions and require approval from municipal authorities and environmental protection services.

Positive characteristics influencing the increase in value (in terms of impact on supply and demand) include a detached single-family residential house of estate type (household), paved and well-maintained access roads, a well-established private residential development area, availability of public and community centers within accessible distance, and a high level of

investment attractiveness for individual residential housing due to proximity to social and public infrastructure facilities.

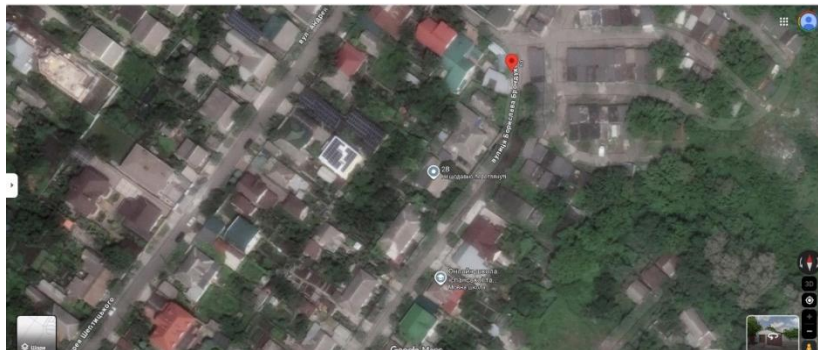


Fig. 1. Location of the real estate object within the block

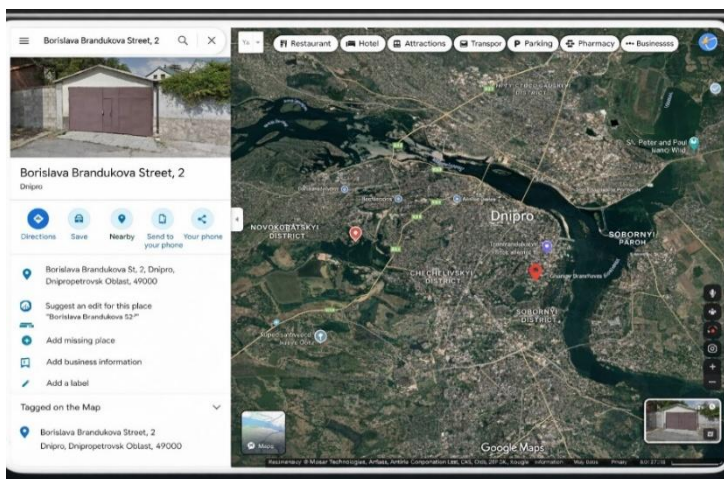


Fig. 2. Location within the city limits

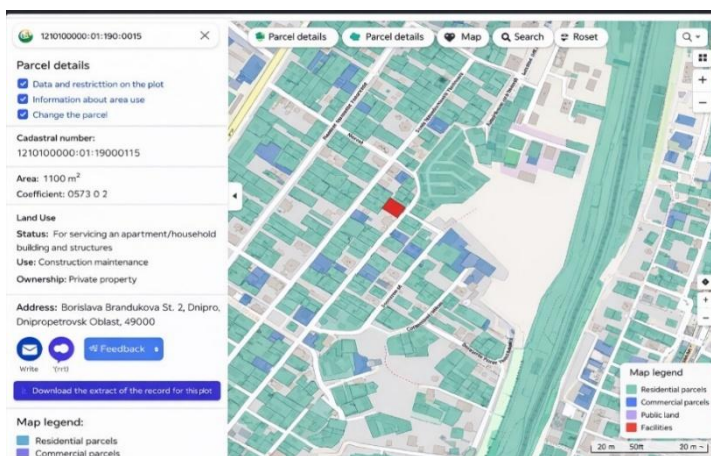


Fig. 3. Cadastral map of the land plot location (No. 12101000000:03:190:0015)

Negative characteristics affecting the value of the property (in terms of supply and demand) include the unstable economic situation and the ongoing war in Ukraine.

The topography of the land plot is characterized by a slope in the south-eastern direction. The vertical planning was carried out taking into account the existing terrain elevations. The site is connected to utility networks, including electricity supply, water supply, and gas supply. The territory had been *благоустроена* (improved and landscaped).

The designated purpose of the land plot is 02.01 — for the construction and maintenance of a residential house, ancillary buildings, and structures (homestead land plot).

Description of the property

Total area: 80.2 m²; living area: 41.6 m². The household consists of the following structures: a residential building, with walls made of slag concrete and brick, having a living area of 41.6 m² and a total area of 80.2 m²; a shed, with slag concrete walls; a shed, with brick walls; a garage, with brick walls; a toilet, with brick walls; fences and auxiliary structures; paved surfaces I and II; an inspection pit in the garage; and a cellar (Fig. 4).



Fig. 4. General appearance of the object.

The residential building has a rectangular plan with dimensions of 8.3×10.12 m. The annex is also rectangular in plan, with dimensions of 5.35×4.65 m. The year of construction of the building is 1958. The building footprint area is 129.0 m². The construction volume is 398 m³. The ceiling height of the premises ranges from 2.45 to 3.0 m. The overall height of the building is 3.55 m.

The structural system of the building is load-bearing masonry (non-frame). The external and internal load-bearing walls are made of slag concrete and brick. The floor structure consists of timber beams, and the roof structure is a wooden attic-type roof. The foundations of the building are cast slag concrete strip foundations and concrete foundations on a natural soil base. The blind area around the building is made of monolithic concrete.

The external and internal walls of the building are 400 mm thick, made of cast slag concrete, with plastered internal surfaces. The walls of the annex are 250 mm thick, constructed of ceramic brick laid on cement-sand mortar. The internal wall surfaces are plastered; in the annex, in the bathroom and kitchen areas, the walls are finished with ceramic tiles.

The floor structure consists of timber beams spaced at intervals of up to 1 m, supported by internal and external walls. The beams are sheathed with boards and plastered over wooden lathing.

The roof of the building is wooden and gable-type, consisting of rafter structures. The load-bearing elements are rafters with a cross-section of 200×50 mm, spaced at 1.0 m. The rafters are reinforced with horizontal ties (collar beams). The roof height is 3.3 m. The roof of the annexe is wooden and gable-type, consisting of rafter structures. The load-bearing elements are rafters with a cross-section of 150×50 mm, spaced at 1.0 m and reinforced with horizontal ties. The roof

height is 2.5 m. The roofing of the annexe consists of corrugated asbestos-cement sheets laid on wooden battens made of unedged boards 150×30 mm. The roofing of the building is single-pitched, made of roofing felt laid on continuous wooden sheathing. The drainage system is external.

