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NASTROY

Strengthening urban resilience (SUR) in the areas of supply infrastructure and housing

Rehabilitation of Series 94 Residential Buildings in Kryvyi Rih, Ukraine

Preliminary Report

Nine-floor Residential Building in vul. Ukrainska, 55
Nine-floor Residential Building in vul. Iehora Birkuna, 8

Die Maßnahme wird im Rahmen der deutschen Übergangshilfe umgesetzt, die vom Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ) in Auftrag gegeben und von der Deutschen Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH durchgeführt wird.

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1 Summary

This report documents the **first step of a pilot project** for the rehabilitation of serial multi-storey residential buildings in Kryvyi Rih, Ukraine. It is **not limited to the repair of two individual buildings**, but rather uses them as case studies to develop **scalable approaches and recommendations** for Ukraine's broader housing recovery. The purpose of the report is to demonstrate how emergency stabilisation, structural reinforcement, and modernization can be combined into a coherent strategy, and to draw lessons for replication across the country.

Scope and purpose

The focus is on **Series 94 buildings**, one of the most widespread Soviet-era housing types in Ukraine. These buildings are both technically vulnerable to war damage and socially significant, accommodating large populations. By rehabilitating two pilot buildings, the project seeks to:

- restore habitability for displaced residents,
- test technical solutions under real wartime conditions,
- clarify governance and ownership challenges,
- model financing structures combining state programmes and international donor support,
- and develop a framework for upscaling to other regions and typologies.

At the time of updated reporting (15 September 2025), works for the pilot project Ukrainska 55 are still ongoing, and pilot project Birkuna 8 has begun hybrid reinforcement works and is expected to be completed by the end of 2025. Their status underscores the pilot character of this study: the aim is not to present finished results, but to derive **interim lessons and recommendations** for Ukraine's national recovery process. During the implementation process, several presenations and workshops took place to discuss the strategy with stakeholders and other experts.

Key challenges and how they are addressed

- **Legal and ownership structures.** Fragmented ownership and the limited legal capacity of homeowner associations (OSBBs) or cooperatives (ZhBKs) are a major barrier. This report highlights the need for legal reforms, emergency trusteeship models, and municipal mandates. The establishment of **steering committees** involving municipalities, contractors, and residents is one practical tool tested in the pilot projects.
- **Financing and risk of double funding.** Many households have already received compensation through programmes such as *eRecovery*. This creates risks of overlap with building-level rehabilitation financed by donors. The report recommends clear **coordination and sequencing** of household- and building-level programmes, as well as transparent recording of disbursed funds to avoid duplication.

- **Technical resilience.** Emergency reinforcement has shown the limits of Soviet-era prefabricated structures. Hybrid methods (steel frames, carbon fibre wraps) proved feasible, though requiring strict fire protection. In modernization, the choice of **non-combustible insulation (mineral wool)** and the **correct placement of new windows** illustrate how resilience-enhancing techniques can be embedded in rehabilitation. Protective shelters (basement upgrades or modular units) and accessibility retrofits are further examples of how safety and inclusivity can be integrated into reconstruction.
- **Economic viability.** Possible energy savings of 37–54% were calculated for the two pilot buildings. However, **payback times of 25–40 years** highlight the necessity of subsidies and donor co-financing. Rolling cost estimation and dual-track monitoring (normative vs. market-based) are recommended to cope with wartime price volatility.
- **Residents' participation.** Rehabilitation depends on functioning homeowner associations. Capacity building is needed not only at the technical but also at the institutional and human level: training in financial literacy, loan applications, project planning, and transparent communication. Steering committees and trauma-informed communication are recommended as scalable models.
- **Role of municipalities.** Urban administrations play a central role in enabling rehabilitation: they coordinate damage assessments, issue permits, co-finance modular or prefabricated solutions, incentivise modernization through local programmes, and strengthen OSBBs/ZhBKs as competent actors. Municipalities are therefore positioned as mediators between state programmes, international donors, and residents.

Lessons for donors and policymakers

For international donors, this report provides a **bridge between local pilot projects and national recovery frameworks** (RDNA4, eRecovery, VidnovyDIM, EnergoDIM, GreenDIM). It shows where donor engagement adds value beyond state programmes:

- in covering long payback horizons,
- in financing resilience-enhancing materials and technologies,
- in supporting institutional reforms and capacity building,
- and in disseminating lessons through handbooks, workshops, and professional exchanges.

The Kryvyi Rih pilots are not isolated technical projects but **testbeds for a new architecture of housing recovery** in Ukraine. By embedding resilience, circularity, inclusivity, and participatory governance into emergency rehabilitation, they contribute to a broader transformation of Ukraine's housing sector. The report thus provides both **practical models** for engineers and municipalities and **strategic recommendations** for donors and policymakers.

2 Introduction and context

2.1 Context and project task

The pilot project described in this report aims to rehabilitate war-damaged serial residential buildings in Kryvyi Rih in order to enable affected residents to return home safely and, at the same time, to develop scalable models for modernization. The project distinguishes three steps that must be addressed consecutively: (1) emergency repair, (2) structural rehabilitation, and (3) medium- to long-term modernization. These phases must be clearly delineated in terms of scope, involved actors, and funding logic.

Ukraine's housing sector has been severely impacted by Russia's war of aggression. As of early 2024, more than 250,000 residential buildings have been damaged or destroyed nationwide, with losses in the housing sector amounting to more than USD 56.8 billion. Multi-storey prefabricated housing types, such as Series 94 buildings, account for a significant share of this destruction. In the city of Kryvyi Rih, located in Dnipropetrovsk Oblast, the damage to multi-storey residential buildings has reached unprecedented dimensions in Europe since the Second World War. The majority of these buildings are industrially prefabricated structures from the Soviet era, designed for a service life of about 30 years, and have already been in use for decades beyond that horizon. This combination of war damage, outdated construction, and missing maintenance has created a particularly challenging starting point for rehabilitation.

One of the central challenges of this project lies in navigating Ukraine's fragmented ownership structures. While individual apartments are privately owned, ownership of common areas and the land parcel remains ambiguous in many cases. Ownership models include OSBB (homeowners' associations), ZhBK (housing cooperatives), and management companies – each with different legal standing, organisational capacity, and implications for reconstruction. This legal complexity must be addressed seriously, as it directly influences decision-making, accountability, and eligibility for public or donor-based funding.

Against this backdrop, the pilot project takes into account not only technical aspects but also structural, social, financial, and organisational dimensions. In addition to restoring structural safety and habitability, rehabilitation is to be linked to modernization measures that increase energy efficiency, climate resilience, and inclusivity. Social structures within the buildings are considered an integral part of the project: wherever possible, residents are to be involved in the planning process. Through careful planning and implementation, the aim is not only to restore the physical structure of the building but also to contribute to the stability and security of the affected community.

The philosophy guiding this approach is summarised in the triad *Circularity – Climate – Community*. This means, firstly, that construction methods and resource management should be guided by principles of circularity, including recycling, re-use of materials, and reduced waste. Secondly, the rehabilitation must be future-oriented in terms of climate adaptation and energy efficiency, to reduce dependence on centralised and vulnerable energy infrastructures. Thirdly, the process must strengthen community involvement and user participation, recognising that social acceptance and cooperation are decisive factors for success. This triad extends beyond construction technology and provides a framework that allows findings from this pilot project to be applied in comparable situations across Ukraine.

The housing stock in Ukraine faces challenges that are deeply rooted both in construction technology and in organisation. More than 70 per cent of existing buildings date from 1955 to 1991 and were not originally designed for long-term use beyond three decades. The lack of technical expertise among residents and the absence of continuous maintenance have resulted in a housing stock that is outdated and, in many cases, in desolate condition. At the same time, above-average energy consumption – mainly due to inefficient heating and insulation systems – has made residential buildings highly dependent on centralised energy sources. This dependency has become a major risk factor under conditions of targeted attacks by the Russian military on civilian infrastructure.

Financing is another critical dimension. Many households lack the necessary funds to invest in urgently needed rehabilitation and modernization. They require technical support, accessible subsidy programmes, and incentives for collective action. Existing national programmes – such as eRecovery for household-level support and VidnovyDIM, EnergoDIM, and GreenDIM at the building scale – play a central role in this regard, but their accessibility depends on clear governance and functioning OSBBs/ZhBKs.

Against this complex background, the pilot project in Kryvyi Rih aims to develop, implement, and evaluate practical, scalable solutions. The primary objective is to generate transferable planning instruments for the rehabilitation of war-damaged prefabricated housing – specifically Series 94 buildings. These instruments are intended to serve not only as technical templates but also as strategic tools for governance, financing, and resident participation across Ukraine. Success will be measured along three dimensions: (1) the development of technically feasible and cost-effective solutions, (2) their implementation under real-world conditions, and (3) their social and institutional acceptance by both residents and municipal actors. Only through such a holistic and multi-level approach can rehabilitation contribute to a lasting improvement of Ukraine's residential infrastructure and create replicable models for national recovery.

2.1.1 Current developments in international support for reconstruction and strengthened resilience (Ukraine Recovery Conference, July 2025)

The reconstruction of war-damaged housing in Ukraine ranks among the most urgent and complex challenges facing the international architecture, planning, and development community since the Second World War. At the centre of the Ukraine Recovery Conference (URC 2025), held in Rome in July, were not only bilateral and multilateral funding commitments for physical reconstruction but also the coordinated development of strategic frameworks for a trans-sectoral, resilient, and socially equitable transformation of the Ukrainian housing sector.

Four key dimensions emerged from the conference: (1) the reconstruction of destroyed housing, (2) the modernization of the existing stock, (3) the mechanisms of international financing, and (4) the governance strategies underpinning these processes. This multi-dimensional perspective reflects the recognition that rebuilding Ukraine is not simply about restoring pre-war conditions but about enabling long-term transformation.

Unlike earlier post-conflict contexts – for example in the Balkans after the Yugoslav wars or in Georgia in 2008 – URC 2025 deliberately refrained from proposing a single overarching master plan. Instead, it adopted a model of *cooperative poly-strategy*. This approach accepts a diversity of initiatives, some coordinated, others independent, brought together under a shared framework. Fragmentation is not perceived as a liability but as an organising principle. It allows different donors and actors – from multilateral development banks to local foundations – to engage according to their capacities, interests, and risk profiles. The result is a flexible governance architecture that oscillates between decentralised autonomy and systemic alignment.

The material foundation of this approach was laid through a broad spectrum of financial commitments. In total, pledges exceeding €10 billion were announced, combining both grants and repayable financing instruments. Among them: the **HOME programme** of the Council of Europe Development Bank (CEB), allocating €100 million for direct compensation and housing reconstruction; a **€2.3 billion EU support package** designed to leverage up to €10 billion of additional investment; and a series of new de-risking instruments and investment guarantees, such as joint facilities by the European Bank for Reconstruction and Development (EBRD) and the International Monetary Fund (IMF).

Beyond the immediate replacement of destroyed housing, modernization of the existing stock has become central. In line with the “Build Back Better” paradigm, the goal is not only to restore the pre-war situation but to achieve a qualitative transformation of Ukraine’s residential environment. This includes thermal upgrading, the integration of renewable energy systems, accessibility improvements, typological diversification, and urban densification. Dedicated programmes, such as the *Ukraine Renewable Energy Risk Mitigation Mechanism* and new EBRD investment lines,

illustrate that modernization is not a secondary issue but a core component of the reconstruction agenda.

The donor community thereby operates within a hybrid governance model that balances top-down coordination with bottom-up autonomy. Local authorities and municipalities are actively involved in planning and implementation. At the same time, reforms of the legal and administrative framework are underway to strengthen the status of homeowner associations (OSBBs), clarify land tenure, and enable municipalities to act as competent contractual partners. RDNA4 had already identified deficiencies in the legal framework and called for institutional strengthening as a prerequisite for scalable housing recovery.

In sum, URC 2025 marks a paradigm shift in post-conflict recovery policy. Instead of rigid, centralised frameworks, it laid the foundation for an integrated reconstruction architecture characterised by structural flexibility, multi-level participation, and clear functional differentiation between emergency response, rehabilitation, and long-term transformation. In this context, housing is more than a physical asset: it becomes a strategic vehicle for building social resilience. Ukraine thus emerges as a laboratory for a multifaceted approach to recovery, where architecture, economics, and international law intersect with an intensity rarely seen in previous reconstruction efforts.

2.2 The specific situation in Kryvyi Rih

Kryvyi Rih is located in Dnipropetrovsk Oblast, which according to RDNA4 accounts for over 11% of total war-related housing damage in Ukraine. More than 13,000 residential buildings in the oblast have been damaged or destroyed, with estimated housing losses exceeding USD 5.2 billion. This figure underlines both the city's exposure and the urgent need for systematic rehabilitation and coordinated donor involvement. Kryvyi Rih's linear urban structure, its industrial profile, and its strategic location near the front line have made it particularly vulnerable to repeated missile and drone attacks.

Almost one-fifth of the total housing stock in the city has been damaged or destroyed since the beginning of the Russian invasion. Out of more than 5,000 multistorey residential buildings, over 1,100 have sustained damage. While repairs have been carried out in some cases, entire sections of other buildings have had to be demolished. Compensation has been paid to the owners of the affected apartments, amounting to approximately USD 25,000 per standard apartment. Such unit-level compensation schemes, however, raise questions regarding the interplay with building-level rehabilitation programmes: without clear coordination mechanisms, there is a risk of double funding or of discouraging collective reconstruction efforts.

According to official data provided by the city administration, as of 15 July 2024 there were 781 multi-storey buildings recorded as damaged; by July 2025 this number had increased to 1,121. Within this total (as of 2024), 670 buildings were recorded with broken windows, 82 with damaged roofs, and 29 with both broken windows and roof damage. These figures demonstrate the variety of damage levels across the housing stock and highlight the need for differentiated strategies – from minor repairs to large-scale reconstruction.

Management structures of the city's 5,324 multi-storey buildings are diverse. About 920 buildings (17%) are organised as OSBBs, 200 as ZhBK housing cooperatives, while the majority – 4,204 buildings – are managed by private or communal companies (60% private, 40% communal). The presence or absence of functioning homeowner organisations is an important parameter for rehabilitation, especially when mobilising state programmes such as VidnovyDIM or EnergoDIM.

Beyond direct housing damage, Kryvyi Rih also faces broader infrastructural challenges. The destruction of the Kakhovka Dam in June 2023 has particularly affected the city's water supply. Energy security is equally fragile, with attacks on centralised heating and electricity systems creating recurring risks for residents. According to Deputy Mayor Oleksandr Katrichenko, each rocket attack causes an estimated economic loss of 10 million UAH. Moreover, the cost of rebuilding residential buildings destroyed in the war has been calculated at roughly twice the level of current compensation payments to households, raising questions about the adequacy and sustainability of existing compensation mechanisms.

Against this background, Kryvyi Rih represents not only a local case of urgent need but also a test ground for scalable solutions that balance emergency response, building-level rehabilitation, and long-term modernization within Ukraine's broader recovery agenda.

Demaged buildings (as of 15 July 2024):

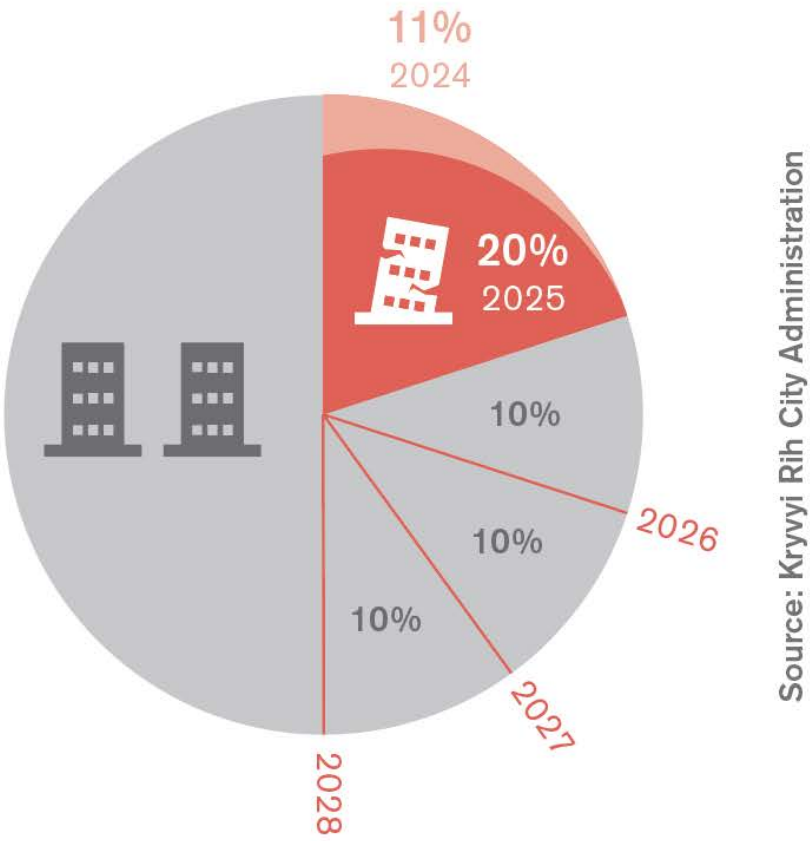
781 multi-storey buildings damaged *(1,121 buildings as of 15 July 2025)*
670 bldgs. with broken windows (2024)
82 bldgs. with damaged roofs (2024)
29 bldgs. with broken windows and damaged roofs (2024)
Source: Kryvyi Rih City Administration (July 2024 and July 2025)

As of the time of writing this report Kryvyi Rih's housing estates (5,324 multi-storey apartment buidings) count the following management structure:

OSBB ..... 920 buildings
Housing cooperatives (ZhBK) ..... 200 buildings
Management companies ..... 4,204 buildings*

* 60 % private management, 40 % communal Managament

Damaged multi-storey residential buildings in Kryvyi Rih



The graphic shows the extent of destruction of multi-storey residential buildings in Kryvyi Rih. By 15 July 2024, 11% of the housing stock was damaged or destroyed; by 15 July 2025, the share had risen to 20%. If this pace continues, half of the city's housing stock could be affected within the next three years.