Floors are concrete with a linoleum finish; in sanitary facilities, ceramic tiles are laid on a cement-concrete base. Windows have double glazing in wooden frames. Interior finishing includes plastered walls finished with wallpaper; in some rooms, walls are painted. Ceilings are plastered and painted. Engineering systems include electricity, gas, and water supply. Heating is individual and water-based, from a gas boiler, and distributed through steel pipes and cast-iron radiators. The sewage system consists of PVC pipes.

The physical deterioration and technical condition of the structures prior to destruction as a result of the military actions of the Russian Federation, depending on the type of building materials used for the main structural elements and the year of construction, may correspond to the technical condition category “unfit for normal operation” or “emergency condition.” Therefore, dismantling damaged sections may lead to the complete destruction of the building.

According to Appendix B [14], the average service life in urban areas, depending on the capital group of buildings, ranges for residential buildings as a whole from 30 to 150 years. These standards are aligned with the “Classification of Residential Buildings Depending on Housing Quality and Available Engineering Equipment” (Appendix A) [15], taking into account the recommendations [16] regarding the minimum effective service life of residential building elements. Data for the main structural elements are presented in Table 1.

Table 1. Average service life

No.	Name of structural elements	Average service life in urban areas by capital group of buildings					
		I	II	III	IV	V	VI
1	Foundations						
	Pile foundations	150	125	100	100	70	30
	Strip rubble masonry on composite or cement mortar, concrete and reinforced concrete	150	125	100	100	70	-
	Strip rubble masonry on lime mortar	-	-	-	-	50	-
	Rubble and concrete columns	-	-	-	-	-	10
2	Walls						
	Especially capital stone walls (brick walls 2.5–3.5 bricks thick) and large-block walls on composite or cement mortar	150	-	-	-	-	-
	Ordinary stone walls (brick walls 2–2.5 bricks thick), large-block, large-panel	-	125	-	-	-	-
	Lightweight masonry walls of brick, slag blocks, shell limestone	-	-	100	100	-	-
	Solid log and timber walls	-	-	-	-	50	-
	Wooden panelized, frame, adobe, and rammed earth walls	-	-	-	-	-	30
3	Floor structures						
	Precast and cast-in-place reinforced concrete	150	125	100	100	-	-
	Brick vaults or concrete infill on metal beams	-	125	100	100	-	-
	Timber floors on metal beams	-	80	60	60	-	-
4	Roof (load-bearing elements)						
	Precast reinforced concrete roof slabs	150	125	100	100	-	-
	Rafters and battens of precast reinforced concrete elements	150	125	100	100	-	-
	Timber rafters and battens	50	50	50	50	40	30

For example, for the building under consideration, which belongs to Capital Group III and was constructed in 1958, the service life as of the date of destruction in 2025 amounts to 67 years. The standard service life of the main structural elements is 100 years; therefore, the normative

wear has already reached 67%, which, in accordance with Table 5 in [13], corresponds to the condition classified as dilapidated. The general technical condition is characterized by an emergency state of the load-bearing structural elements, while the non-load-bearing elements are in a very dilapidated condition. The building elements perform their functions only to a limited extent [15].

The overall conclusion regarding the technical condition of the property, in accordance with the Report (document registration number: TO01:6554-1223-9722-2293, ITE No. 123/15.07.2025-2 dated 07.09.2025), based on the results of the preliminary engineering and technical inspection and assessment of the technical condition of the buildings and structures of the household located at 2B Boryslava Brondukova Street, Dnipro, Dnipropetrovsk Region, is as follows: technical condition category 4 “Emergency.” The overall conclusion regarding the damage classification of the object is Damage Category II.

According to the appraiser’s inspection conducted in 2026, the recorded defects had intensified due to the lack of protection of structural elements from atmospheric precipitation and temperature fluctuations during the autumn–winter period. Deformations of the cast slag concrete walls increased under the influence of moisture and the accumulation of condensation within the powder-like components of the material. In certain areas, the destruction became more extensive, and unsecured rafter and roofing structures began to lose their stability.

In accordance with [2], destroyed real estate objects are real estate properties located in Ukraine that have become unfit for their intended use as a result of hostilities, terrorist acts, or sabotage caused by the armed aggression of the Russian Federation against Ukraine and whose restoration is impossible through current or capital repair, reconstruction, or restoration or is economically impractical.

The justification of economic feasibility is the process of analyzing and substantiating the viability and profitability of an investment project. It includes the assessment of costs, benefits, potential profitability, and payback period, as well as technical, operational, and market aspects in order to make a well-founded decision regarding implementation. It is a key component of a feasibility study, demonstrating whether it is reasonable to invest funds by evaluating the expected financial return and associated risks.

The determination of the reasonableness of expenditures consists in assessing the level of risk that the amount of funds planned for the restoration of damaged real estate may exceed the previously determined market value of the property prior to the occurrence of losses.

Economic feasibility (meaning) of a financial transaction is a reasoned justification that such a financial transaction is aimed at achieving an economic result or economic and personal goals that do not violate legal requirements and are not intended to circumvent them [17]. Economic feasibility of restoration of the object is understood as restoration through new construction or proposals for the construction of new objects instead of those that have been damaged or destroyed.

In fact, such restoration costs through new construction or proposals for the construction of new objects instead of those that have been damaged or destroyed represent the gross development value in accordance with the requirements of [14].

In order to determine the economic feasibility or infeasibility of restoration, it is necessary to calculate the construction cost and indirect expenses sufficient for the creation of the corresponding improved property. Thus, in order to determine the economic feasibility or infeasibility of restoration, it is necessary to calculate the construction cost and indirect expenses. These cost components include the determination of demolition costs for emergency structural elements and preparation of the construction site and engineering networks:

- the calculation of costs required to restore the building’s structural elements, without which the house cannot function, in order to transfer the building from condition category 4 (emergency) to category 2 (satisfactory and suitable for operation);

- the determination of the gross development value, defined as the price that can be obtained at the valuation date from the sale of the fully developed (constructed) real estate property on the market;
- the performance of an analysis of residential real estate values;
- the determination of the market value, defined as the price at which the valuation object could be transferred on the market for similar property at the valuation date under an agreement concluded between a willing buyer and a willing seller, after appropriate marketing, provided that each party acted knowledgeably, prudently, and without compulsion, and/or the appraisal value, defined as the value determined according to an established algorithm and specified input data;
- the determination of the amount of compensation for the destroyed real estate object; and the reconciliation through direct comparison of the gross development value (restoration cost) of the real estate object with its market value.

Determination of gross development value

Gross development value is the price that can be obtained at the valuation date from the sale of a real estate object that has been fully completed through development (construction) on the market. It corresponds to the monetary amount sufficient to cover the costs of acquiring the land plot and improving it, including the cost of financing these expenditures and the developer's profit [18]. Therefore, in order to obtain a sale price, the residential building must have completed construction, and the price must include the amounts necessary to finance construction costs as well as the developer's profit.

The residential building of old construction (built in 1958), which sustained damage as a result of the armed aggression of the Russian Federation, is considered in accordance with [19]. The life cycle of real estate is defined as the period of time during which the property exists as a physical object.

According to the Life-Cycle Cost (LCC) analysis, the building was at Stage C—the operation/use phase—which includes life-cycle costs during use (operational expenses), maintenance, and technical servicing of the real estate object. Therefore, prior to the occurrence of damage, the residential building existed as a physical asset in its operational stage.

The determined replacement (reproduction) cost of improvements (V_c) consists of reconstruction costs (established on the basis of a cost estimate calculation derived from the defect list of work volumes in the technical inspection report), associated expenses, and the value of the land plot. All indicators are adjusted to account for the time value of money (compounding rate).

Gross development value is calculated according to the following formula [18]:

$$V_o^{GDV} = V_L \times (1 + i) + V_c \times (1 + i)^{0.5} \quad (1)$$

where: V_o^{GDV} - gross development value of the destroyed real estate object; V_L - value of the land plot; V_c - replacement (reproduction) cost of improvements; i - compounding rate (time value of money adjustment factor).

The gross development value of a part of a destroyed real estate object is determined as its proportional share in the total area (building volume or other unit of functional designation) of such an object.

In the case of damage to or destruction of land improvements of a real estate property, the amount of required restoration funding is equal to the gross development value reduced by the value of the destroyed (damaged) real estate property.

The value of the land plot is determined either by comparison with sales of vacant land plots similar in location, size, and intended type of improvements, or by calculating its residual

value as part of recently completed developed real estate with characteristics similar to those of the property being appraised.

Determination of capital repair and restoration costs of an emergency residential building

As an indicator of the cost of residential construction, the data from the cost estimate documentation were usenamely, thethe Consolidated Cost Estimate for the Project—"Capital Repair of Buildings and Structures of the Household Located at 2B Boryslava Brondukova Street, Dnipro, Dnipropetrovsk Region (Implementation of Measures to Eliminate Emergency Conditions in the Residential Building after a Missile Attack)," prepared at current prices as of December 22, 2025, Table 2.

Table 2. Consolidated cost estimate for the construction project "Capital repair of buildings and structures of the household located at 2B Boryslava Brondukova Street, Dnipro, Dnipropetrovsk Region"

No.	Estimate / cost calculation reference	Description of chapters, complexes, works and expenses	Mining works, thousand UAH	Construction works, thousand UAH	Equipment, furniture and inventory, thousand UAH	Other expenses, thousand UAH	Total estimated cost, thousand UAH
1	02-01	Chapter 2. Main purpose facilities. Major repair of buildings and structures of the household property located at:	11.127	836.702	—	—	847.829
		Dnipropetrovsk region, Dnipro, Boryslava Brondukova Street, building 2B					
		Total for Chapter 2	11.127	836.702	—	—	847.829
		Total for Chapters 1–7	11.127	836.702	—	—	847.829
		Total for Chapters 1–8	11.127	836.702	—	—	847.829
		Total for Chapters 1–9	11.127	836.702	—	—	847.829
2	Guideline [4.34]	Chapter 12. design, survey works, expertise and author's supervision	—	—	—	—	—
	Guideline [4.34]	Cost of design works	—	—	—	—	—
		Cost of design documentation expertise (K = 1.1)	—	—	—	6.133	6.133
	Guideline [4.34]	Total for Chapter 12	—	—	—	6.133	6.133
		Total for Chapters 1–12	11.127	838.702	—	6.133	853.982
	Guideline [4.38]	Estimated profit (P)	—	115.612	—	—	115.612

No.	Estimate / cost calculation reference	Description of chapters, complexes, works and expenses	Mining works, thousand UAH	Construction works, thousand UAH	Equipment, furniture and inventory, thousand UAH	Other expenses, thousand UAH	Total estimated cost, thousand UAH
	Guideline [4.39]	Funds to cover administrative expenses of construction organizations (AE)	–	–	–	23.122	23.122
		Subtotal	11.127	952.314	–	29.255	992.696
	Guideline [4.43]	Value added tax (VAT)	–	–	–	198.539	198.539
		Grand total of the consolidated cost estimate	11.127	952.314	–	227.794	1,191.235

Consolidated cost estimate in the amount of UAH 992.626 (total estimated cost excluding VAT). The estimate documentation does not provide for the repair and renovation of engineering networks. The results of the analysis are presented in Table 3.

Table 3. Indicator of the cost of construction and repair works

Indicator	Total building area, m ²	Construction works, thousand UAH (excluding VAT)	Per m ² , UAH (excluding VAT)
Major overhaul of a residential building at the address 2B Brondukova Street, Dnipro (implementation of measures to eliminate emergency damage to the residential building after a missile attack)	80.2	992.626	12.377

Thus, the indicator of the cost of construction and repair works per m² of the total area amounts to UAH 12.377 per 1 m², rounded to the nearest whole number.

Determination of indirect costs (consultants' fees and marketing expenses)

When buying and selling residential properties, the commission of a realtor or agency typically amounts to 3–5% of the transaction value. In the case of premium real estate, it may reach up to 10%. In the rental segment, a realtor charges 50–100% of the monthly rent (see [20]). Therefore, the minimum level of indirect costs that should be taken into account is 5%, or UAH 619 per m².