2.3 Legal considerations

Compared with Western European contexts, Ukraine's housing sector is characterised by a unique legal situation: more than 95% of the housing stock is privately owned. This stems from regulations in the early 1990s that transferred state-owned housing to the registered residents of each apartment. However, this transfer excluded the land beneath the buildings and often left ownership of common property insufficiently defined. As a result, a number of legal challenges now affect the organisation of rehabilitation and reconstruction.

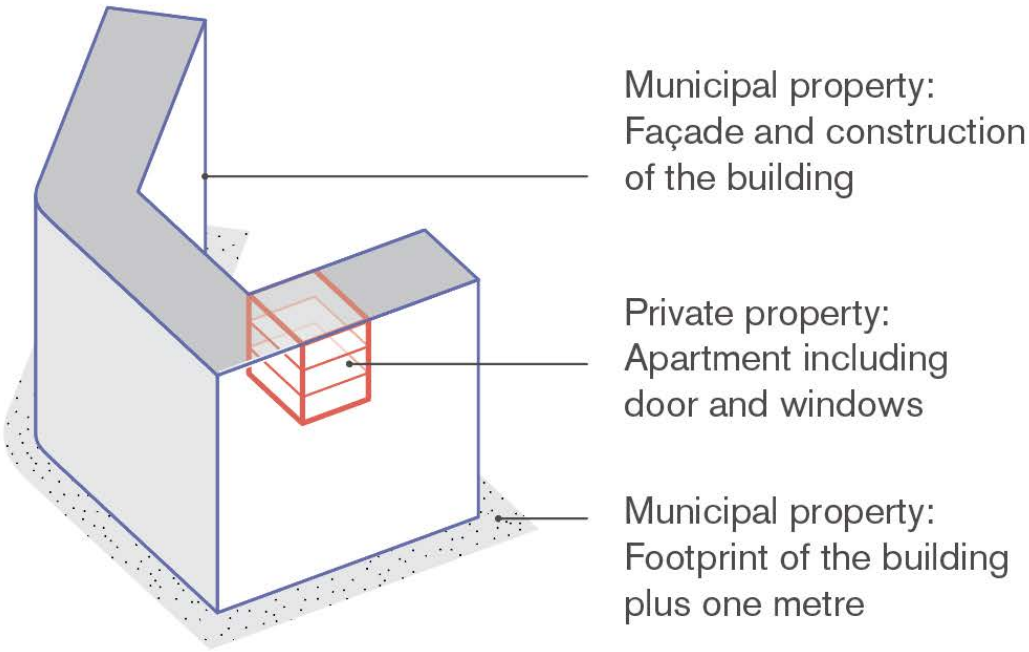
According to the Fourth Rapid Damage and Needs Assessment (RDNA4, 2025), the absence of clearly defined legal ownership of land parcels and communal property constitutes a major barrier to scaling housing reconstruction, particularly for multi-family apartment blocks. While OSBBs can act as collective entities, they often lack the full legal capacity to sign construction contracts, receive public funding, or engage effectively with international donors. RDNA4 therefore calls for the legal and institutional empowerment of these associations as a prerequisite for recovery.

For practical implementation, several dimensions require clarification:

1. **Representation and capacity of homeowner associations.** It must be clarified whether OSBBs or ZhBKs are legally able to enter binding contracts on behalf of all owners, to receive funds, and to bear liability. Without such capacity, collective reconstruction is hindered, and donor funds cannot be channelled effectively.
2. **Decision-making under emergency conditions.** Since 2014, and increasingly since 2022, the war has created unprecedented situations where urgent measures – such as demolishing partially intact building sections that pose a risk to safety, or altering gas, water and electricity connections – must be undertaken without full owner consent. In practice, many of these decisions have relied on a principle of "implied consent". While this may be pragmatic, it creates legal uncertainty, especially in cases where residents challenge decisions or claim damages. A codified emergency procedure is therefore needed, defining thresholds, responsibilities, and liability protections for urgent interventions.
3. **Programme alignment.** Reconstruction projects rely on access to state-funded programmes such as eRecovery (єВідновлення), VidnovyDIM, EnergoDIM and the emerging GreenDIM. Each of these instruments has different eligibility rules and governance mechanisms. Without harmonisation, there is a risk of duplication, double funding, or exclusion of beneficiaries.

Informing residents about actions taken remains crucial, even in emergency contexts. Transparent communication is a legal safeguard as well as a practical necessity, especially when international donor organisations such as GIZ are involved.

Different property rights of residential buildings in Ukraine



Property rights of residential buildings in Ukraine are more complex than in market-based legal systems. Apartment owners hold title to their individual units but lack co-ownership rights to the underlying land parcel. Consequently, mortgages must be collateralized by other assets. Introducing land title shares for apartment owners would improve collateral security and facilitate the modernisation of the Ukrainian housing stock.

RDNA4 further stresses the role of the Ministry for Communities, Territories and Infrastructure Development (MCTID) in coordinating a coherent legal framework. This includes ensuring alignment across funding streams, spatial planning instruments, and housing policy priorities, while also preparing Ukraine for compliance with EU standards.

It is therefore strongly recommended that the legal framework for the renovation and reconstruction of residential buildings be supported by a formal legal opinion. Such an expert assessment should (a) clarify ownership structures for land, buildings and apartment units within the Ukrainian legal system; (b) define the scope of action of OSBBs and ZhBKs, including their comparability to Western condominium models; and (c) examine transitional governance models for cases where homeowner consensus cannot be achieved. These models may include temporary trusteeship, delegated municipal control, or exceptional emergency procedures. Only on this basis can continuity of decision-making, liability clarity and donor security be guaranteed.

2.3.1 Differences between OSBB and ZhBK

According to Ukraine's current housing policy, the majority of multi-apartment buildings are expected to be managed by self-organised bodies in the near future. Two primary forms of legal entities exist: **ZhBKs (housing cooperatives)** and **OSBBs (condominium associations)**.

ZhBKs were typically established in Soviet times as construction cooperatives. Members held shares in the cooperative that entitled them to specific apartments once construction was completed. Although private housing ownership was not officially permitted under Soviet law, ZhBKs functioned in a quasi-private mode. After the collapse of the USSR, most cooperative apartments were privatised, but ZhBKs retained their legal status under the Housing Code of the Ukrainian SSR from 1983 – a framework still technically in force today. No new ZhBKs can be formed for existing buildings, but many legacy structures remain.

OSBBs, by contrast, were introduced in the early 2000s under the 2001 Law "On Condominiums" and reflect a more modern legal architecture. In practice, they function similarly to condominium associations in Western Europe: apartment owners jointly manage communal property, contract services, and undertake renovations. OSBBs are generally more flexible and better aligned with contemporary financing instruments, such as EnergoDIM, than ZhBKs. The law allows ZhBKs to be converted into OSBBs upon decision by residents, and such conversion is often recommended in the context of rehabilitation projects. However, the transition process can be complex and usually requires legal assistance and local government support.

Despite these legal frameworks, the overall situation in Ukraine's housing sector remains fragmented. There is no unified legal definition of ownership of shared infrastructure or land plots. OSBBs have partial administrative authority but often lack sufficient financial and legal capacity to coordinate reconstruction independently. ZhBKs operate under outdated regulations that do not correspond to today's challenges. Management companies – especially municipal ones – can act only within narrowly defined mandates from property owners.

This fragmentation generates several risks for rehabilitation projects:

- **Consent and representation.** If associations cannot secure clear owner mandates, decisions taken during rehabilitation may later be contested, undermining legal certainty for contractors and donors.
- **Claims and liability.** If damage occurs during rehabilitation, questions of who bears liability – the association, individual owners, or contractors – remain open.
- **Delays and inaction.** Where no clear legal pathway exists, urgently needed works may be stalled, exposing residents to further risks.

Possible solutions under discussion include temporary legal exceptions, codified emergency procedures, or delegated municipal trusteeship. Another pathway is strengthening OSBBs' internal governance tools, such as powers of attorney, clear super-majority rules, and digital voting mechanisms, so that they can more effectively represent all owners.

RDNA4 emphasises that **legal clarity is a prerequisite for investment mobilisation**. Without reforms, donors and implementing agencies face significant uncertainty. Clear procedures for decision-making, liability allocation, and owner representation are therefore essential to ensure that rehabilitation projects can proceed without legal contestation.

2.4 Considerations regarding state funds

Ukraine has established several national support mechanisms aimed at the reconstruction and modernization of residential buildings. These programmes are essential for scaling pilot initiatives, ensuring long-term energy security, and strengthening structural resilience. Access to these funds is, however, largely dependent on the legal organisation of buildings: in practice, registered OSBBs – and in some cases legacy ZhBKs – are the main eligible applicants.

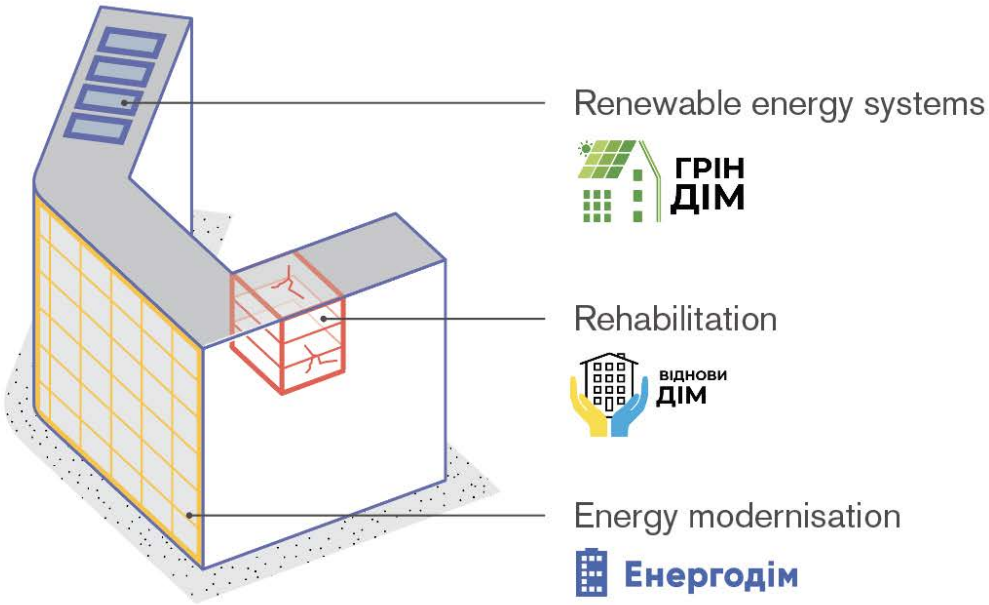
Two key instruments must be distinguished:

- **eRecovery (єВідновлення).** This programme targets individual homeowners. Applications are submitted digitally via the Diia platform, and compensation is disbursed directly to individuals. It covers small-scale repair or reconstruction, such as replacement of windows, minor structural repairs, or damaged roofing. Payments are capped at **approximately 200,000 UAH per household (≈ €4,150, exchange rate 15 September 2025)**. eRecovery is therefore designed as a rapid-response tool for households rather than a building-level solution.
- **VidnovyDIM.** This programme operates at the building scale and is directed at OSBBs (and, in some cases, ZhBKs). It supports more comprehensive repair and modernization measures for entire apartment buildings. Applications require verified damage reports, engineering documentation, and collective approval by the association. Funding is tied to a cost-sharing model, making it more suitable for systemic rehabilitation. Transparency is increased by a publicly accessible counter that displays available resources. Given the high demand, early application and complete documentation are critical for approval.

For modernization, two further programmes are central:

- **EnergoDIM.** This is the flagship programme of the Energy Efficiency Fund. It supports OSBBs in carrying out comprehensive energy retrofits, including façade insulation, heating system upgrades, and metering systems. The programme typically reimburses up to 70% of eligible costs, with the remainder to be co-financed by residents or municipalities. Participation requires a certified energy audit, which then informs the choice of technical measures. Post-implementation monitoring has confirmed energy savings of 50–70% in participating projects.
- **GreenDIM.** Currently in pilot phase, GreenDIM is intended to reduce dependency on fossil fuels by supporting the installation of renewable energy systems such as rooftop photovoltaics, heat pumps, and storage solutions. The programme aligns Ukraine's housing sector with the objectives of the EU Green Deal and is expected to become a cornerstone of future funding for climate-resilient housing.

State programs for rehabilitation and modernisation of residential buildings in Ukraine (2025)



State support programmes in Ukraine address different aspects of the housing sector: *VidnovyDIM* finances the rehabilitation of war-damaged residential buildings, *EnergoDIM* supports the energy-efficient modernisation of buildings‘ outer shell, and *GreenDIM* promotes the installation of renewable energy systems. During wartime reconstruction, it is essential to integrate considerations for subsequent energy modernisation from the outset.

A central challenge across all these programmes lies in the **interaction between household-level and building-level funding**. If individual households within a building have already received compensation through eRecovery, this may create complications for subsequent collective applications under VidnovyDIM or EnergoDIM. Without clear regulation, there is a risk of **double funding** or of discouraging collective rehabilitation because owners perceive their individual compensation as sufficient. This raises important questions for both Ukrainian authorities and international donors:

- How can compensation already paid to individuals be transparently recorded and reconciled with later building-level support?
- What safeguards are needed to avoid duplication of funds while ensuring that residents are not excluded from collective rehabilitation?
- How will such overlaps affect the willingness of donors to contribute, given the requirement for accountability and efficient use of resources?

According to practitioners such as **Tetyana Afanasyeva**, successful participation in these programmes depends not only on financial readiness but also on informed decision-making and behavioural change. Residents need to understand new heating and energy systems and must accept collective responsibility for building-level property management. Advisory services, legal assistance, and targeted user education are therefore indispensable components for successful implementation.

In summary, national state funds provide an indispensable backbone for reconstruction and modernization. However, to ensure their effective use in large-scale rehabilitation projects, three measures are essential:

1. **Clear coordination between household- and building-level programmes**, to avoid overlaps and ensure fairness.
2. **Simplified legal and administrative procedures**, particularly for OSBBs and ZhBKs, to lower entry barriers.
3. **Accompanying support structures** in the form of technical advice, legal counselling, and user education, so that residents can make informed decisions and assume responsibility.

2.5 Considerations regarding the local construction industry

The construction sector in Dnipropetrovsk Oblast, including the city of Kryvyi Rih, is operating under severe strain due to ongoing hostilities, regional displacement, and disrupted logistics. According to the RDNA4 report (2025), construction output in frontline regions has declined by more than 60% compared to pre-war levels. At the same time, material prices have increased by 45–70% across major categories, particularly for cement, insulation materials, and bitumen.

Kryvyi Rih, traditionally a hub for industry and mining, has experienced a sharp decline in new residential construction. Activities have shifted almost entirely towards the repair of existing buildings, maintenance of critical infrastructure, and emergency stabilization measures. Strategically, the regional construction sector is undergoing a structural transition – away from new housing development towards the consolidation of existing assets and adaptation to donor-funded recovery protocols.

One of the most pressing challenges is the acute shortage of qualified labour. The Confederation of Builders of Ukraine reports that approximately 73% of construction workers have been mobilised into military service, drastically reducing sectoral capacity (**Lev Partskhaladze,** Chairperson of the Confederation of Builders of Ukraine, MistoBUD Conference, O. M. Beketov University of Urban Economy in Kharkiv, 30 January 2025). This shortage is compounded by the emigration of skilled workers, particularly from the private sector, resulting in a growing reliance on informal labour arrangements. Such informal practices undermine construction quality and compromise both safety standards and legal accountability.

Logistical bottlenecks represent another persistent barrier. Local production gaps, disrupted transport routes, and rising fuel costs contribute to volatility in supply chains. Imported systems, such as prefabricated units or specialised MEP components, face delays and price surges. RDNA4 therefore recommends early engagement with regional suppliers, decentralised warehousing, and inter-oblast coordination of procurement strategies as practical mitigation tools.

Practitioners working on donor-funded projects, such as **Tetyana Afanasyeva**, have emphasised that capacity constraints are not limited to technical skills but also extend to the management of international funding procedures. Afanasyeva is a longstanding expert in municipal energy programmes and has advised OSBBs on their participation in state funds such as EnergoDIM. Her perspective is relevant because it highlights the *interface* between construction industry capacity and the administrative ability of homeowner associations to participate in funding programmes. According to her, successful implementation depends not only on financial readiness but also on informed decision-making and behavioural change among residents.

To address these challenges in the medium to long term, several strategies are recommended:

- **Multi-level public–private partnerships (PPPs)** to stabilise the sector and provide predictable demand.
- **Regional training centres** focusing on sustainable construction and the reskilling of demobilised soldiers.
- **Incentives for domestic production** of standardised retrofitting components, such as insulation panels or modular reinforcement elements.
- **Scaling modular and prefabricated techniques** not only for efficiency but also to revitalise local industrial capacities.
- **Systematic mapping and certification of architectural and engineering expertise** in the region, ensuring that qualified professionals are integrated into national programmes such as EnergoDIM and GreenDIM.

Lessons from post-conflict reconstruction in other regions – such as the Balkans or Iraq – show that early investment in local manufacturing, contractor qualification, and workforce development can significantly accelerate recovery and create systemic resilience. Applying these lessons to Kryvyi Rih means that the local construction industry should not be viewed merely as an executor of donor-funded projects but as a strategic partner in Ukraine's long-term housing transformation.

2.6 Considerations regarding the scalability of this project

Beyond the deadly risks and inhuman tragedies of the war, the rehabilitation of multi-family residential buildings in Ukraine also opens an opportunity to address long-standing systemic challenges. This pilot project in Kryvyi Rih is therefore conceived not only as a site-specific intervention but also as a contribution to a comprehensive framework that can be scaled to other regions and housing typologies across the country.

According to the Fourth Rapid Damage and Needs Assessment (RDNA4), more than 1.4 million housing units across Ukraine require repair or reconstruction. The damage is heavily concentrated in ten oblasts, which underscores the need for strategies that are both regionally adaptable and nationally scalable. Rehabilitation efforts cannot remain ad hoc; they must generate replicable models that can be integrated into broader housing and recovery policies.

Research by **Nataliia Mysak and Philipp Meuser** (co-author of this report) has highlighted the necessity of diversifying Ukraine's housing system beyond its current ownership-dominated structure. They propose six categories of housing – ranging from emergency shelters to long-term housing strategies – which provide a new planning matrix reflecting social needs, temporal urgency, and spatial context. Within this framework, the Kryvyi Rih pilot contributes most directly to *Track 3*

(urgency housing) and *Track 4 (accelerated housing programmes)*, offering methods that can be adapted for similar urban areas in frontline or recently liberated regions.

Scalability requires progress on three interlinked levels:

1. **Technical typologies.** Rehabilitation of Series 94 buildings provides a starting point, but scalable models must also include related prefabricated series. A typology catalogue of damage patterns, model-based technical solutions, and indicative cost frameworks should be developed to serve as a practical reference for engineers, municipalities, and donors.
2. **Policy and governance.** Technical solutions alone cannot achieve scale. Policy reforms are required, including revisions of land law, the enabling of municipal housing stock, and support for non-commercial actors such as cooperatives or civil society alliances. Local administrations, especially in frontline and recently de-occupied regions, must be legally and financially empowered to take leadership roles in reconstruction, reflecting both local conditions and social inclusion needs.
3. **Circular resources and sustainability.** Scalable rehabilitation must integrate sustainable material use from the outset. Ukraine's Waste Management Law (No. 2320-IX, 2022) defines construction and demolition waste as a regulated category, subject to recovery and reuse wherever technically feasible. This opens the way to embed *reduce, reuse, and recycle* strategies directly in reconstruction design. War debris and demolition waste, particularly concrete and metal components, should be prioritised for reuse. Although contamination risks or logistical limitations may slow implementation, planning should anticipate reuse potential in order to establish circular material loops.

The Ministry for Environmental Protection and Natural Resources has already encouraged the development of regional sorting and recycling infrastructure. Pilot projects like this one should therefore not only stabilise damaged buildings but also test small-scale circular systems at the community level. Experiences from Syria and Lebanon show that early coordination of debris logistics, certification, and reuse standards can prevent landfill overload and stimulate secondary markets – outcomes that are both environmentally and economically significant given the high disposal costs and limited transport capacities in war-affected areas.

Finally, scalability also implies **integration into European frameworks**. Alignment with the European Green Deal and participation in initiatives such as the *New European Bauhaus* can provide a long-term orientation that goes beyond technical reconstruction. By embedding rehabilitation in a discourse of resilience, circularity, and social inclusion, Ukraine can position its housing recovery as part of a broader European transformation.

In summary, this pilot project must be seen not only as an isolated technical intervention but as a **policy testbed** for legal harmonisation, sustainable material

practices, and community-driven planning. Its insights should be scaled to similar buildings across Ukraine and thereby contribute to the formation of a national reconstruction architecture rooted in resilience, circularity, and social inclusion.

2.7 Considerations of communication with homeowners and among local stakeholders

The rehabilitation of war-damaged residential buildings is not only a technical and financial process; it also depends fundamentally on effective communication between stakeholders. Decision-making in multi-owner buildings is inherently complex, and becomes even more difficult in times of crisis, when resources are limited and emotions are heightened. International experience and lessons from the Lviv Urban Forum (June 2025) underline that transparent, inclusive, and professional communication is essential to build trust, to accelerate decision-making, and to ensure legitimacy.

In Ukraine, resident participation in construction initiatives is often limited by high costs and by the difficulty of building consensus. The legal form of building management strongly influences communication dynamics:

- **OSBBs** generally demonstrate lower consensus-building costs because their creation already requires a minimum level of collective organisation.
- **ZhBKs** retain a legacy of joint action, but their outdated organisational forms often no longer reflect the realities of current residents.
- **Buildings without collective bodies** face the greatest barriers to effective communication and joint decision-making, often reflecting deeper social fragmentation.

Workshops and discussions at the Lviv Urban Forum recommended that OSBBs be strengthened to act not just as administrative units but as active agents in rehabilitation. This includes responsibilities for contractor selection, co-financing negotiations, and public accountability. To fulfil these roles, OSBBs require professionalisation: training for their leadership in legal, technical, and communication matters is a critical enabler of success.

Communication strategies should combine digital and analogue tools to reach all residents and ensure inclusivity. Standard formats include surveys, town hall meetings, and moderated workshops to identify priorities and preferences. At the same time, it is essential to manage expectations clearly: messages must define what is technically and financially feasible to avoid disillusionment. Transparent communication is therefore both a governance requirement and a psychological support measure for communities that have experienced displacement and trauma. Trauma-informed communication, supported by mental health professionals, should be considered an integral component of reconstruction.

Practical structures to coordinate communication are already being tested. On 18 July 2025, a project steering group was established to accompany the rehabilitation of Birkuna 8. This group includes representatives from the municipality, the construction company, the homeowners, all planning partners, and GIZ. Its main purpose is to coordinate the project, ensure joint decision-making, and strengthen accountability among stakeholders. Regular meetings every four to five weeks serve to maintain dialogue, resolve conflicts early, and monitor progress transparently. Such steering groups provide a prototype for future projects, demonstrating how inter-institutional cooperation and structured communication can be institutionalised in reconstruction practice.

In summary, communication with homeowners and local stakeholders should be regarded as a **standard and integral part of any reconstruction project**. It requires structured formats, professionalisation of resident organisations, transparent information flows, and the inclusion of psychosocial support. Only under these conditions can technical and financial measures achieve acceptance and sustainability.

Ukrainska 55, meeting with OSBB reps on 7 November 2024

Birkuna 8, meeting with ZhBK reps on 7 November 2024

Constitutive meeting of the steering committee “Birkuna 8” on 18 July 2025

Joint site inspection “Birkuna 8” on 18 July 2025

3 Building data of residential buildings under investigation

As a first step, suitable pilot buildings among the war-damaged residential stock in Kryvyi Rih were identified. To ensure a sound technical and political basis for selection, a transparent and adaptable set of evaluation criteria was developed in consultation with all relevant stakeholders. The matrix is designed to guide decision-making in a professional and comprehensible way, while remaining flexible enough for different geographic and political contexts. Individual factors can be prioritised or de-prioritised depending on local conditions; equally important is that decisions are taken through a transparent process and broad professional consensus.

Method. The development began with a *long list* of more than 20 potential criteria. Through iterative discussion, these were consolidated into a *shortlist of ten core criteria* used for ranking, complemented by a small set of *operational criteria* for verification and risk control (e.g., funding integrity). This approach explains why working tables may display more than ten fields.

Shortlist of core criteria (used for ranking):

1. Distribution and prevalence of the specific prefabricated typology (Series 94 and related) within Kryvyi Rih.
2. Availability and completeness of original construction documents and surveys.
3. Structural system and typical damage risks (frameless large-panel, block construction, masonry).
4. Geotechnical conditions (incl. mining-affected areas, seismic risks).
5. Social vulnerability of residents (e.g., share of elderly, families with children).
6. Urban visibility and demonstration value (location, frontage, symbolic effect).
7. Feasibility of energy modernization (insulation potential; roof suitability for IHP/PV).
8. Model character and potential for replication/knowledge transfer.
9. Eligibility for state/donor programmes (e.g., VidnovyDIM, EnergoDIM).
10. Expected implementation readiness (clarity of scope, access, site logistics).

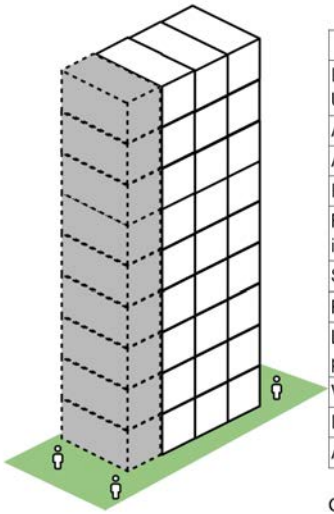
Operational verification & risk-control criteria (applied without affecting the core score where required):

- Ownership/management structure and capacity (OSBB/ZhBK/management company).
- Existence and quality of damage assessments.
- Material and labour availability under current supply chains.
- Neighbourhood-level integration and conflict sensitivity.
- **Funding integrity:** whether individual households have already received compensation (e.g., eRecovery) and how to **avoid double funding** in a building-level intervention.

Using this framework, the long-listed buildings were scored. Results were normalised to 100% for the highest-scoring building; other candidates were weighted in relation to this benchmark, providing a clear, comparable ranking to identify the two pilot projects.

Bldg. 1: Residential building at vul. Ukrainska, 55

Residential building of nine floors made of precast concrete panels (Series 94). It has a section with a deformation seam into two block sections. The block section consists of two entrances. The building is designed based on the standard series 94-017. The structural system is frameless with longitudinal and transverse load-bearing walls. The spatial rigidity is provided by the joints of the floor slabs that form a hard disk. The foundations are square section reinforced concrete piles with a monolithic grillage under the outer walls and separate grillage under the inner walls. External wall panels are made of ceramist concrete with a thickness of 350 mm. Internal wall panels of heavy concrete 120 and 160 mm thick. Ceiling elements – precast concrete flat slabs 160 mm thick. The floor slabs are precast concrete ribbed slabs. One section of the building was significantly damaged by the missile strike one 31 July 2023.

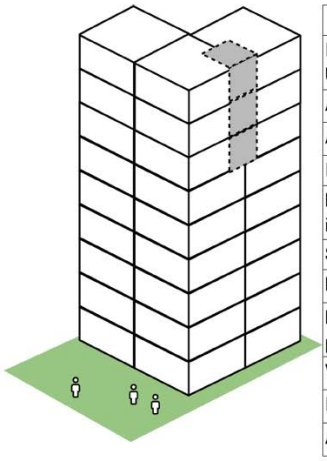


Критерій	Оцінка
Distribution of the type of prefabricated building in Ukraine	○○○○○
Availability of project and working documentation	+
Availability of report of damage assessment	+
Recurrence of building damages	○○○○○
Possibility of using eco-friendly materials for wall insulation	+
Scalability of modernization measures	○○○○○
Possibility of installing a solar PV system on the roof	+
Location in the city and visibility of the pilot project/iconic project	○○○○○
Verification of the possibility of reusing materials	+
Existing of OSBB	+
Availability of photo/video evidence of misile hit	+

Compliance with the criteria: 100%

Bldg. 2: Residential building at vul. Iehora Birkuna, 8

Residential building of 9 floors made of precast concrete panels (Series 94). The building is L-shaped in plan. It has a section with a deformation seam into two block sections. The block section consists of two entrances. The house is designed on the basis of the standard series 94. The structural system is frameless with longitudinal and transverse load-bearing walls. The spatial rigidity is provided by the joints of the floor slabs that form a hard disk. The foundations are square-section reinforced concrete piles with a monolithic grillage under the outer walls and separate grillage under the inner walls. External wall panels are made of expanded clay concrete 350 mm thick. Internal wall panels of heavy concrete 120 and 160 mm thick. Ceiling elements - precast concrete flat slabs 160 mm thick. The floor slabs are precast concrete ribbed slabs. Part of the facade, balconies and interior walls were damaged by debris of a drone shot by Ukrainian air defence followed by a huge fire.

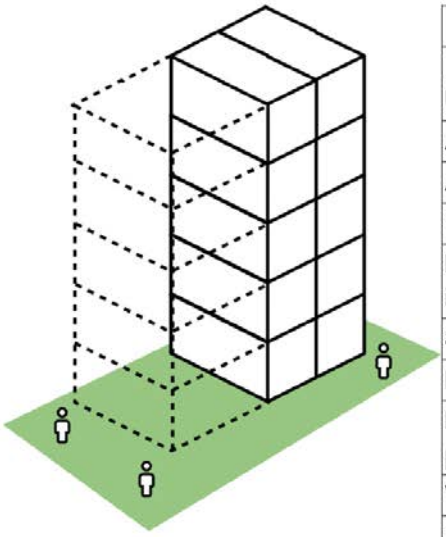


Критерій	Оцінка
Distribution of the type of prefabricated building in Ukraine	●●●●●
Availability of project and working documentation	+
Availability of report of damage assessment	+
Recurrence of building damages	●●●●▮
Possibility of using eco-friendly materials for wall insulation	+
Scalability of modernization measures	●●●▮▮
Possibility of installing a solar PV system on the roof	+
Location in the city and visibility of the pilot project/iconic project	●●●▮▮
Verification of the possibility of reusing materials	+
Existing of OSBB	+
Availability of photo/video evidence of misile hit	-

Compliance with the criteria: 82.4%

Bldg. 3: Residential building at vul. Heroiv ATO, 75

The 5-storey, 4-entrance residential building was built according to the standard series I-438. The walls are made of large concrete blocks with a 2-tiered section. The structural system is frameless with longitudinal load-bearing walls. Spatial rigidity is ensured by the joints of the floor slabs that form a hard disk. The roof is flat, without an attic. The floor slabs are hollow core reinforced concrete. The missile hit caused a fire that destroyed two entrances. The destroyed entrances have now been dismantled.

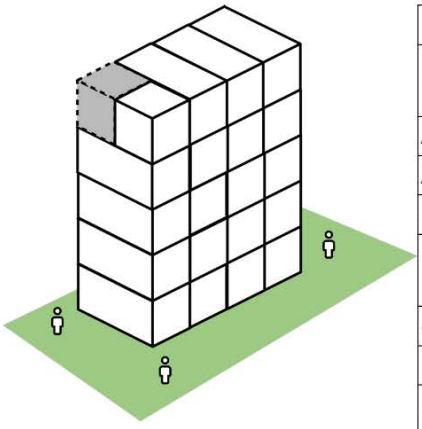


Критерій	Оцінка
Distribution of the type of prefabricated building in Ukraine	○○○▮▮
Availability of project and working documentation	+
Availability of report of damage assessment	+
Recurrence of building damages	○○○○▮
Possibility of using eco-friendly materials for wall insulation	+
Scalability of modernization measures	○○○○▮
Possibility of installing a solar PV system on the roof	+
Location in the city and visibility of the pilot project/iconic project	○○○○▮
Verification of the possibility of reusing materials	-
Existing of OSBB	-
Availability of photo/video evidence of misile hit	-

Compliance with the criteria: 55.8%

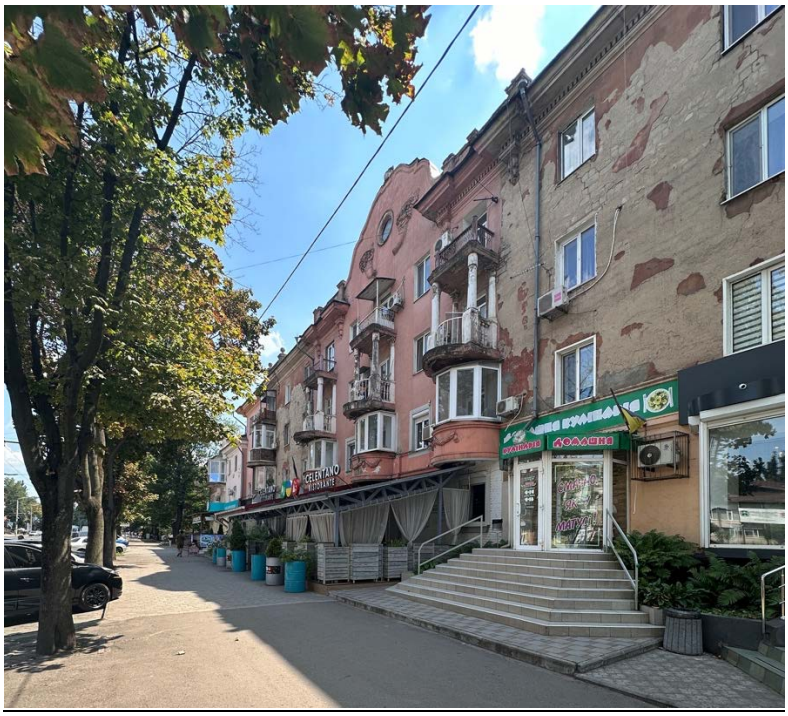
Bldg. 4: Residential building at vul. Vitalia Vlasova, 5

The 5-storey, 4-sections residential building was built according to the standard series 87. The walls are made of large concrete blocks. The structural system is frameless with longitudinal load-bearing walls. Spatial rigidity is ensured by the joints of the floor slabs that form a hard disk. The roof is flat with an attic. The floor slabs are hollow core reinforced concrete. The end face of the building was damaged because of the hit. No significant damage was found to the supporting structures outside the damaged entrance. A project to restore the damaged part is currently being developed.