Determination of the value of the land plot underlying the subject of appraisal using the methodological approach based on comparison of sales prices of similar land plots

Based on the purpose and designation of the subject of appraisal (a residential land plot), the valuation was carried out using a methodological approach based on comparison of sales prices of similar land plots, taking into account that this approach is supported by the most comprehensive information necessary for conducting valuation procedures.

The subject of appraisal is a land plot located in Dnipro, 2B Brondukova Street. Comparable properties include the following: Comparable Property No. 1 – land plot, Dnipro,

upland part of the city, Kyshynivska Street [21]; Comparable Property No. 2 – land plot, Dnipro, upland part of the city – Teshchyn Yazyk area, 9 Sichnia Street [22]; Comparable Property No. 3 – land plot, Dnipro, upland part of the city, Boryslava Brondukova Street [23]; Comparable Property No. 4 – land plot, Dnipro, upland part of the city, Teshchyn Yazyk area – with a view of the city and Tunelna Balka [24].

To determine the market value using the comparative approach, adjustments were made to the asking prices to account for differences from the subject property. Where the characteristics of the comparable properties and the subject property were identical, no adjustments were applied.

According to statistical market analysis data and information provided by market operators, it has been determined that for the given time period and location, bargaining on land plots ranges from 5% to 35%. For all comparable properties in this case, an adjustment of 30% has been applied, which is considered appropriate for similar properties and is also reflected in market analytics provided by the Uvecon company.

The primary price-forming factor in determining the market value of real estate properties is location. It is this factor that causes significant variation in value within a single settlement: depending on its size and status, the minimum and maximum values may differ several times over.

The assessment of the location of the subject property and the selected comparable properties is typically carried out based on the following factors:

- distance from the center of business activity and essential infrastructure, including administrative, public, financial, retail, and warehouse facilities, as well as sources of resource supply;
- prestige and comfort of the local location of the property as a social factor, characterized by the concentration within the neighborhood of “branded” companies or facilities, including historical and architectural landmarks, protected areas, and other notable buildings and structures;
- transport and pedestrian accessibility of the property, including proximity to primary and secondary transport routes, parking areas, and public transport stops;
- the nature of the immediate surroundings, including the type of development and architectural features of buildings and structures; proximity to recreational areas such as forests, parks, lakes, or rivers; as well as distance from sources of environmental discomfort such as landfills, chemical plants, and other hazardous industries.

To calculate the adjustment coefficient for location, a “point-based assessment” method is applied, which involves evaluating its components in points and calculating an aggregated indicator that represents a quantitative measure of this parameter.

The point-based method of location assessment includes the following stages. At the first stage, for each location component, depending on the characteristics of the settlement in which the subject property is located, the type of real estate, and its functional purpose, evaluation criteria are determined and a corresponding list is compiled. At the second stage, each location component is assigned a share (weight) f_i depending on its impact on the value of the real estate property, with the total of all shares equal to 100% (or 1.0). At the third stage, depending on the diversity of selected and existing zoning criteria of the settlement, a point scale from 3 to 1 is chosen. The highest score B (3), depending on the selected scale, is assigned to the most advantageous location, while the lowest score B (1) is assigned to the least favorable location (see Table 4).

Table 4. Parameters of the point-based assessment

Location score	Distance from the center of business activity and essential infrastructure	Prestige / comfort of the local location of the property	Transport and pedestrian accessibility of the property	Nature of the immediate surroundings
(fi)	0.2	0.3	0.2	0.3
3	Central part of the city	High social status of the neighborhood; presence of a green (recreational) area within walking distance	Within walking distance (5–10 minutes) to main city-forming roads and public transport interchanges (bus, trolleybus, or other routes with transfer options in different directions)	Neighborhood with well-developed social infrastructure (shops, municipal institutions)
2	Middle zone	Development with a medium social level of residents; convenient access to the building and availability of parking spaces	Local streets; public transport stops within walking distance	Neighborhood with underdeveloped social infrastructure; presence of older buildings; potentially hazardous areas due to geophysical characteristics (possible flooding, ground instability, etc.)
1	City periphery	Social level of residents below average; access via unpaved roads; unfavorable areas	Local street located far from public transport stops	Neighborhood with poorly developed social infrastructure; presence of old buildings; hazardous residential areas due to geophysical characteristics (flooding, ground subsidence, etc.); environmentally hazardous areas

After selecting the point scale that takes into account the advantages of the property's location, a weighted assessment of the location A_n of the subject property and the selected comparable properties is carried out using the following formula:

$$A_n = B_{n1} \times f_1 + B_{n2} \times f_2 + \dots + B_{ni} \times f_i \quad (2)$$

where: A_n – weighted assessment of the location of the real estate property; $B_{n1}, \dots, B_{ni}$ – point score of the i -th location criterion of the real estate property; $f_1, \dots, f_i$ – share (weight) of the location criterion; $n = 0$ – subject property; $n = 1 \dots m$ – number of comparable properties.

The value of the location adjustment coefficient K_{mr} (in percent) is calculated using the following formula:

$$K_{mr} = \frac{A_0 - A_a}{A_0 + A_a} 100\% \quad (3)$$

where: A_a – weighted assessment of the location of the comparable property; A_0 – weighted assessment of the location of the subject property.

The calculation of the weighted assessment of the quality of location of the subject property and comparable properties, as well as the value of the location adjustment coefficient, is presented in the calculation of the value of the subject property, Table 5.