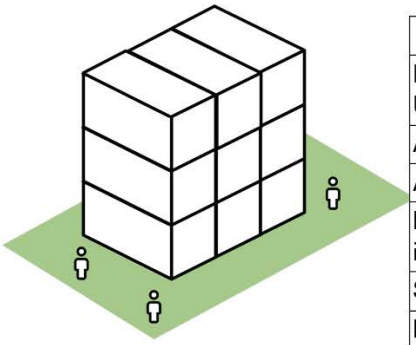
Критерій	Оцінка
Distribution of the type of prefabricated building in Ukraine	○○○◧◧
Availability of project and working documentation	+
Availability of report of damage assessment	+
Recurrence of building damages	○○○○◧
Possibility of using eco-friendly materials for wall insulation	+
Scalability of modernization measures	○○○○◧
Possibility of installing a solar PV system on the roof	+
Location in the city and visibility of the pilot project/iconic project **/raise awareness of donors**	○○○○◧
Verification of the possibility of reusing materials	-
Existing of OSBB **/Housing Cooperative**	-
Availability of photo/video evidence of misile hit	-

Compliance with the criteria: 55.8%



Bldg. 5: Residential building at pr. Haharina, 30

The 3-4-storey, five-entrance residential building was built according to a standard project (type series unknown) in 1954. The walls are brick and cinder block. The structural system is frameless with longitudinal load-bearing walls. Spatial rigidity is provided by transverse walls. The roof is pitched from asbestos-cement sheets (slate) with an attic. Detailed information on the building's structures is currently unavailable. No structural inspection has been conducted so far. The building has many damages because of prolonged use. It was not damaged by hostilities.



Критерій	Оцінка
Distribution of the type of prefabricated building in Ukraine	○○■■■
Availability of project and working documentation	-
Availability of report of damage assessment	-
Possibility of using eco-friendly materials for wall insulation	-
Scalability of modernization measures	○○○○■
Possibility of installing a solar PV system on the roof	-
Location in the city and visibility of the pilot project/iconic project	○○○○■
Existing of OSBB **/Housing Cooperative**	+

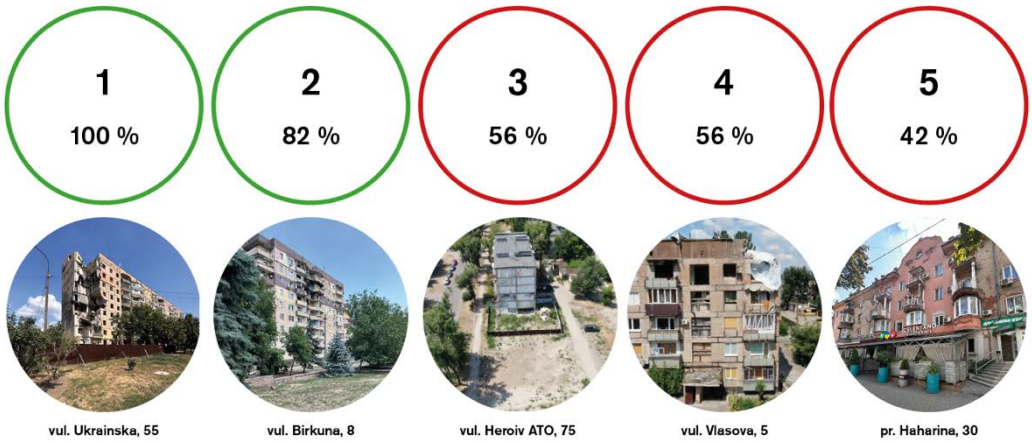
Compliance with the criteria: 42%

During the evaluation of the completed list, it became evident, as expected, that the results varied. To achieve comparability, the best result was normalized to 100%, with the other four objects adjusted in relation to this benchmark. Consequently, this approach provided a clear overview of the outcomes.

Assessment of the priority of reconstruction of buildings damaged because of armed aggression in Kryvyi Rih, Dnipro region, Ukraine

Ranking of visited buildings:

1. Residential building at vul. Ukrainska, 55
2. Residential building at vul. Iehora Birkuna, 8
3. Residential building at vul. Heroiv ATO, 75
4. Residential building at vul. Vitalia Vlasova, 5
5. Residential building at pr. Haharina, 30



Source: Identification of a prefabricated residential building in Krivyi Rih / Decision paper /31 August 2024

3.2 Basic data of Series 94

The Series 94 residential buildings in Ukraine, designed by Ukrmiskbudproekt, are a prominent example of Soviet-era architectural design. Constructed from the late 1970s until the early 1990s, these buildings feature a load-bearing structure made of concrete panels. The spans of these panels typically measure 2.70 meters and 3.30 meters, with a storey height of 2.8 meters from floor to ceiling. The buildings range from 5 to 16 storeys and can be found throughout Ukraine. This series reflects the utilitarian and functional approach of the time, aiming to provide efficient and durable housing solutions across the country.

In the 1980s Series 94 was among the most widespread third-generation series built in Ukraine. Developed by Ukrmiskbudproekt in Kharkiv, it proved this design institute's most popular series. The transverse load-bearing walls span 3.30 and 2.70 metres. The idea was that these could be manufactured at house-building factories already producing another very common series, the I-464. This kind of production of prefabricated parts was implemented at existing house-building factories in Odesa, Kherson, Kryvyi Rih, Chernihiv, and Bila Tserkva, a town in Kyiv Region. Series 94 also went into production at new factories in Simferopol, Poltava, Rivne, Kupiansk, and Lozova in Kharkiv Region.

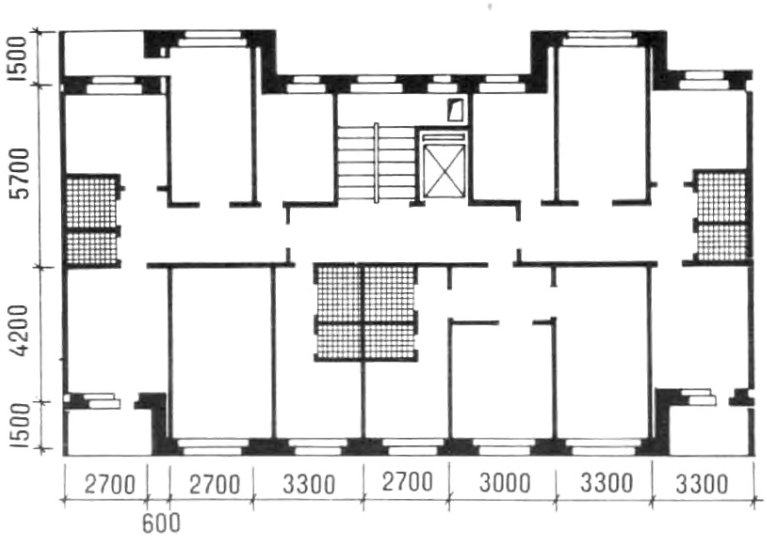
Series 94 had a lot in common with its peer series, the 96, developed by Kyiv-TsNIIEP: both were designed considering new requirements and larger normative floor areas under Sanitarnye normy i pravila (SNiP) II-L.1-71, the new edition of the Soviet building code issued in 1971. Series 94 was developed with a broad range of apartment types for a variety of climatic and geological conditions. Its block-sections included ten types of apartments with one to five rooms that came in two sizes – smaller (type A) and larger (type B) – for each apartment type. This variety provided the flexibility needed to accommodate different kinds of family. The different block-sections developed for this series went into real-life production. They included a couple of free-standing mono-section towers, multiple end block-sections, insert block-sections, and 'turning block-sections' designed to connect two parts of a building placed at 135 degrees to one another. Series 94 was intended for building on regular and weak soils alike. For weak soils or soils in mining areas, the foundations were to be designed separately from the above-ground part of the building to take local conditions into account.

Typical nine-floor Series-94 building.
Source: Zabolotnyi State Scientific Architecture and Construction Library

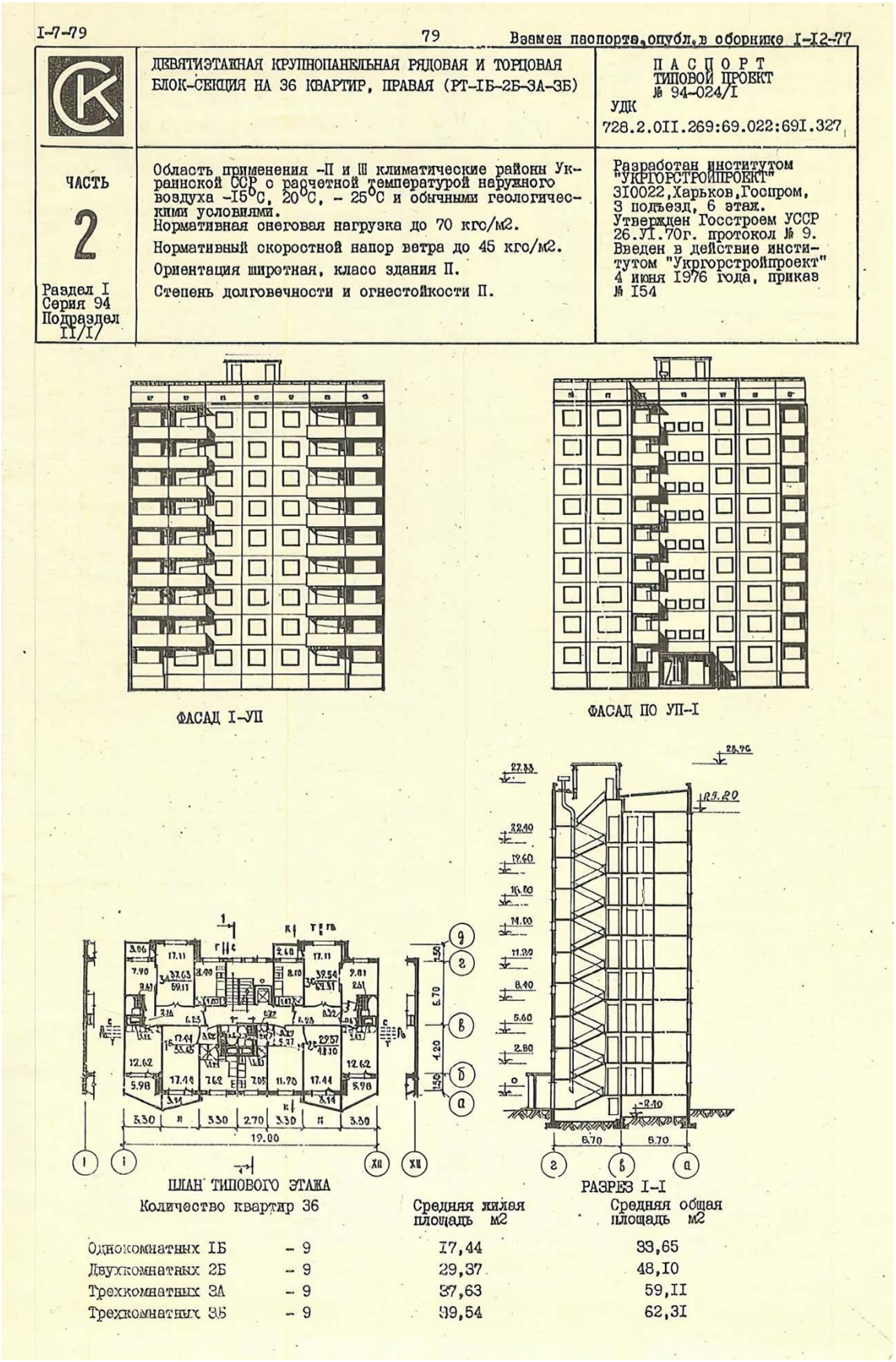
Besides providing variations in types of apartment, Series 94 needed to resolve other problems typical of the third generation of Soviet mass housing: the form of the buildings, developed using the block-section method, needed to respond adequately to the various types of urban development and help construct memorable skylines; and the façades needed to fight the notorious monotony of mass-built residential neighbourhoods. By the late 1970s and 1980s, when Series 94 was being built in abundance, the architectural community in the Ukrainian SSR was highly aware of the problems with the block-section method. Although this method was intended to diversify newly built cityscapes previously composed of single-block first- and second-generation series, the third-generation block-section method failed in creating sufficient variety in every case. This is because the method increased the number of prefabricated parts that the house-building factories had to produce, but these factories' production capacities remained unchanged. As soon as block-section projects hit the reality of construction, it turned out that only very few sections of the generously planned variety could be built because factories could often only master prefabrication of a few sections at a time. In other words, the issues with monotony remained. Just as was the case with other block-section series – including 67, 84, 87, 96, and 134 – Series 94 became outdated and had to be either replaced or revised. Because of its omnipresence throughout Ukraine, Series 94 got lucky: it was revised to become a part of the new Series APPS-94, a new type using 'enlarged block elements' based on panels already in production by housing-construction factories. This transition from Series 94 to Series APPS-94 is described in more detail in our chapter on Series APPS throughout Ukraine.

In Series 94 the problem of monotony and character was also addressed locally, on the much smaller scale of building parts. To humanise serially produced buildings, architects employed higher 'detailisation' of façades using various plastic elements – most frequently, decorative, open stairwell panels and railings because these elements were easy to manufacture independently at just one factory, without the need to develop special windows, doors, or sidings. As a result, the appearance of Series-94 buildings can vary dramatically, making them hard to recognise based on façade elements alone. Better identifying marks are the section joins and the more elaborate façade geometry deriving from the complex patterns in which the sections are put together. At the same time some Series-94 buildings can have relatively simple and modest façade geometries, such as in Borodianka in Kyiv Region, where a Series-94 building became tragically famous after being heavily damaged by the Russian army in the first weeks of Russia's full-scale war against Ukraine.

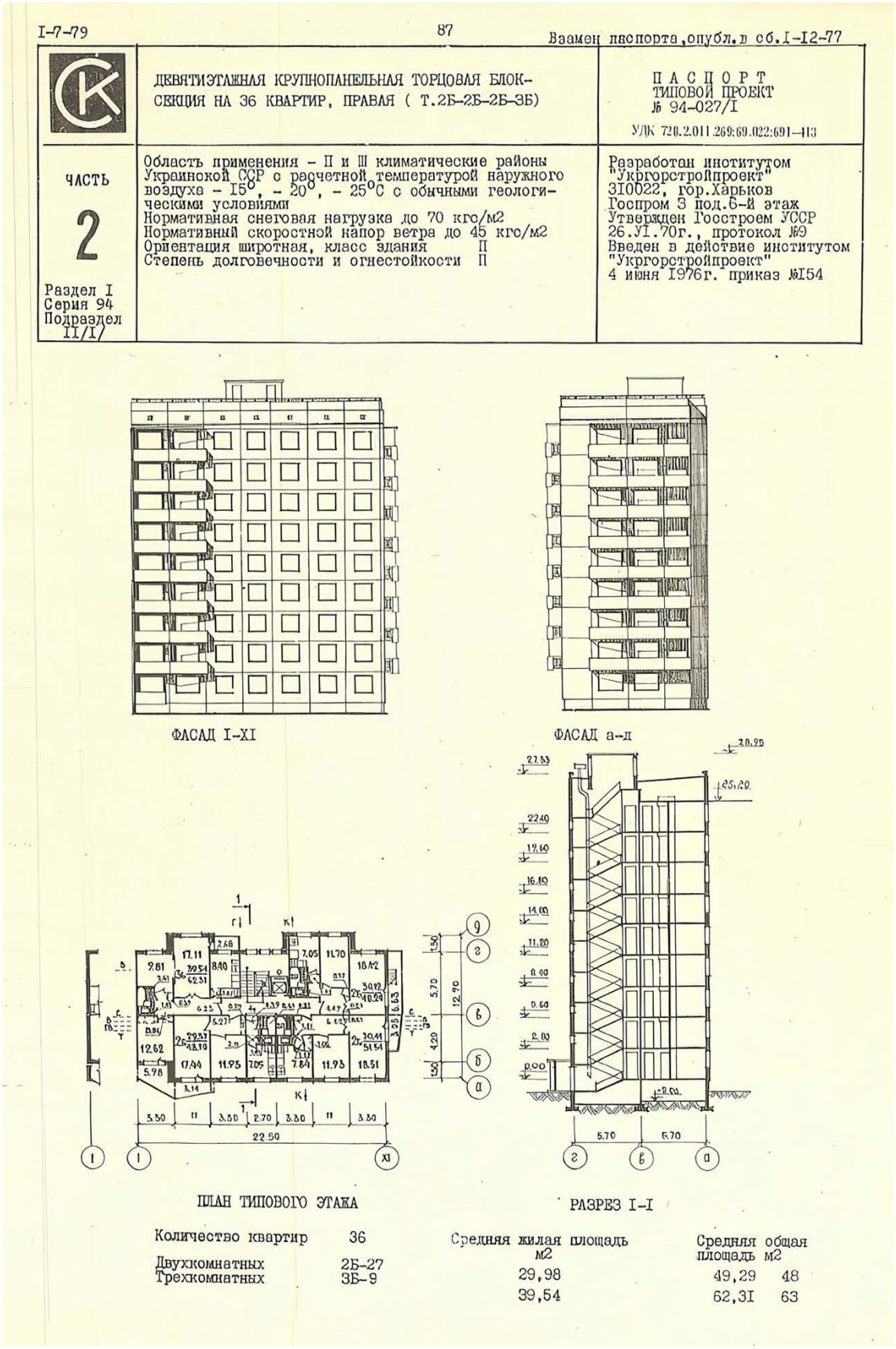
(Source: Malaia, Kateryna/Meuser, Philipp: Mass Housing in Ukraine. Building Typologies and Catalogue of Series 1922–2022. Berlin: DOM publishers, 2024, pp. 238-247).



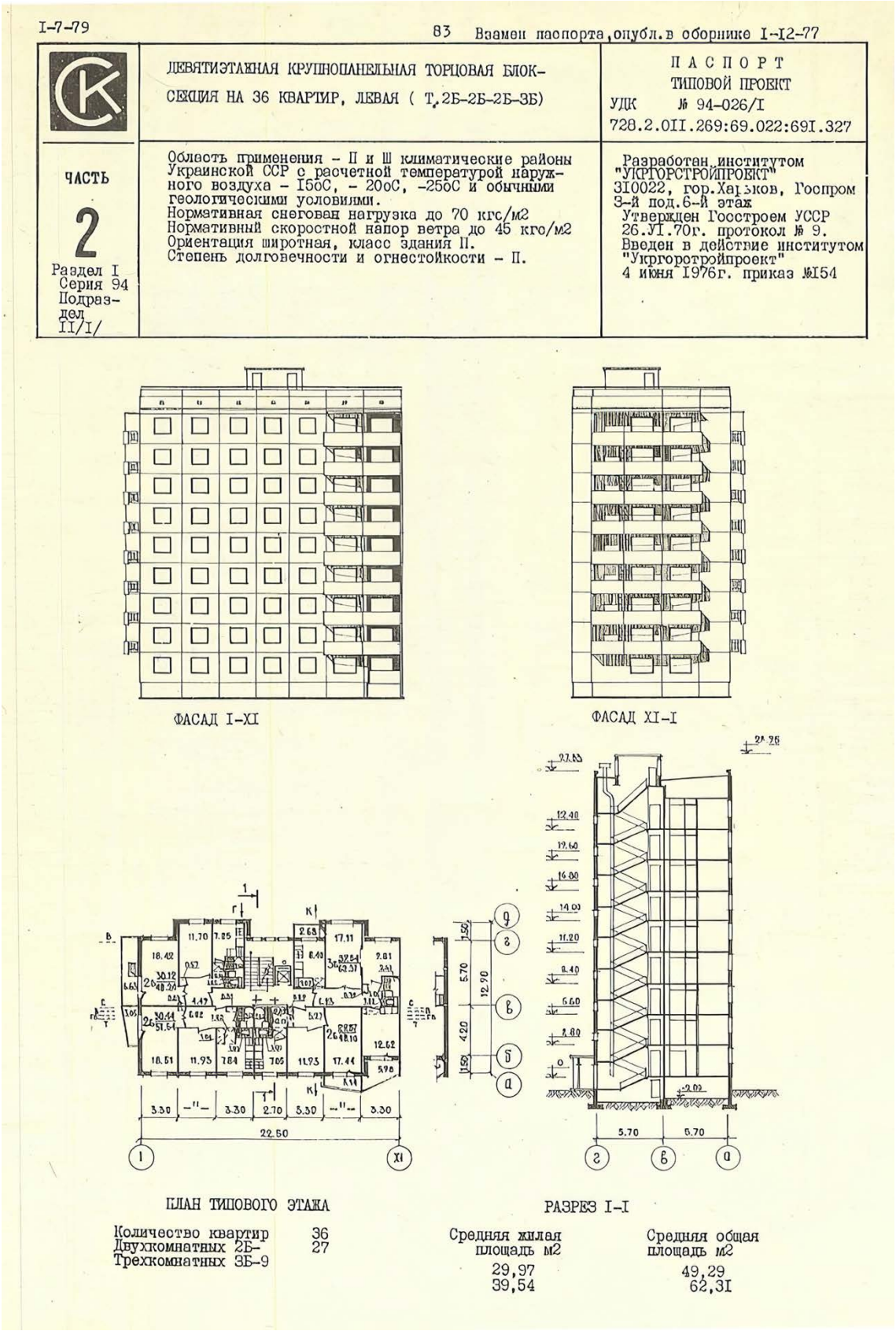
Block-section from Series 94.
Source: Zabolotnyi State Scientific Library



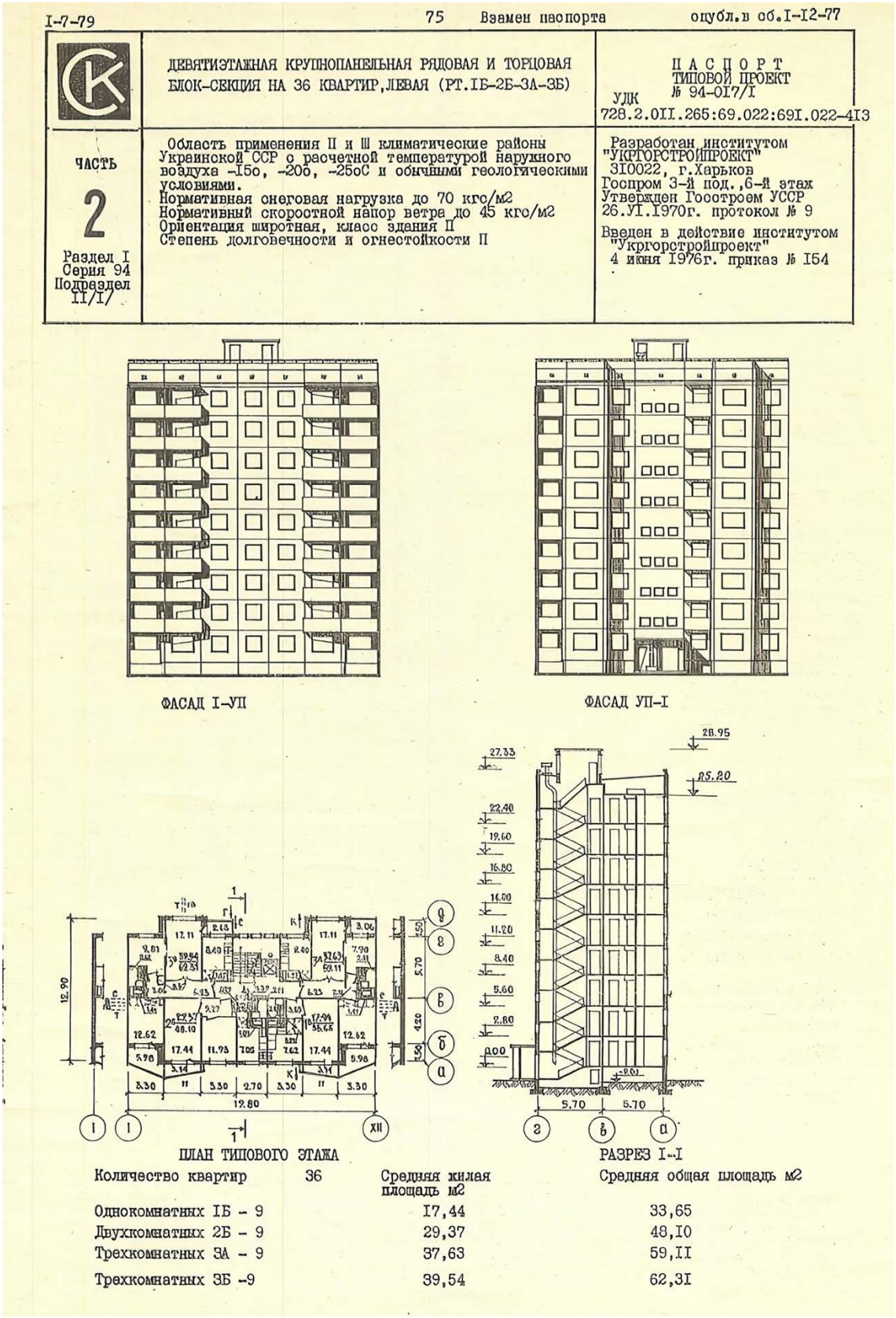
Serial project blueprint for sections in Series 94, variant 94-024/1.
Source: Zabolotnyi State Scientific Library



Serial project blueprint for sections in Series 94, variant 94-027/1.
Source: Zabolotnyi State Scientific Library



Serial project blueprint for sections in Series 94, variant 94-026/1.
Source: Zabolotnyi State Scientific Library



Serial project blueprint for sections in Series 94, variant 94-017/1.
Source: Zabolotnyi State Scientific Library

3.3 Building data of residential building in vul. Ukrainska, 55

3.3.1 General information

The building is a 9-storey large-panel building with a technical underground, a through passage, a warm attic, built according to the standard series 94-017, with a four-entrance (four-section) design. The year of construction is 1984.

The maximum damage from the missile strike was caused to the 4th section (apartments 109-144). After dismantling the 4th entrance, the building became a three-entrance building with 108 apartments

A typical project of a large panel house of the 94-017 series is characterized by a narrow transverse wall spacing (2.7 m and 3.3 m), support of floor panels along the contour and cassette technology for manufacturing basic precast concrete products. The building consists of block sections with 36 apartments, with four apartments per floor. The total number of apartments in the building is 144.

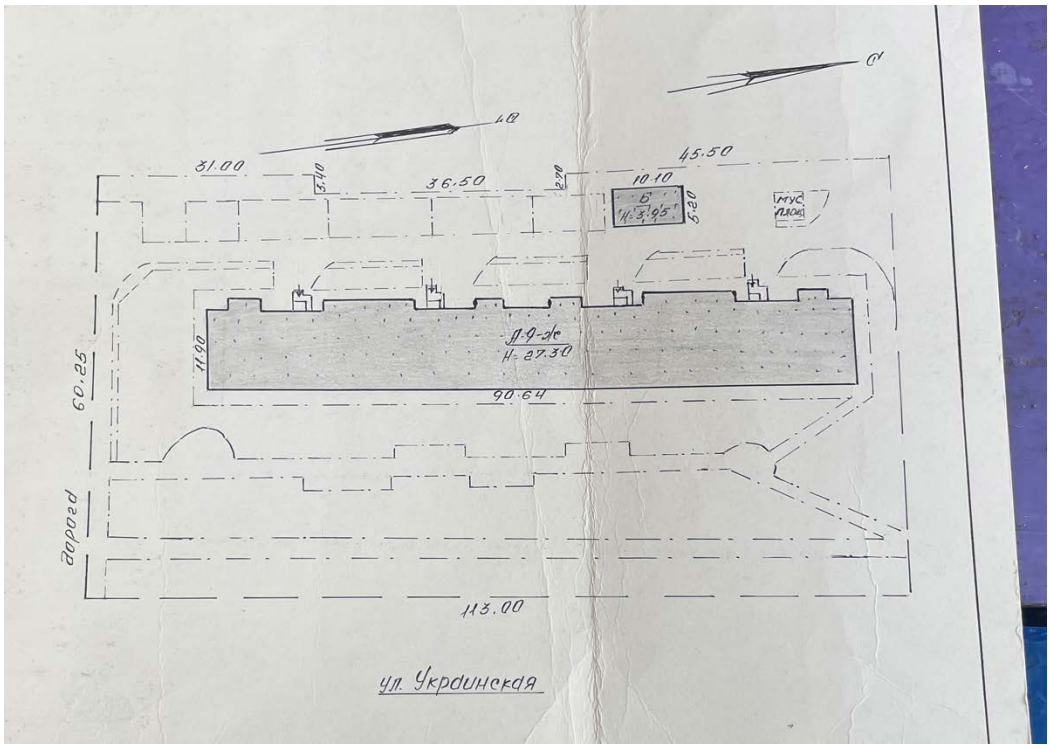
The height of the floor in the building is 2.80m. The height of the premises is 2.64m. The layout of the apartments is typical on all floors. The length of the building along the main and courtyard facades - in the axes "1–44" – is 90.54 m, along the end facades – in the axes "A –D" – 12.50 m.

The structural scheme of the building: longitudinal external and internal walls connected by rigid horizontal floor disks. All the elements of the structural scheme form a spatial box that holds all the vertical and horizontal loads acting on the building and ensures its strength and
spatial rigidity.

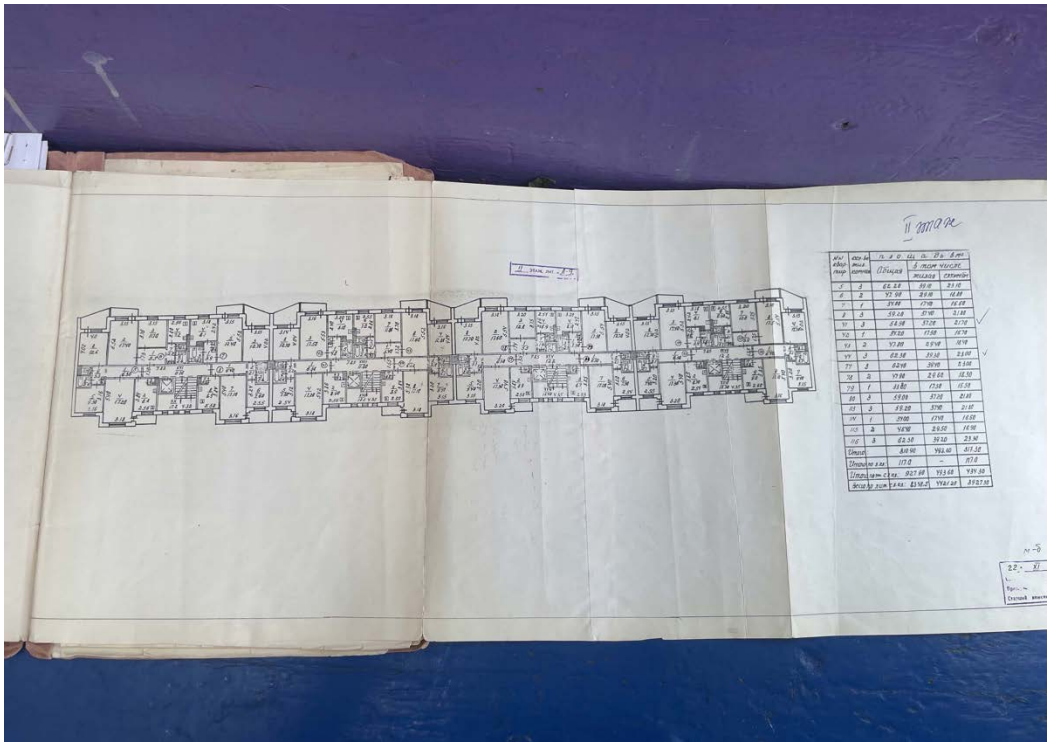
Demographic data	Entrances 1–3	Entrance 4	Total
Number of inhabitants 2021	220	74	294
Number of inhabitants 2024	182	-	182
Number of empty apartments 2021	4	1	5
Number of empty/lost apartments 2024	17	74 (lost)	91

The total area of the building is 5,465 m^2
The residential area of the building is 3,331 m^2