Table 5. Calculation of the value of the appraised land plot

Element of Comparison	Subject Property	CP No. 1	CP No. 2	CP No. 3	CP No. 4
Asking price	\$	–	79,900.0	68,000.0	78,000.0
	UAH	Exchange rate 41.9331	3,350,454.69	2,851,450.80	3,270,781.80
Land plot area	m ²	574.00	800.00	777.00	1,000.00
	UAH/m ²	–	4,188.07	3,669.82	3,270.78
Intended use of land plot		02.01 Homestead land plot	Homestead land plot	Homestead land plot	Homestead land plot
Adjustment	%	–	0	0	0
Coefficient		–	1	1	1
Market conditions		–	bargaining	bargaining	bargaining
Adjustment	%	–	-30	-30	-30
Coefficient		–	0.7	0.7	0.7
Description of location characteristics		Close to the city center	Close to the city center	Close to the city center	Close to the city center
Distance from the center of business activity and infrastructure	score	3	3	3	3
Prestige / comfort of local location	score	3	3	3	3
Transport and pedestrian accessibility	score	2	2	2	2
Nature of immediate surroundings	score	3	3	3	3
Weighted location score	score	2.80	2.80	2.80	2.80
Coefficient		–	1	1	1
Plot area		574.0	800.0	777.0	1,000.0
Adjustment	%	–	2	2	3
Coefficient		–	1.02	1.02	1.03
Availability of improvements (buildings)		Conditionally absent	Conditionally absent	Conditionally absent	Conditionally absent
Adjustment	%	–	0	0	0
Coefficient		–	1	1	1
Engineering and infrastructure factors		Utilities available	Utilities on the plot	Utilities along the street	Utilities on the plot
Adjustment	%	–	0	10	0
Coefficient		–	1	1.1	1
Total adjustment coefficient		–	0.71	0.79	0.72
Adjusted value		–	2,973.53	2,899.16	2,354.96
Final adjusted value	UAH/m ²	2,750	–	–	–
	UAH	1,578,219	–	–	–

Adjustment for area. The adjustment is made depending on the size of the area, namely, the price per square meter is inversely proportional to the size of the area. The adjustment coefficient is calculated using the formula $K=(S_a/S_o)0.05$, where S_a is the area of the comparable property and S_o is the area of the subject property. The price damping coefficient (0.05) was determined empirically for similar properties.

Adjustment for availability of utilities. When comparing the level of access of the subject property and comparable properties to engineering utilities, the Appraiser typically applies adjustments at the level of 2–5% per utility type in case of differences, but not exceeding 15% in total.

Determination of the compounding rate

The value of the compounding rate i , which is determined by the duration of construction (development) expressed in the number of months h , is calculated on the basis of the annual compounding rate i_A :

$$i = (1 + i_A)^{h/12} - 1 \quad (4)$$

The value of the annual interest rate i_A , which ensures the investor's return (cost of financing) i_F and the developer's return (developer's profit) i_D , is calculated using the following formulas:

$$i_A = (1 + i_F) \times (1 + i_D) - 1 \quad (5)$$

or

$$i_A = i_F + i_D + i_F \times i_D \quad (6)$$

For the purposes of [14], the cost of financing as of the valuation date is calculated as an interest rate based on data from the website www.Global-Rates.com regarding the annual USD LIBOR rate, increased by a country risk premium. Since the USD LIBOR rate has ceased to be published as of January 1, 2024, the analogous SOFR rate is used. SOFR, based on the U.S. Treasury repo market, reflects the cost of overnight cash borrowing secured by U.S. Treasury securities; it is a volume-weighted median rate calculated from various repo transactions.

In this case, the annual rate selected as of December 26, 2025, according to [25], is 3.76%. The country risk premium (CRP) serves as an additional compensation (relative to the Euribor rate) for systematic risks specific to a particular country as perceived by the market. The CRP may be calculated as the average difference in yields between 10-year U.S. Treasury bonds (10Y YTM) and Ukrainian Eurobonds issued for a comparable maturity (Ukraine 2034–2035–2036) during 2025. An equivalent indicator of the country risk premium is the analytical measure published at [26] (which provides risk premium estimates for markets based on country ratings assigned by Moody's; since June 2012, it also includes equity risk premiums based on CDS spreads where available). As of July 1, 2025 (data updated twice a year in January and July), the country risk premium for Ukraine amounts to 17.75%.

The developer's interest (developer's profit; risk premium associated with real estate development) is determined based on market information by comparing the revenue from the sale of the completed development project with the amount of costs (taking into account the time factor and development duration) related to its development. The quantitative value of this parameter in Ukraine is, firstly, non-public information usually known only to the developer, and secondly, it largely depends on the organization of the developer's operational and financial activities, the type of property, and other factors. According to indirect expert estimates, as of early 2022, the developer's profit ranged from 3% to 15–20% per annum. In this report, for the subject property, this value is assumed at 4% (residential real estate).

Additionally, this value may be supported by the following considerations. The risk premium associated with real estate development is typically several percentage points higher than the cost of financing (borrowed capital) for the construction of similar projects. According to <https://index.minfin.com.ua/ua/banks/nbu/rates/>, lending rates for construction amounted to 8–9% in USD and EUR. Accordingly, a development risk premium at the level of approximately 10–11% appears to be entirely reasonable.

The value of the compounding rate (i), which is determined by the duration of construction (development) expressed in the number of months (h), is calculated on the basis of the annual compounding rate (i_A):

$$i = (1 + i_A)^{h/12} - 1 \quad (7)$$

The duration of the construction (development) period is determined on the basis of [27] in the case of construction, or in the case of development (major overhaul). According to the initial data, as of the inspection date, the legally required procedures for the preparation of design and estimate documentation had not been completed since the date of occurrence of the damage, and conservation or preparatory works had not been initiated. Therefore, in accordance with DSTU, the period for carrying out restoration works will amount to 5 months ([27], Annex A).

The calculation of the compounding rate is presented in Table 6.

Table 6. Calculation of the compounding rate

Indicators	Source	Value
SOFR USD as of 26.12.2025	[28]	3.76%
Country Risk Premium (%), CRP	[29]	17.75%
Investor's return (%), (i_F), total	—	21.51%
Developer's return (%), (i_D)	Calculation [30]	4.00%
Annual compounding rate (%), (i_A)	Calculation, Clause 3.9 of Section III of [14]	26.37%
Construction duration (months)	[27] Annex A	5
Rate (i), %	—	10.24%
Compounding multiplier, (i)	Clauses 3.5, 3.12 of Section III of [14]	1.0500

The gross development value is calculated as follows:

$$V_{GDV} = 1\,578\,219 \times (1 + 10.24\%/100) + ((12\,377 + 619) \times 80.2) \times (1 + 10.24\%)^{0.5} = 2\,674\,250 \text{ UAH} \quad (8)$$

Analysis of the value of residential real estate

According to residential real estate market research conducted by [31], the average price per square meter of residential property (detached houses) on the secondary market in the Dnipropetrovsk region amounts to USD 561 per m².

The analysis was carried out using the “UVEKON Geoportal” service, a cross-analytics tool that reflects data on quantitative and price indicators of the real estate market, information on capitalization rates, bargaining coefficients, and exposure periods, as well as the number of concluded transactions according to the Ministry of Justice of Ukraine and data on mortgage lending market activity (Fig. 5).