3.3.2 Drawings

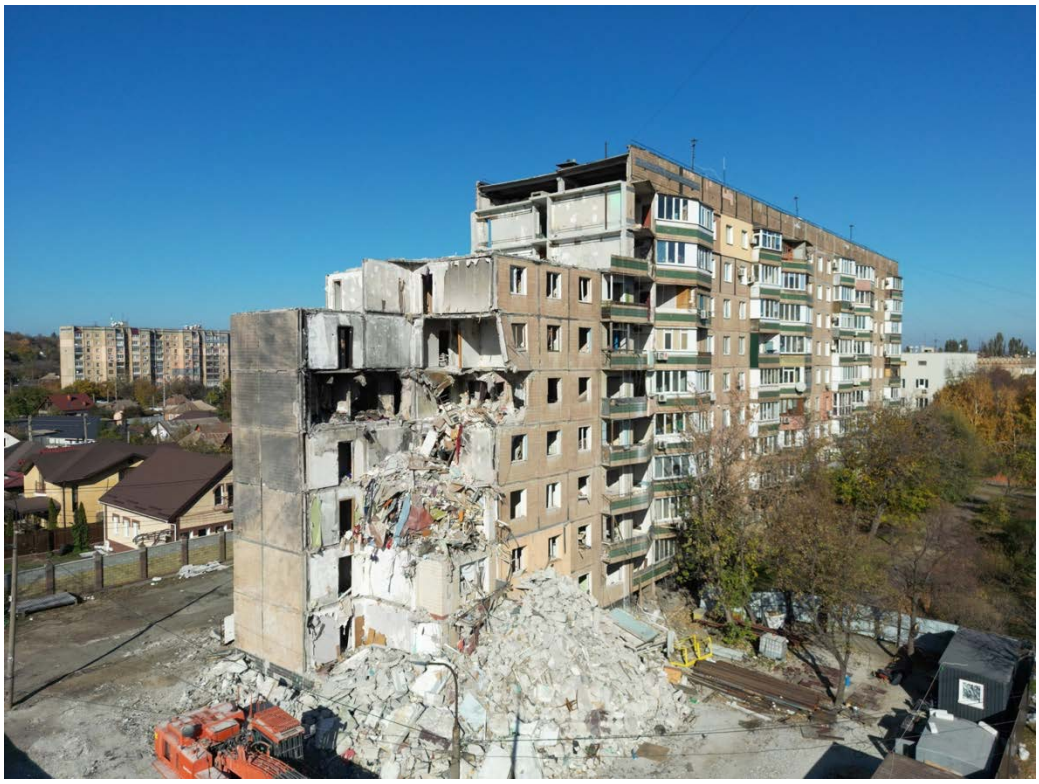


Site plan, 1984



Plan of a standard floor

3.3.3 Photographs



Ukrainska 55, drone picture taken on 7 November 2024

Ukrainska 55, drone picture taken on 7 November 2024

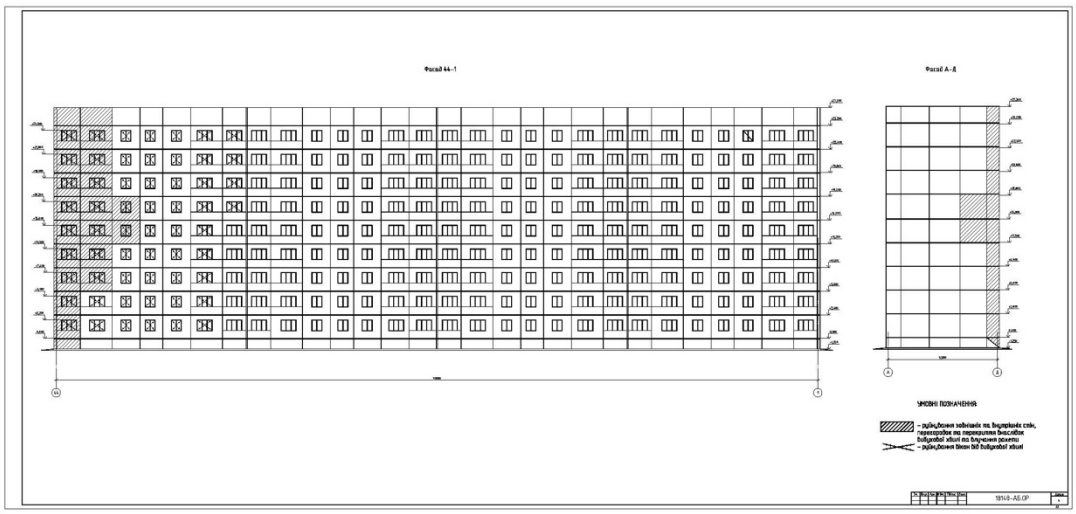
Ukrainska 55, reinforcing works

Ukrainska 55, reinforcing works

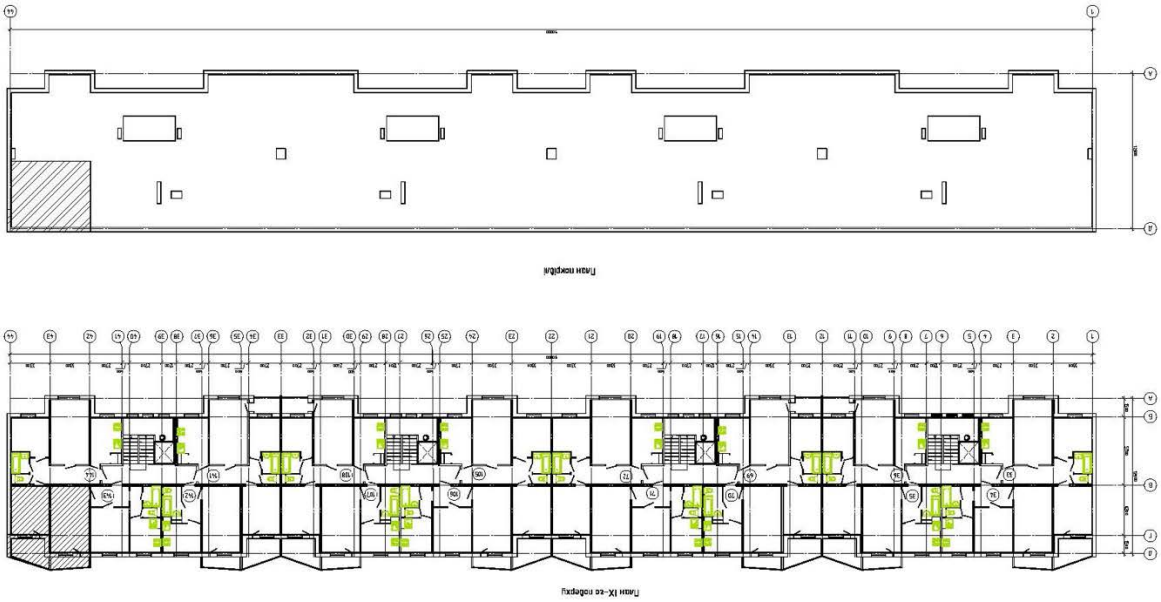
Ukrainska 55, before demolition works (July 2024)

Ukrainska 55, after demolition works (July 2025)

3.3.4 Destruction by war



Elevation of damaged façade, Ukrainska 55 (no scale)



Plan of damaged standard floor, Ukrainska 55 (no scale)

3.4 Building data of residential building in Yegora Birkuna, 8

3.4.1 General information

The building is a 9-storey large-panel building with a technical underground, a warm attic, built according to the typical series 111-94, with five entrances (five sections), with one expansion joint. Block sections 1,2 are separated from block sections 3, 4 and 5 by a expansion joint.

A typical design of a large-panel house of the 111-94 series is characterized by a narrow transverse wall spacing (2.7 m and 3.3 m), contour support of floor panels and cassette technology for manufacturing basic precast concrete products.

The building consists of block sections with 36 apartments, with four apartments per floor. The total number of apartments in the residential building is 179. The floor height in the building is 2.80m. The height of the premises is 2.64m. The layout of the apartments is typical on all floors.

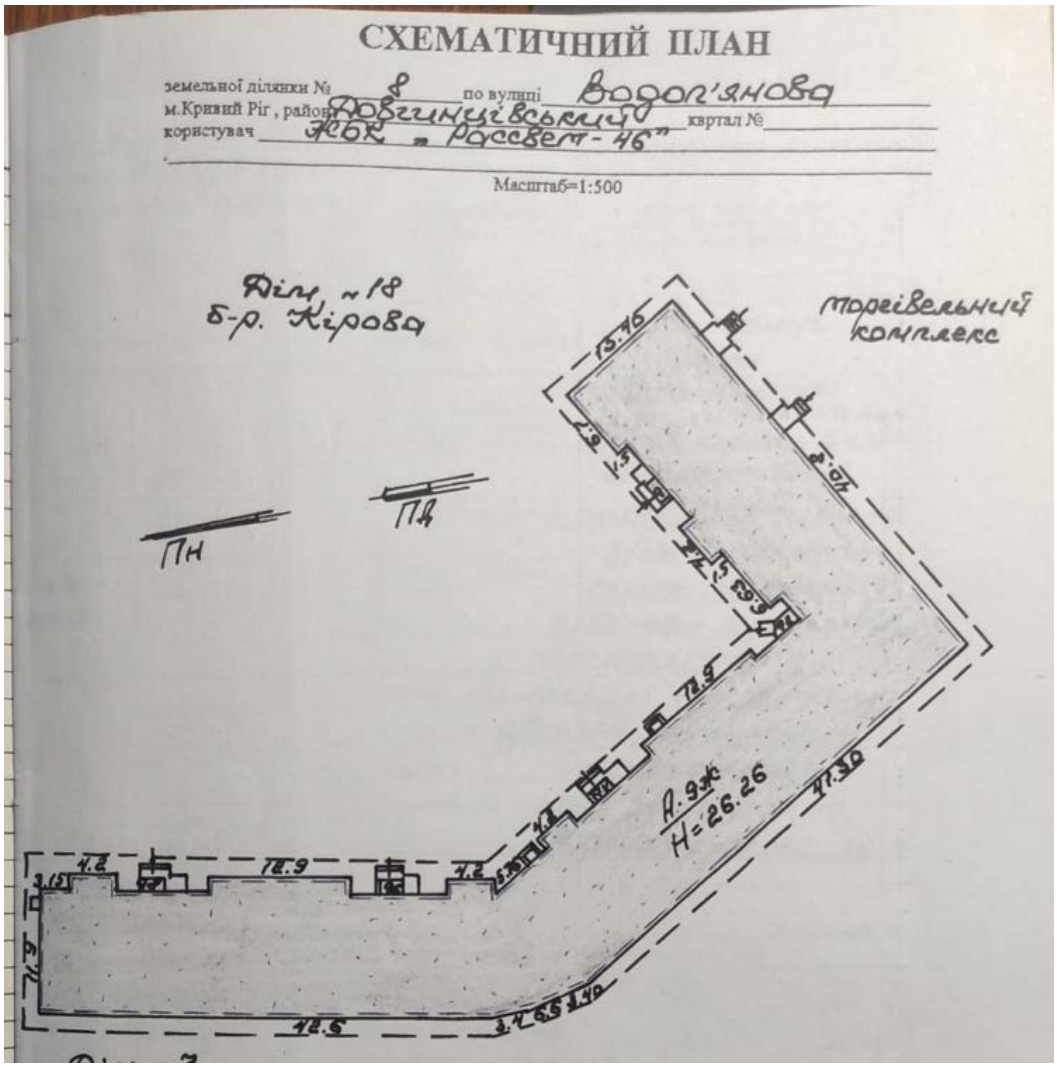
Structural diagram of the house: longitudinal external and internal walls, connected by rigid horizontal floor disks. All the elements of the structural scheme form a spatial box that holds all the vertical and horizontal loads acting on the building and ensures its strength and spatial rigidity. Typical challenges include corrosion at joints, restricted convertibility, and thermal inefficiencies.

The 1st and 2nd entrances (apartments 1–72) were damaged: block sections 94-017 (straight) and 94-046 (corner).

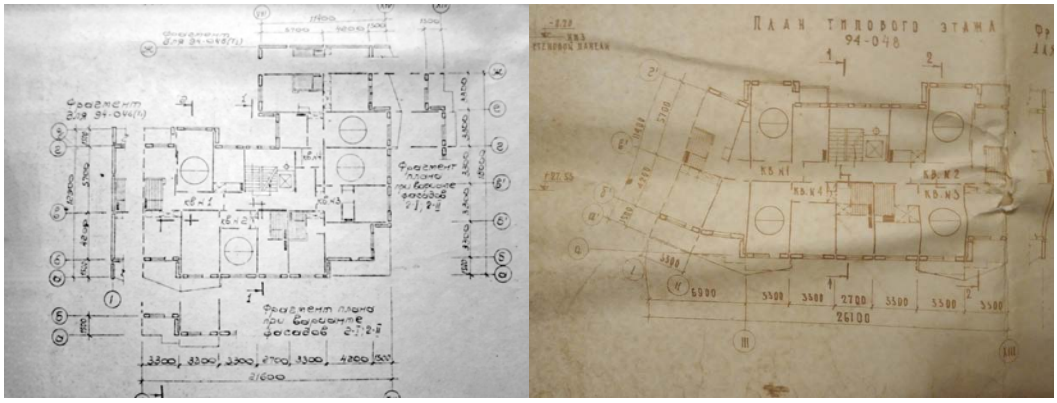
As of 1 February 2025, 350 people live in the building.

The total area of the building is 10,071.11 m^2
The residential area of the building is 5,938.37 m^2

3.4.2 Drawings



Site plan, not dated



Floor plans of block sections 94-017 (straight) and 94-046 (corner).

3.4.3 Photographs

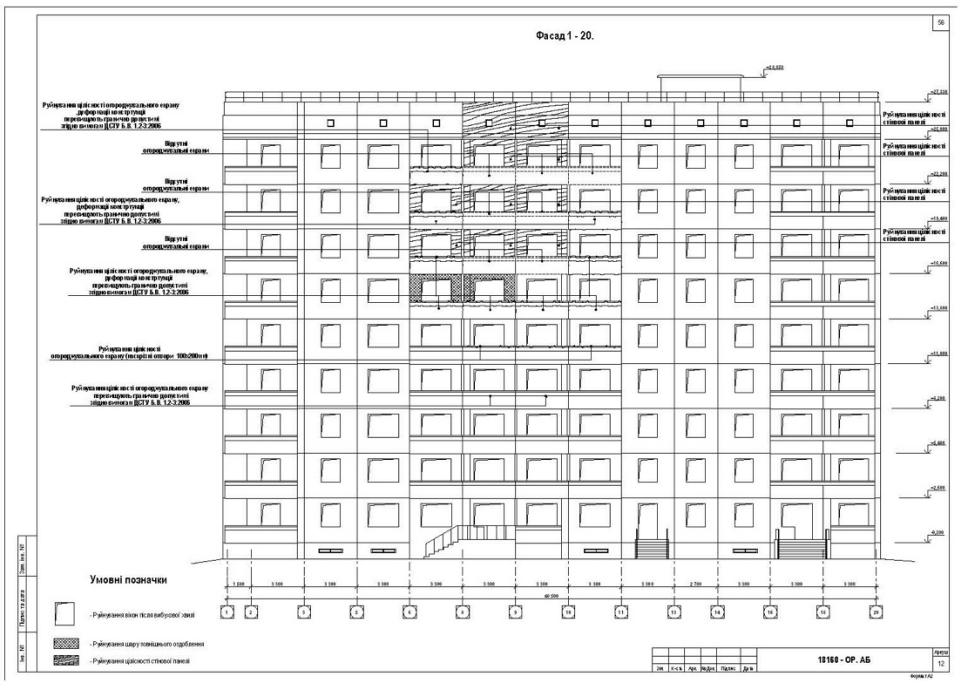
Birkuna 8, drone picture taken on 7 November 2024

Birkuna 8, drone picture taken on 7 November 2024

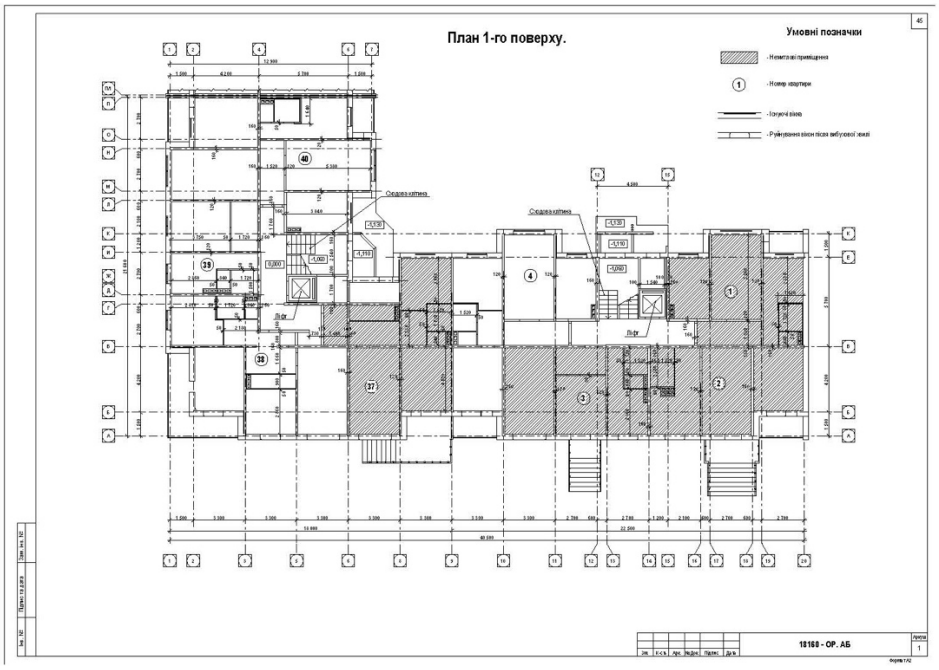
Birkuna 8, drone picture taken on 18 July 2025

Birkuna 8, drone picture taken on 18 July 2025

3.4.4 Destruction by war



Elevation of damaged façade, *Birkuna 8* (no scale)



Plan of damaged standard floor, *Birkuna 8* (no scale)

3.4.5 Project status (as of 18 July 2025)

General project status
Demolition and safety work has begun at Birkuna 8, a typical type 94 residential building. Current efforts focus on securing damaged structural components (especially ceilings) and on preparatory dismantling in the affected zones.

Demolition and dismantling
Ceiling slabs, wall panels, and non-load-bearing elements were removed in multiple units. Following the destructions of the rocket impact in the north-east, temporary timber supports and steel props were installed to ensure safe, step-by-step dismantling in accordance with the original construction sequence.

Structural assessment
The original ceiling load capacity of 0.8 kN/m² can no longer be fully verified. A provisional capacity of 0.2 kN/m² is assumed. In severely affected storeys, timber frameworks were added to safely redirect vertical loads.

Site observations
Debris from the initial destruction remains in several units, hindering technical access and forensic documentation. Full removal is required prior to structural intervention.

Construction site *Birkuna 8*, 18 July 2025

4 Measures for rehabilitation (ad-hoc and short-term)

The ongoing war in Ukraine has resulted in the widespread destruction of residential buildings, with many structures sustaining severe damage from missile strikes, artillery shelling, or blast waves. These forces were not anticipated in the original design of Soviet-era prefabricated housing, often leading to unexpected structural failures and, in some cases, progressive collapse.

According to RDNA4 and field studies in Kryvyi Rih, the majority of war-related damage affects multi-storey panel buildings of the Soviet period. Their lack of redundancy in load-bearing systems increases the risk of domino-like failure. Findings from the Lviv Urban Forum (2025) stress the importance of early damage triage based on both social and technical criteria, such as resident vulnerability and architectural salvageability. Emergency protocols must therefore be flexible, inclusive, and standardised to ensure rapid intervention and community safety.

In the immediate aftermath of a missile or drone strike, a clearly structured emergency response must be initiated. Ukrainian legislation, notably Cabinet of Ministers Resolution No. 473 of 19 April 2022, regulates urgent works for eliminating the consequences of armed aggression. It defines thirteen specific measures to ensure structural safety, public health, and environmental protection. The initial step is a two-tiered structural assessment: (1) a preliminary inspection to identify acute risks of progressive collapse and (2) a detailed inspection to evaluate the structural condition in line with the *Protocol for Technical Assessment of Buildings Damaged by Hostilities*.

Based on these inspections, buildings are categorised into three types:

- **Type I:** minor damage, suitable for routine repairs.
- **Type II:** substantial but repairable damage (41–80%), requiring structural intervention.
- **Type III:** severe damage (81–100%), requiring full demolition and reconstruction.

Ukrainian law further requires that any structural reconstruction project include full static calculations of the remaining building, taking into account geometrical nonlinearity, partial loss of elements, and redistribution of internal forces. Hybrid reinforcement methods – such as the combination of steel framing and carbon fibre strengthening – have proven promising, as seen in Kryvyi Rih. They offer reduced structural weight, faster installation, and design flexibility, but require careful fire protection measures (non-combustible cladding, intumescent coatings).

Equally important is the environmentally safe handling of war debris. Cabinet of Ministers Resolution No. 1073 of 27 September 2022 sets binding requirements

for demolition and conflict-related waste. On-site separation, certified logistics, and options for recycling or reuse must be integrated into early reconstruction planning.

To ensure consistency and scalability, it is recommended that local and national authorities consolidate emergency practices into a typology of standardised rehabilitation responses. This aligns with RDNA4's proposal for a catalogue of prototypical interventions. Furthermore, OSBBs and municipal engineering offices should be institutionally embedded in the emergency response process. Reconstruction must be understood not only as a technical task but as a multidimensional challenge requiring coordination between civil protection, public works, social services, and legal governance.

4.1 Emergency measures after missile attack

In the immediate aftermath of a missile or drone strike on a residential building, a clearly structured and legally compliant emergency response must be initiated. The experience of Kryvyi Rih demonstrates how crucial such measures are in preventing further casualties, stabilising partially damaged structures, and preparing the ground for later rehabilitation or reconstruction.

The Ukrainian government has set out a binding legal framework for such interventions. Cabinet of Ministers Resolution No. 473 of 19 April 2022 regulates urgent works for the elimination of consequences of armed aggression. It specifies thirteen measures that authorities, contractors, and municipal services are obliged to follow in order to ensure structural safety, public health, and environmental protection. These include the immediate isolation of utilities (electricity, gas, water), the dismantling of severely damaged components, the installation of temporary supports, and the clearance of debris that obstructs safe access.

The process begins with a **two-tiered structural assessment**:

1. **Preliminary inspection.** This rapid assessment identifies acute risks of progressive collapse and determines whether immediate stabilisation is required. The inspection is carried out visually, supported by simple measurement tools, and documents observable damage such as large cracks, displacements, or tilted wall panels.
2. **Detailed inspection.** Once acute risks are secured, a more comprehensive evaluation follows. This inspection, in line with the *Protocol for Technical Assessment of Buildings Damaged by Hostilities*, includes static calculations, photographic documentation, and recommendations for either temporary stabilisation, partial dismantling, or full demolition.

Based on these inspections, buildings are classified into three categories:

- **Type I: Minor damage** – buildings with limited destruction, suitable for routine repairs.
- **Type II: Substantial but repairable damage (41–80%)** – buildings requiring structural intervention, reinforcement, and selective dismantling.
- **Type III: Severe damage (81–100%)** – buildings requiring full demolition and replacement.

In practice, most war-damaged multi-storey residential buildings in Ukraine fall into Type II. This reflects the construction logic of Soviet-era panel housing, which lacks redundancy: damage to one load-bearing element often threatens the stability of an entire section. Findings from Kryvyi Rih and the Lviv Urban Forum (2025) underline that triage decisions must be based on both **technical** and **social criteria**. Technical criteria include the scale of structural damage, feasibility of repair, and availability of replacement components. Social criteria include the vulnerability of residents, symbolic visibility of the building in its neighbourhood, and potential for demonstration as a model project.

Emergency measures typically involve **temporary stabilisation** through timber supports, steel props, or scaffolding; **partial dismantling** of collapsed sections to prevent further failure; and **hybrid retrofitting** methods that combine steel frames with carbon fibre reinforcement. The latter method has proven effective in Kryvyi Rih because it reduces structural weight, allows rapid installation, and increases flexibility in design. However, such reinforcement also introduces new requirements: fire protection must be enhanced by adding non-combustible cladding and intumescent coatings to steel components, since their fire resistance is lower than that of reinforced concrete.

A critical dimension of emergency measures is the **handling of war debris**. Cabinet of Ministers Resolution No. 1073 of 27 September 2022 governs the management of waste generated by hostilities. It requires on-site separation of materials, controlled transport logistics, and where possible, reuse of concrete and metal debris. Integrating waste management into the earliest phases of intervention reduces ecological risks, prevents landfill overflow, and can create opportunities for local recycling industries.

The Ukrainian legal system also stipulates that every reconstruction project include full **static recalculations**. These calculations must take into account the loss of elements, the redistribution of loads, and geometrical non-linearities caused by damaged components. Simulation tools are increasingly used to test how reinforcement elements interact with surviving structures. This approach is indispensable for multi-storey panel buildings, which are highly vulnerable to progressive collapse.

Examples from Kryvyi Rih show how such emergency measures are applied in practice. At Birkuna 8, hybrid reinforcement combining steel frames with carbon fibre was implemented after severe drone-related damage. At Ukrainska 55, entire sections were dismantled to prevent collapse, and adjacent walls were reinforced and insulated to become new exterior walls. These case studies illustrate the importance of adapting methods to the specific structural typology and damage pattern of each building.

Finally, emergency measures cannot be seen as isolated technical acts. They are the **first step of a phased process** that leads into structural rehabilitation and eventually long-term modernization. Embedding these measures into standardised typologies – as recommended by RDNA4 – will enable municipalities and OSBBs to act more quickly in the future. Institutionalising these practices also means building the capacity of civil protection services, municipal engineering offices, and homeowners' associations to coordinate effectively under extreme conditions.

In summary, emergency measures after missile or drone attacks rest on six pillars:

1. Clear legal guidance through binding regulations.
2. Rapid two-tiered structural assessments.
3. Immediate stabilisation to prevent progressive collapse.
4. Hybrid reinforcement methods adapted to Soviet-era building typologies.
5. Integrated waste management to mitigate environmental risks.
6. Institutional collaboration between residents, municipalities, and implementing agencies.

By embedding these principles into reconstruction practice, Ukraine strengthens not only the safety of its citizens but also the resilience and preparedness of its housing stock for future recovery phases.

4.1.1 Emergency measures for the residential building vul. Ukrainska, 55

On **31 July 2023, around 09:00 h**, a missile strike severely damaged the nine-storey Series 94 residential building at vul. Ukrainska 55. Immediately after rescue operations were completed, the building was inspected by local engineers. The inspection revealed that the fourth entrance (apartments 109–144) had suffered catastrophic structural damage and posed a risk of progressive collapse. A rapid decision was taken to dismantle large parts of this entrance to stabilise the remaining structure.

Engineer **Serhii Kurinnyi** subsequently developed a detailed reinforcement project. His plan included three principal components:

1. **Dismantling** most of the fourth entrance to remove unstable load-bearing walls and floor slabs.
2. **Reinforcing adjacent structures** in the third entrance to ensure that they could safely carry redistributed loads.
3. **Insulating and reinforcing the newly exposed wall**, which after dismantling became an external façade.

A competitive tender was held to select a contractor, and work commenced with preparatory dismantling and reinforcement tasks.

Methods of dismantling

Two technical options were assessed for dismantling the damaged entrance:

- **Dismantling with crane.**
  This method allows the careful removal of individual panels, enabling potential reuse in reconstruction or recycling. It reduces the amount of construction waste, lowers landfill costs, and maintains better control over structural stability during removal. However, it requires technically complex operations to open the original panel seams, prolongs dismantling time, and is significantly more costly if panels are already deformed or cracked.
- **Dismantling with hydraulic scissors.**
  This method is faster and requires less preparatory work. It lowers immediate dismantling costs and accelerates debris clearance. On the other hand, it generates larger amounts of construction waste, increases landfill costs, and often makes the reuse of panels impossible. If dismantling is limited to partial sections rather than entire block modules, additional preparatory reinforcement is required to maintain stability during works.

Given the site conditions and the severe level of destruction, the project combined both methods: crane dismantling was used where panels could be safely detached, while hydraulic scissors were employed for heavily damaged or unsafe sections.

Reinforcement strategy

A critical structural issue was the absence of a natural deformation joint at the boundary of the dismantled section. Without additional measures, the loss of the fourth entrance would have reduced the spatial rigidity of the building and endangered the stability of the remaining three entrances. To address this, engineers opted to leave a **one-panel-wide section** of the fourth entrance in place, which was then reinforced with steel props and concrete overlays to ensure stability.

An alternative scenario – dismantling the entire entrance and reinforcing the bordering wall of the third entrance – was also analysed. This solution would have resulted in a flat façade that would have been easier to insulate during modernization. However, it would have required installing reinforcement structures directly inside private apartments, causing disruption to residents and reducing usable floor area. For this reason, the partial retention and reinforcement method was chosen as the more balanced option.

Implementation and timeline

The dismantling and reinforcement works are technically complex and require continuous monitoring. Construction work was completed by **June 2025**, with phased milestones for dismantling, reinforcement, and weather-proofing. Temporary insulation and bracing measures were implemented to ensure that the building remained habitable for residents of the unaffected sections during the winter of 2024/25, although safety concerns remain for apartments directly adjacent to the dismantled zone.

Lessons and transferability

The case of Ukrainska 55 illustrates the central dilemma of rehabilitating war-damaged panel housing: balancing safety, technical feasibility, resident comfort, and cost. The combined dismantling method and reinforcement solution developed here provide a **replicable model** for other multi-entrance Series 94 buildings that suffer partial entrance destruction. The experience also underlines the importance of early engineering assessments, transparent tendering, and adaptive technical decision-making.

4.1.2 Emergency measures for the residential building vul. Birkuna, 8

On the evening of **12 March 2024, around 18:40 h**, a missile strike hit the nine-storey Series 94 building at vul. Yehora Birkuna 8 (formerly Vodop'yanova 8) in the Dovhynziwskyj district, micro rayon Skhidny-1 of Kryvyi Rih. The attack caused a direct impact on the residential block, resulting in severe structural damage, particularly to block sections 1 and 2. Ukrainian media reported at least five fatalities and between 43 and 49 injured residents**,** with earlier reports indicating three deaths and 36–44 injured. Nine people were rescued alive from the rubble before emergency operations concluded at around 22:00 on the same day. One of the victims was a passer-by at the site. According to initial statements by the Ukrainian Air Force, the munition was likely a **guided air-to-surface missile of the Kh-59 type**, although this has not been formally confirmed.

Following the immediate rescue operations, a building survey was conducted. Engineers determined that, despite the heavy damage, the structure could be restored rather than demolished. Temporary reinforcements were first installed using wooden props and makeshift support frames. However, an inspection in September 2024 revealed significant shortcomings: many of the timber supports had shifted, loosened, or even collapsed due to the use of raw, untreated wood. These deficiencies created further risks of collapse and demonstrated the limitations of improvised materials for stabilisation under long-term loads.

Engineer Serhii Kurinnyi then prepared a comprehensive reinforcement project to address the destroyed walls, ceilings, and balconies. The proposed solution relied on **metal columns and beams** to replace lost structural elements. Balcony slabs were to be dismantled and replaced with reinforced versions. While this approach does not fully restore the original structural capacity of the building, it provides sufficient rigidity to ensure safe continued use.

Construction works at Birkuna 8 commenced in July 2025**.** They focus on the step-by-step dismantling of irreparably damaged slabs and panels, followed by reinforcement through steel frameworks. Temporary timber supports were replaced with telescopic formwork posts and metal props to redirect vertical loads. Additional bracing was introduced in severely affected areas to prevent progressive collapse. At the same time, debris clearance was accelerated to allow safe access for both construction teams and residents.

Due to the scale of destruction and the complexity of Series 94 structures, full restoration cannot replicate the original design. Instead, the adopted approach relies on hybrid reinforcement with steel frameworks and targeted replacements of non-load-bearing components. This solution ensures stability, but with a slightly lower rigidity than in the undamaged structure.

The works are ongoing and expected to be completed by the end of 2025 (as of 3 September 2025)**.** Throughout the process, safety of residents in less

affected parts of the building has remained a challenge. The project is being closely monitored by municipal authorities, contractors, and international partners to ensure compliance with safety standards and to serve as a model for similar interventions in other Ukrainian cities.

The case of Birkuna 8 demonstrates the extreme conditions under which emergency stabilisation is taking place in Ukraine: rapid rescue operations, provisional stabilisation with limited resources, reassessment under technical scrutiny, and eventual transition to professional reinforcement. It also illustrates the importance of learning from early shortcomings (e.g. improvised timber supports) to establish replicable standards for future emergency measures.

4.2 Challenges of cost calculation in times of war

Cost estimation in post-conflict and wartime conditions is inherently uncertain. In Ukraine, traditional methods of preparing budgets and bills of quantities are frequently inadequate because they rely on stable supply chains, predictable labour markets, and regional price averages. Under current conditions – disrupted logistics, inflation, and a shortage of qualified labour – these assumptions no longer hold. As a result, cost calculations can become outdated within weeks or even days, leading to discrepancies between planned budgets and actual expenditures.

One of the most significant factors is the volatility of supply chains**.** Transport routes are frequently disrupted by military activity or re-prioritised for defence purposes. Materials such as cement, insulation boards, and structural steel may be delayed for weeks. Prices can rise rapidly, not only due to scarcity but also due to high transport costs. Imported systems – for example prefabricated façade panels or specialised MEP (mechanical, electrical, plumbing) components – are particularly vulnerable to delivery bottlenecks. In practice, this means that even well-prepared estimates can become obsolete before works begin.

Labour shortages further compound the problem. According to the Confederation of Builders of Ukraine, more than two-thirds of skilled construction workers have been mobilised for military service. Many others have emigrated, leaving a reduced and fragmented workforce. Wage levels on the open market are therefore significantly higher than the official benchmarks used in the national *Guidelines for Determining Construction Costs*. Engineers and contractors face a dilemma: they are legally bound to outdated cost norms yet must pay far higher wages to secure qualified workers. This gap introduces substantial risks for both contractors and project managers.

The pilot projects in Kryvyi Rih illustrates these challenges. At **Ukrainska 55**, the initial cost estimate was prepared strictly according to Ukrainian normative standards. However, donor requirements demanded a parallel calculation based on real market prices. The Ukrainian engineering firm Nastroy therefore produced a second bill of quantities that reflected actual procurement costs, using live market indices and supplier quotes. The difference between the two approaches was striking: for some material categories, market-based prices exceeded normative values by **30–70%**. This discrepancy did not result from mistakes but from structural differences between regulated cost systems and real market dynamics during wartime.

The financial model of the pilot project further underlines these tensions. Material procurement was provided by GIZ, while the municipality of Kryvyi Rih covered labour and installation. This split-cost arrangement had advantages – international procurement ensured high-quality materials, while municipal contractors remained in charge of on-site works – but also created risks. Coordination between the two funding streams was critical. In practice, delays occurred not because materials were unavailable but because preparatory works and municipal schedules were

misaligned with the delivery of materials. This demonstrates that timing mismatches between different actors can be as disruptive as shortages themselves.

These experiences highlight the need for new models of cost management. Several approaches are under discussion:

- **Rolling cost estimation.** Budgets are updated continuously based on live market data rather than fixed at the beginning of a project. This requires integration of escalation clauses, risk margins, and contingency reserves directly into contracts.
- **Dual-track monitoring.** One track follows Ukrainian national norms (to ensure legal compliance), while a second track documents actual market-based expenditures (to ensure transparency for donors). Comparing the two provides a realistic picture of financial risks.
- **Modular tender packages.** Instead of one comprehensive contract, works are divided into smaller packages that can be adjusted mid-process without jeopardising the entire project. This provides flexibility in responding to market fluctuations.
- **Milestone-based payment systems.** Payments are linked to completed phases verified on site, ensuring that financing reflects real progress and reducing the risk of frozen budgets.

The Lviv Urban Forum (2025) called for precisely such adaptive models, emphasising that Ukraine's reconstruction will fail if it relies solely on rigid national standards. Instead, harmonisation between national frameworks and donor expectations is needed.

Another structural issue is that all construction-related documentation in Ukraine must be submitted via the **Unified State Electronic System for Construction (EDESSB)**. This system requires cost estimates for the registration of completed buildings, regardless of funding source. Even private developers who are not legally obligated to produce full estimates must comply if they wish to register a building. This effectively makes cost estimation a universal requirement, but one that remains mismatched with wartime realities.

In summary, cost estimation in times of war is not simply a technical exercise but a **strategic management challenge**. To maintain credibility and trust with both communities and international donors, Ukraine must adopt adaptive, transparent, and modular systems of cost control. By doing so, reconstruction projects can better withstand volatility, reduce the risk of delays, and ensure that limited resources are deployed effectively.

5 Measures for modernization (mid-term and long-term)

5.1 Measures for safety and security

Given the structural design of Soviet-era prefabricated buildings, it is not feasible to significantly improve their resistance to future missile or drone attacks. These buildings were not engineered for military loads, and even major reinforcement cannot protect them against direct strikes. However, there are still measures that can enhance the **safety of residents in case of renewed hostilities**. In Ukraine, the focus has therefore shifted away from attempting to harden the buildings themselves and towards creating protective infrastructure *within or near* residential environments.

According to the **Civil Protection Code of Ukraine**, residential buildings are generally not prioritised for the construction of full-scale bomb shelters. Instead, protection is organised through a layered system of shelters, safe rooms, and civil defence facilities. The Lviv Urban Forum (2025) recommended that rehabilitation projects adopt a **dual strategy**:

1. **Adapt existing basements** where technically feasible, upgrading them to serve as shelters during air alerts.
2. **Complement basement adaptation with modular above-ground or semi-submerged shelters** installed in the vicinity of residential buildings.