For the Dnipropetrovsk region as a whole, the average price per m² amounts to USD 561, the median price amounts to USD 448, the bargaining index is 21%, and the exposure period is 4 months.

For the Sobornyi District of the city of Dnipro as a whole, the average price per m² amounts to USD 943, the median price per m² amounts to USD 882, the bargaining index is 18%, and the exposure period is 4 months

For the Sobornyi District of the city of Dnipro, the average price per m² in residential condition amounts to USD 771, and the median price amounts to USD 641.5. The average price per m² after builders (shell condition) amounts to USD 687.30, and the median price also amounts to USD 687.30. The overall average price per m² amounts to USD 958.40.

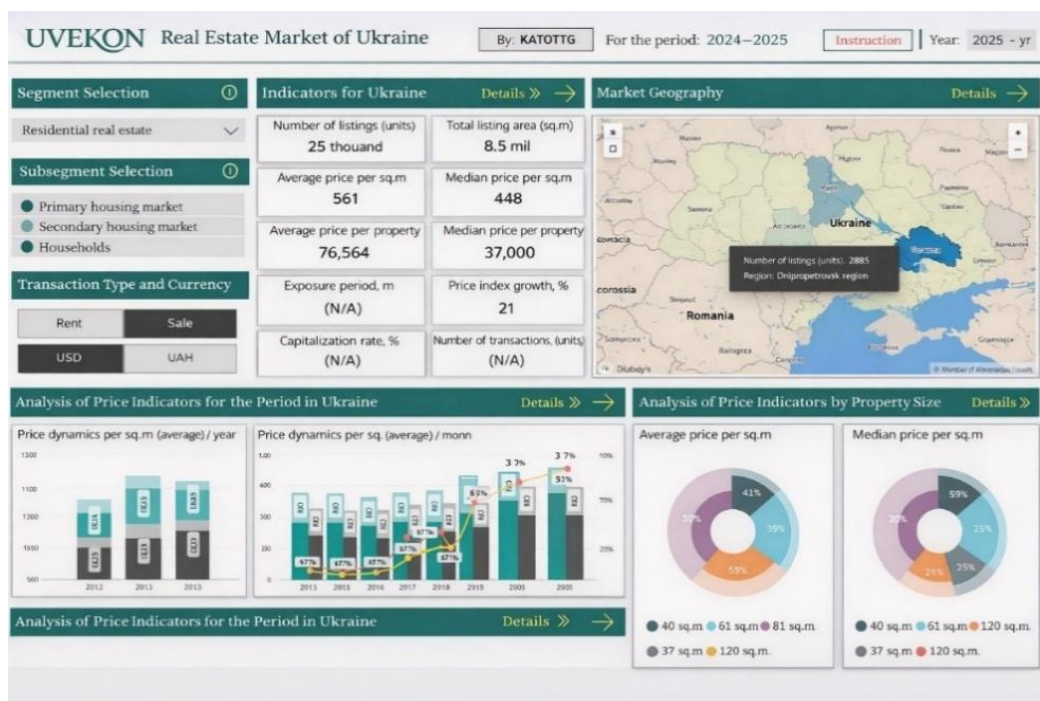


Fig. 5. Analysis of price indicators for the period 2024-2025

Based on the data from the residential real estate market analysis, the following conclusions have been drawn regarding the value of the residential property subject to inspection:

- the average value of residential real estate on the secondary market (detached houses) in the city of Dnipro, Sobornyi District, amounts to USD 977 per m².
- the value of residential real estate on the secondary market in habitable condition in the city of Dnipro, Sobornyi District, amounts to USD 791 per m².

Therefore, the indicative value based on the market analysis for residential building No. 2B, with a total area of 80.2 m², living area of 41.6 m², single-story, ceiling height of 3.55 m, commissioned in 1958, and located at 2B Brondukova Street, Dnipro, amounts to the following:

For a secondary market property, the average asking price for such домоволодіння (household property) is USD 78,355 (UAH 3,285,668 at the exchange rate as of the valuation date of UAH 41.9331 per USD 1). For a secondary market household property in habitable condition, the value amounts to USD 63,438 (UAH 2,660,160).

Determination of the appraised value of the real estate property

To determine the appraised value of a real estate property, the Unified Database of Valuation Reports [32] generates an electronic certificate of its appraised value (e-Certificate), which remains valid for 30 calendar days from the date of its issuance by the Unified Database.

For taxation purposes related to the sale (exchange) of real estate owned by individuals, online services have been introduced for both individuals and legal entities, enabling the generation of an e-Certificate of the appraised value of a real estate property.

Based on the technical passport provided by the owner, a certificate of the appraised value of the real estate property as of December 26, 2025, was obtained.

The appraised value of the real estate property in the form of a household (detached residential property), located on a land plot with an area of 574 m² at 2B Brondukova Street, Dnipro, amounts to UAH 1,845,905.

An electronic certificate of the appraised value of a real estate property is a document generated upon request of an individual or legal entity based on information about the respective property entered into the Unified Database of Valuation Reports. Such a certificate is created via the Internet and contains the appraised value of the property determined by the electronic calculation module.

Determination of the market value of the real estate property

In the opinion of the Appraiser, in this case the only feasible approach for valuing a detached residential house of estate type, among the three existing approaches, is the comparative approach, which, due to better data availability, provides the most objective result.

Thus, the comparative approach is based on the direct comparison of the subject property with other similar real estate properties that have been sold or offered for sale. This approach involves the analysis of sale and asking prices of comparable properties with appropriate adjustments for differences between the comparable properties and the subject property.

To determine the market value of the property using the comparative approach, information about comparable properties must meet the following requirements. The terms of sale and offering conditions must not differ from those consistent with the criteria for determining market value. The transfer of comparable properties must have been carried out under standard payment conditions. The market conditions that influenced the formation of sale or asking prices as of the valuation date must not have changed significantly, or such changes cannot be reliably accounted for.

The main elements of comparison include the characteristics of comparable properties, particularly their location, physical and functional parameters, and conditions of sale. Adjustments to the value of comparable properties are made by adding or subtracting a specific monetary amount, applying an appropriate coefficient (percentage) to the sale or asking price, or by combining these methods.

For the purpose of analyzing and determining the value of the subject property from the perspective of sales comparison, the Appraiser performed the following steps.

First, a search was conducted in the market for sale prices and asking prices of properties that could be comparable to the subject property. Second, information was collected and verified for each property regarding the sale price and/or asking price, transaction terms, physical characteristics, location, and other specific transaction conditions. Third, each comparable property was analyzed and compared with the subject property in terms of location, physical characteristics, and sale conditions. Fourth, adjustments were made to the price of each comparable property in accordance with the identified differences between it and the subject property. Fifth, the adjusted prices of the comparable properties were analyzed, and a value indicator for the subject property was derived.

In order to study offers for the sale of real estate similar to the subject property and to select comparable properties, information from local media, real estate agencies, and specialized Internet websites was analyzed. Information on comparable properties was classified according to the following elements of comparison: functional purpose, location, physical characteristics, and availability of engineering utilities.

The details of the comparable properties selected by the Appraiser in the course of this work are presented in the Report in the section devoted to market analysis.

In these calculations, value added tax (VAT) is neither included nor separately identified, since in accordance with Subparagraph 197.1.14 of Paragraph 197.1 of Article 197 of the Tax

Code of Ukraine, transactions involving the supply of housing (residential property) are exempt from taxation (except for the first supply).

The determination of the market value of the subject property using the comparative approach was carried out on the basis of data on market sale prices of real estate, determined according to asking prices within the relevant segment of the real estate market in the city of Dnipro. When selecting comparable properties, particular attention was paid to structural and technical characteristics corresponding to those of the subject property, as well as to location and consumer qualities. Prices for comparable properties were taken from online resources and marketplaces (<https://www.olx.ua> and <https://www.dom.ria.ua>).

In accordance with Clause 3 of NSO No. 1, the comparables selected for the calculations are residential buildings located on Brondukova Street and adjacent streets in the Sobornyi District of the city of Dnipro and meet the definition of similar property — property that, in its characteristics and/or properties, is similar to the subject property, taking into account differences, and has the same investment attractiveness.

For valuation using the comparative approach, research and analysis of the residential real estate market in the city of Dnipro were conducted. Four comparable properties were selected that most closely correspond to the subject property in terms of purpose, characteristics and properties, location, and spatial and planning characteristics and have the same investment attractiveness. The calculation tables present the market asking prices of the comparable properties and the market prices per m² in UAH, rounded to the nearest whole number.

Comparable properties:

- CP1 – residential building, Dnipro, 25B Brondukova Street [33],
- CP2 – residential building, Dnipro, 5 Brondukova Street [34],
- CP3 – residential building, Dnipro, 59 Sheptytskoho Street [35],
- CP4 – residential building, Dnipro, Tykhvynska Street [36].

To determine the market value of the residential property using the comparative approach, adjustments were made to the asking prices of properties offered for sale to account for differences from the subject property. Where the characteristics of the comparable property and the subject property were identical, no adjustments were applied.

Market conditions

An adjustment was made to account for a possible reduction in the asking price of the comparable properties (bargaining). The prices presented on the market are asking prices. Actual transaction prices constitute commercial confidential information. Market analysis and consultations with market professionals make it possible to estimate the level of bargaining, which, depending on the condition of the relevant market segment and the specifics of the properties, may range from 5% to 35%. Taking into account the combination of factors, namely the location of the property, physical characteristics, availability of utilities, level of finishing, and other positive and negative factors, the average bargaining level in this case is assumed to be -18% [31], Table 7.

Adjustment for Area Size was made depending on the size of the premises, namely, the price per square meter is inversely proportional to the size of the area. The adjustment coefficient was calculated using the formula $K=(S_a/S_o)0.05$, where S_a is the area of the comparable property and S_o is the area of the subject property. The price damping coefficient (0.05) was determined empirically for similar properties.

Table 7. Determination of the Market Value of the Property “Residential Building, with a total area of 80.2 m², built in 1958, located at 2B Brondukova Street, Dnipro” in the condition prior to the occurrence of damage (in conditionally serviceable condition)

Element of Comparison	Subject Property	CP1	CP2	CP3	CP4
Asking price	USD	–	55,000.00	50,500.00	45,000.00
	UAH (rate 41.9331)	–	2,306,321	2,117,622	1,886,990
Total area	m ²	80.20	51.70	39.00	67.30
Land plot area	m ²	319.00	538.00	280.00	400.00
Ownership right		Private	Private	Private	Private
Adjustment	%	–	0	0	0
Movable property included		Conditionally absent	Furniture, appliances	Furniture, appliances	Furniture, appliances
Adjustment	%	–	0	0	0
Market conditions (bargaining)		–	Bargaining	Bargaining	Bargaining
Adjustment	%	–	-18	-18	-18
Price after bargaining (per property)	UAH	–	1,891,182.81	1,736,449.67	1,547,331.39
Price after bargaining (per m ²)	UAH/ m ²	–	36,579.94	44,524.35	22,991.55
Location		2B Brondukova St.	25B Brondukova St.	5 Brondukova St.	59 Sheptytskoho St.
Location coefficient		–	1	1	1
Land plot area (comparison)	m ²	574.00	538.00	280.00	400.00
Adjustment	%	–	0	4	2
Coefficient		–	1.00	1.04	1.02
Total building area	m ²	80.20	51.70	39.00	67.30
Adjustment for area difference	%	–	-4	-7	-2
Adjustment for number of floors	%	–	1	1	1
Construction materials		Walls – brick; floors – wood	Walls – brick; floors – wood	Walls – brick, foam insulation; floors – wood	Walls – brick; floors – wood
Adjustment	%	–	0	0	0
Interior finishing level		Residential condition, satisfactory	Cosmetic repair, residential	Major repair, residential	Residential condition, satisfactory
Adjustment	%	–	-20	-30	0
Electricity		Available	Available	Available	Available
Water supply		Available	Available	Available	Available
Sewerage		Available	Available	Available	Available
Heating		Autonomous	Autonomous	Autonomous	Autonomous
Gas		Available	Available	Available	Available
Yard development (outbuildings)		Structures, garage, shed; low landscaping level	Structures present; medium landscaping	Structures present; medium landscaping	Structures present; medium landscaping
Adjustment	%	–	-10	-10	-10
Total adjustment coefficient		–	0.69	0.61	0.90
Adjusted value	UAH/ m ²	–	25,240.16	27,159.85	20,692.40

If the subject property and the comparable properties differ in physical characteristics (physical condition), an adjustment is applied in the value calculations in accordance with [15], according to the following scheme:

The cost of repair works is not fully reflected in the market value due to the principle of contribution. This means that the expenses incurred by the property owner for repair works are generally not fully (only partially) reflected in the overall value of the real estate. In addition, the extent of the adjustment depends on the locality (the less developed the market, the less the incurred costs are reflected in the property value). Therefore, for adjustment purposes (to transition from one condition to another), a percentage range of 10% to 30% is applied, depending on the level of finishing and compliance with modern standards.

The subject property includes outbuildings and auxiliary structures. The comparable properties also include outbuildings and structures such as garages, sheds, gazebos, and canopies. Based on the analysis of the residential real estate market, such auxiliary elements may influence the value of a household property within up to 10%. More well-developed plots (improved and landscaped territory; presence of structures; separation of the garden from the residential area, i.e., zoning of the plot, landscape design, and an automatic irrigation system) may increase the value of the household property by an additional average of 10%.

Final Adjusted Market Value (rounded): 24,962.09 UAH/m²

Equivalent values: USD/m²: 595 (CP1: 601.9; CP2: 647.7; CP3: 493.5; CP4: 638.1)

Total value: UAH 2,001,960.00 USD 47,741.76

The determined market value per m² (as the price that could be obtained as of the valuation date upon sale of a completed development (construction) real estate property on the market in conditionally serviceable condition) amounts to UAH 24,962.

Thus, the market value prior to the occurrence of damage (in conditionally serviceable condition) of the residential building, with a total area of 80.2 m², commissioned in 1958, located at 2B Brondukova Street, Dnipro, amounts to UAH 2,001,960.

Determination of the amount of compensation for destroyed real estate property

The amount of compensation for a destroyed real estate property is calculated in accordance with [37] for a detached residential house, garden house, or summer house using the following formula:

$$B_i = B_{sr} \times K_r \times S_{zn} \geq B_{ipov} \quad (9)$$

where: B_i – the amount of compensation for the destroyed real estate property (individual residential house), UAH; B_{sr} – the average cost indicator per m² of individual residential houses on the secondary market across Ukraine, which amounts to UAH 22,197.14; K_r – the regional coefficient reflecting differences in the price per m² depending on the location of the destroyed real estate property (individual residential house), specified in Appendix 6; in this case ($K_r = 1.059$).

The amount of compensation shall not be lower than the cost of constructing housing of the corresponding area, calculated using the indirect cost indicator in the regions of Ukraine, according to the location of the property, B_{ipov} .

In the event that the compensation recipient purchases housing, the costs of acquiring the land plot on which the housing is located are taken into account, provided that this does not result in exceeding its maximum value calculated in accordance with this provision.

S_{zn} – the area of the destroyed real estate property, m², but not exceeding 150 m² for an apartment and not exceeding 200 m² for a detached residential house, garden house, or summer house. In this case, the house area is 80.20 m².

Calculation: $B_i = 22\,197.14 \times 1.059 \times 80.20 = 1\,885\,243$ UAH.

Conclusions on the economic feasibility/infeasibility of restoring the residential building

To determine the economic feasibility or infeasibility of restoration, a comparison of the obtained results will be carried out for the real estate property in the form of buildings and structures of a household located on the privatized land plot with cadastral number

12101000000:03:190:0015, at the address Dnipropetrovsk Region, city of Dnipro, 2B Boryslava Brondukova Street, Table 8.

Table 8. Comparison of the obtained results

No.	Indicator	Value, UAH
1	Gross development value	2,674,250
2	Estimated value of residential real estate according to market analysis (range)	1,600,000 – 1,900,000
3	Appraised value of the real estate property: household with land plot	1,845,905
4	Market value of the real estate property prior to damage	2,001,960
5	Compensation value for the destroyed real estate property	1,885,242
6	Economic feasibility (Item 4 < Item 1) / infeasibility (Item 4 > Item 1) of restoration	Economic restoration of the inspected property is not feasible

The estimated value of residential real estate according to the market analysis is provided to confirm the accuracy of the calculated market value of the property. In this case, the market value of the real estate corresponds to the price range of the target segment of the secondary market for household properties (private houses).

The calculation of the appraised value of real estate is applied exclusively to determine the tax base in case of disposal of property by individuals (sale, exchange, donation, or inheritance), except in cases where a zero-tax rate is established. In case of disagreement with the automated valuation, the owner may initiate a professional market valuation of the property by contacting a certified appraiser. As can be seen from Table 8, the appraised value falls within the range of the estimated value of residential real estate according to the market analysis. The value of the property prior to the occurrence of damage exceeds the appraised value. The compensation value calculated in accordance with the methodology is lower than the market value of the property and lower than the gross development value but remains within the range of the estimated residential real estate value. The gross development value amounts to UAH 2,674,250.

Taking into account that the residential building, with a total area of 80.2 m², commissioned in 1958 and located at 2B Brondukova Street, Dnipro, is in an *аварійний стан* (technical condition category 4, damage category II), unfit for use for its intended purpose as a result of hostilities, terrorist acts, and sabotage caused by the armed aggression of the Russian Federation against Ukraine, and that its restoration is economically infeasible, the building is classified as a destroyed real estate property: the gross development value exceeds the market value of the real estate property.

Conclusions

The results obtained in the course of the study emphasize the importance of determining not only the technical condition and the category of damage but also, in certain cases, the economic feasibility of restoring damaged property. The application of such calculations will enable owners of damaged properties to receive more substantial and legally justified financial support from the state for the restoration of their property or the purchase of new housing.

The case study of a residential building in Dnipro showed that:

- the building is in emergency technical condition;
- the restoration cost significantly exceeds its market value;
- reconstruction is therefore economically impractical.

Consequently, the property should be classified as destroyed real estate, enabling the owner to receive compensation according to national legislation. It is also important to recognize that the issue of determining compensation for damaged or lost property classified as architectural heritage is becoming increasingly relevant.

Future research should focus on the development of methodologies for evaluating compensation for buildings that possess historical or architectural heritage value, as these structures present additional challenges for economic and cultural preservation.

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