Most basements in Soviet-era housing blocks are **not adequate** for use as bomb shelters in their current state. Common shortcomings include insufficient ceiling height, lack of ventilation, no emergency exits, inadequate structural reinforcement, and the absence of independent utility connections. For example, the basement beneath Entrance 4 of Ukrainska 55 could only be transformed into a usable shelter after significant reconstruction, including:

- increasing the interior height by modifying foundations,
- installing reinforced concrete ceilings above the basement,
- creating at least one independent emergency exit to the outside,
- providing independent heating, water, power, and sewer systems,
- and adding an earth covering above the ceiling slab to increase blast resistance.

The cost of upgrading a basement to serve as a shelter for approximately 200 people is estimated at **more than €400,000** (around €2,000 per resident). This exceeds the financial capacities of most homeowners' associations, even with partial state support.

As an alternative, many Ukrainian municipalities have begun to install **prefabricated modular shelters** near residential areas. These reinforced concrete units, sometimes semi-submerged, are designed as so-called "debris shelters": they protect residents during short-term threats from blast waves and falling debris but are not

intended for long-term habitation. Their modular character allows adaptation to the number of residents and quick installation in available open spaces. The estimated cost for a modular shelter with capacity for 170 people is **approximately €170,000** – significantly less than retrofitting a basement to modern shelter standards.

International comparisons – for example, civil defence structures in Israel or modular shelters deployed in post-war reconstruction in the Balkans – confirm that such decentralised, small-scale shelters are more realistic than comprehensive underground bunkers in residential contexts. They can be deployed rapidly, replicated across multiple neighbourhoods, and integrated into everyday urban landscapes without massive structural interventions.

In the context of Ukraine's integration into the **European Civil Protection Mechanism**, local and regional authorities are encouraged to adopt **layered protection models**. These include not only modular shelters and upgraded basements, but also secure rooms within apartments (reinforced with additional slabs or steel elements) and early warning systems integrated into buildings. Municipal co-financing and donor involvement are necessary to ensure equitable access across all districts, independent of residents' income levels.

Pilot projects such as those in Kryvyi Rih can serve as testbeds for such scalable protection strategies. By systematically evaluating cost, functionality, and user acceptance, they can provide replicable models for municipalities across Ukraine.

In summary, while it is not possible to shield Soviet-era residential buildings against direct military attack, **civil protection measures integrated into rehabilitation projects** can significantly improve the safety of residents. The most promising strategy is to combine limited basement upgrades with the installation of modular shelters nearby, supported by municipal and donor funding. Such layered solutions are not only more cost-effective but also more feasible for replication at scale.

5.2 Measures for energy-efficient modernization

The modernization of war-damaged buildings cannot be reduced to restoring their original state. To ensure long-term sustainability, safety, and affordability, energy efficiency must be addressed as an integral part of rehabilitation. This is particularly relevant for Series 94 buildings, which, like most Soviet-era prefabricated housing, suffer from poor thermal performance, outdated heating systems, and high dependence on centralised energy supply.

The proposed modernization measures aim to align with Ukrainian building regulations, especially **DBN B.2.6-31:2021 ("Thermal insulation and energy efficiency of buildings")** and **DBN B.2.6-33:2018 ("External wall systems with thermal insulation – Design and Installation Requirements")**. At the same time, they

anticipate future European standards and funding requirements, ensuring that investments made today will not become obsolete tomorrow.

The **RDNA4 report (2025)** and the housing research by **Mysak/Meuser (2023)** emphasise that energy modernization must be embedded in a larger post-war transformation strategy. This strategy should not only reduce dependence on fossil fuels and centralised energy infrastructures, but also integrate considerations of military resilience (e.g. fire safety of insulation materials), long-term cost savings, and adaptability to new technologies such as decentralised heat and power generation.

The modernization measures for the pilot buildings in Kryvyi Rih therefore include:

1. **Insulation of external structures** (walls, roofs, basements, windows, doors).
2. **Reconstruction and upgrading of heating systems**, including decentralised regulation.
3. **Installation of rooftop photovoltaic systems** for decentralised electricity generation.
4. **Exploration of further decentralised energy options**, including heat pumps.

These measures are not isolated interventions but must be seen as a **package**: insulation without modern heating control can lead to overheating; rooftop PV systems without preparation of roof statics and cabling will create costly rework; and upgrading heating without insulation reduces efficiency.

5.2.1 Insulation of external structures

Comprehensive insulation of the building envelope is the cornerstone of energy modernization. For Series 94 buildings, this involves:

- Thermal insulation of all exterior walls,
- Replacement of windows and entrance doors,
- Insulation of the attic floor,
- Insulation of the basement ceiling.

In Ukraine, façades are typically insulated with expanded polystyrene (EPS) or mineral wool, finished with plaster or paint. However, in war-affected regions, **fire safety** is a decisive factor. EPS requires fire protection belts of mineral wool, whereas mineral wool alone provides full non-combustibility and higher resistance. For this reason, **exclusive use of mineral wool** is recommended for façades in Kryvyi Rih, even though costs are higher.

Basement ceilings can be insulated with extruded polystyrene (XPS), which has high compressive strength and moisture resistance. Attic floors can be upgraded with rigid mineral wool boards. Attention must be paid to thermal bridges and interface details, as poor execution here undermines the entire insulation strategy.

Windows must be replaced with thermally insulated, airtight models. Before replacement, a survey is needed to document which units have already been exchanged – often during emergency repairs after missile attacks. A crucial technical aspect is the **positioning of windows**: if additional façade insulation is planned, new windows should be placed closer to the outer edge of the wall to optimise thermal performance and avoid condensation risks. This must be anticipated even during emergency repairs, otherwise costly retrofits may be necessary later.

Entrance doors must comply with **DBN V.2.2-40:2018 ("Inclusivity of buildings and structures")**, meaning they must be thermally insulated, airtight, and equipped with low thresholds to ensure barrier-free access.

5.2.2 Reconstruction of the heating system

Insulation measures only achieve their intended effect when paired with modern heating systems. Without heat regulation, insulation can create thermal imbalances and discomfort. Therefore, the modernization strategy for Kryvyi Rih foresees:

- Installation of an **Individual Heating Point (IHP)**,
- **Hydraulic balancing** through new balancing valves,
- Replacement of one-pipe systems with **two-pipe systems**,
- Insulation of distribution pipelines in unheated basements.

IHPs are particularly important. They allow precise adjustment of heat input according to outside temperature and building demand. Without IHPs, insulation may lead to overheating rather than savings. However, IHPs require a stable electricity supply. Given the risk of blackouts, hybrid inverters and battery storage should be included, ideally combined with rooftop PV systems.

Replacing outdated one-pipe systems with two-pipe systems allows equal distribution of heat, unit-by-unit regulation, and transparent billing. This increases installation complexity, as new risers often need to pass through private apartments, but communication and early involvement of residents can build consensus.

Experience from projects in Kyiv, Zaporizhzhia, and Vinnytsia shows that such combined measures reduce heating energy demand by up to **50–60%**. These values have been confirmed by monitoring within the **EnergoDIM programme** and were highlighted again in RDNA4 as crucial for energy resilience and affordability.

5.2.3 Installation of a solar power plant on the roof

The war has exposed the vulnerability of Ukraine's centralised energy system. Decentralised production is therefore a strategic priority. Large flat roofs of prefabricated housing blocks are structurally well suited for photovoltaic (PV) installations.

Although PV is not an immediate emergency priority, **preparation must start early**. Rooftop repairs should include static reinforcement, cabling infrastructure, and orientation planning to avoid future "throw-away investments". Failing to consider PV integration now will result in costly retrofits later.

PV systems can be combined with battery storage and hybrid inverters to provide autonomous electricity for heating controls (IHPs) during blackout scenarios. In the long term, such systems may also contribute to municipal micro-grids, depending on regulatory frameworks.

5.2.4 Further decentralisation of energy production

Beyond photovoltaics, additional decentralised technologies should be considered: **air-to-water or ground-source heat pumps** are efficient, increasingly supported by funding instruments such as GreenDIM, and align with EU energy policy. Before implementation, compatibility with Ukrainian building codes and infrastructure must be confirmed, and maintenance capacity for new technologies must be secured.

Pilot installations can serve to familiarise local contractors and OSBBs with these technologies. Integrating decentralised systems into building modernization from the outset helps to avoid redundant investments and positions Ukraine's housing sector on a sustainable path.

In summary, energy-efficient modernization of Series 94 buildings in Kryvyi Rih is not only a matter of technical upgrades but also a **strategic component of national recovery**. Combining envelope insulation, modern heating systems, rooftop PV, and decentralised technologies creates synergies that reduce energy costs, strengthen resilience against attacks on centralised infrastructure, and align Ukraine with European energy and climate goals.

5.3 Measures for inclusivity

Both pilot buildings in Kryvyi Rih – Ukrainska 55 and Birkuna 8 – were constructed according to the **Series 94**standard. As with most Soviet-era prefabricated housing, they do not comply with today's accessibility and inclusivity requirements. Narrow doors, steep staircases at entrances, and outdated lifts (or their absence) create barriers for people with reduced mobility, elderly residents, and families with children.

In the current context, inclusivity is no longer a secondary consideration but a **strategic priority**. Ukraine has committed to harmonising its building standards with European regulations, and the war has led to a sharp increase in the number of citizens with physical disabilities. Thousands of veterans and civilians injured in hostilities will require barrier-free housing in the coming years. According to RDNA4 and the research by Mysak/Meuser (2023), inclusivity must therefore be considered a **core element of reconstruction**, alongside structural safety and energy efficiency.

A fully barrier-free reconstruction of Series 94 buildings is technically and financially unrealistic. Instead, the pilot projects in Kryvyi Rih pursue a **staged accessibility strategy**, which integrates modular improvements that can be expanded step by step.

The following measures are recommended:

- **Elevators:** The existing shafts are too small for cabins of modern standard dimensions (1.1 × 1.4 m). Full replacement of shafts would be technically and financially prohibitive. Where lifts are essential, external platform lifts at selected entrances may be considered.
- **Access to the first floor:** Due to limited space, ramps are generally impossible. Instead, mechanical platform lifts offer a feasible solution to overcome level differences.
- **Entrance doors:** All entrances should be fitted with doors at least 900 mm wide, equipped with automatic closing delays and, where necessary, colour markings for visibility. This intervention can be combined with energy-efficiency upgrades.
- **Tactile guidance systems:** Installing tactile tiles at entrances and porches is technically simple and significantly improves orientation for visually impaired residents.
- **Barrier-free outdoor access:** Entrances from street level should be regraded to minimise steps and thresholds. In many cases this requires adjustments to drainage and paving but can be implemented within larger site works.
- **Signage in Braille:** Simple, low-cost interventions such as address plates, entrance numbers, and floor markings in Braille should be installed.

- **Handrails:** All staircases should be equipped with handrails on both sides to support mobility-impaired residents.

Where full accessibility cannot be achieved, **alternative strategies** are recommended. These include the designation of ground-floor apartments as priority units for people with reduced mobility, or the introduction of **apartment swap systems** that allow affected households to move within the building to more accessible units. Such approaches must be supported by OSBBs and municipalities through legal frameworks and social mediation.

Workshops with homeowner associations, disability organisations, municipal authorities, and architects should be used to develop **typologies of retrofittable inclusivity**. These typologies can define realistic minimum standards and establish step-by-step pathways for gradual adaptation.

Pilot projects in Kryvyi Rih provide an opportunity to test these measures in practice. For example, lifts could be installed at only one or two entrances, paired with the relocation of residents in need to those accessible sections. Similarly, a limited number of ground-floor apartments could be comprehensively adapted with widened doors, barrier-free bathrooms, and accessible kitchens, ensuring that at least part of the building meets full accessibility standards.

At the **Lviv Urban Forum (2025)**, inclusivity was described not just as a technical requirement but as a **human right and social investment**. Addressing accessibility now avoids locking future generations into exclusionary housing environments. By implementing pilot measures in Kryvyi Rih, Ukraine can establish replicable models for other cities and begin the gradual transformation of its mass housing stock.

In summary, inclusivity measures must be realistic, prioritised, and embedded in broader rehabilitation. They should focus on modular, scalable solutions, combine technical upgrades with organisational mechanisms such as apartment swaps, and treat accessibility as a right rather than a luxury. Only under these conditions can housing rehabilitation contribute to social resilience and equal opportunities for all residents.

5.4 Construction cost calculation

Disclaimer: The following cost calculations are based on data available as of November 2024. They represent preliminary estimates prepared during the planning phase of the pilot project. Final and verified figures will only be available after the expected completion of works at the end of 2025.

To estimate the costs of the proposed modernization measures, comparable facilities in Ukraine were analysed, and commercial offers were obtained from construction companies. Prices reflect market conditions as of November 2024 and therefore remain subject to fluctuations in material supply and labour availability.

vul. Ukrainska, 55

- Façade insulation: 10,509,000 UAH
- Insulation of attic and basement: 2,400,000 UAH
- Replacement of windows: 5,594,508 UAH
- Installation of IHP: 1,900,000 UAH
- **Total estimate:** 20,403,508 UAH
- Equivalent in Euro (3 February 2025): ≈ €470,600

vul. Birkuna, 8

- Façade insulation: 18,240,433 UAH
- Insulation of attic and basement: 4,000,000 UAH
- Replacement of windows: 9,744,000 UAH
- Installation of IHP: 1,100,000 UAH
- **Total estimate:** 33,084,433 UAH
- Equivalent in Euro (3 February 2025): ≈ €763,000

For benchmarking, a comparable case was examined in **Zaporizhzhia**: the nine-storey, four-entrance residential building at vul. Zestafonska 8 (Series 1-480a). Damaged by a missile strike, two entrances were dismantled, and the remaining part is under restoration. Data from this site provided reference values for prices of windows, external works, and the installation of solar power plants in the Kryvyi Rih region.

It must be emphasised that these estimates do not yet reflect **all potential cost categories**. They cover direct construction measures (insulation, window replacement, IHP installation) but exclude:

- Additional reinforcement works required by unforeseen damage,
- Costs of accessibility upgrades,
- Potential integration of renewable energy (e.g. PV systems),
- Inflationary effects during 2025,
- Administrative costs for project management and legal documentation.

Moreover, the estimates illustrate the **financial burden on homeowners' associations**. Even with co-financing through programmes such as EnergoDIM or VidnovyDIM, the amounts exceed what most residents can afford without subsidies. This highlights the importance of state and donor involvement in financing modernization.

Given the high volatility of the Ukrainian construction market, a **rolling cost estimation approach** is recommended. This involves continuous updates of budgets based on current market indices and supplier quotes, ensuring transparency for residents, municipalities, and donors alike.

In conclusion, the cost estimates presented here provide a first orientation. However, only after the **completion of works in late 2025** will reliable figures on total costs, financing structures, and actual expenditures be available. These will be indispensable for scaling the findings of the pilot project to other Ukrainian cities.

5.5 Financial consideration of the construction costs in relation to energy cost savings

In order to evaluate the economic viability of the proposed modernization measures, actual consumption data from the two pilot buildings – Ukrainska 55 (OSBB) and Birkuna 8 (ZhBK) – were analysed. Heat consumption figures from the winters of 2021–2024 were compared with normative indicators under standard climatic conditions and projected savings after rehabilitation. This comparison provides an important benchmark for residents, municipalities, and donors, as it allows an assessment of the relationship between **investment costs and potential energy savings**.

vul. Ukrainska, 55

- **Annual heat consumption (Winter 2022–2023, 4 entrances):** 432 Gcal = 502,416 kWh = 83.26 kWh/m²·year ≈ 734,800 UAH
- **Annual heat consumption (Winter 2023–2024, 3 entrances):** 415 Gcal = 482,645 kWh = 109.67 kWh/m²·year ≈ 705,900 UAH
- **Calculated consumption under standard climatic conditions:** 637 Gcal = 741,224 kWh = 168.43 kWh/m²·year ≈ 1,084,100 UAH
- **Projected consumption after insulation and IHP installation:** 344 Gcal = 400,212 kWh = 90.94 kWh/m²·year ≈ 585,300 UAH
- **Projected savings:** approx. **54% reduction** in annual heat demand.
- **Projected investment:** 20,403,508 UAH (≈ €470,600).
- **Payback period (without state support):** ≈ 40.9 years.

vul. Birkuna, 8

- **Annual heat consumption (actual, Winter 2021):** 809 Gcal = 940,651 kWh = 98.26 kWh/m²·year ≈ 1,375,000 UAH
- **Calculated consumption under standard climatic conditions:** 1,120 Gcal = 1,303,110 kWh = 296.11 kWh/m²·year ≈ 1,905,000 UAH
- **Projected consumption after insulation and IHP installation:** 416 Gcal = 483,640 kWh = 109.90 kWh/m²·year ≈ 707,000 UAH
- **Projected savings:** approx. **37% reduction** in annual heat demand.
- **Projected investment:** 33,084,433 UAH (≈ €763,000).
- **Payback period (without state support):** ≈ 27.6 years.

Interpretation of results

The calculations demonstrate substantial technical potential for energy savings: 54% at Ukrainska 55 and 37% at Birkuna 8. However, the **payback periods** – 28 to 41 years – are very long, and in many cases exceed the likely occupancy horizon of current residents. Without financial assistance, most homeowners' associations will find it impossible to implement such modernization measures, even if they promise long-term energy efficiency and comfort gains.

It should also be noted that the calculations*:

- Use **November 2024 prices**; inflation, material shortages, or energy price changes may significantly alter outcomes.
- Exclude households with autonomous heating (electric or gas), whose consumption patterns differ from the collective system.
- Do not account for expected increases in energy tariffs in the coming years, which would shorten the real payback period.

* The figures shall be regarded as indicative rather than definitive.

Financing strategies

To make modernization financially viable, complementary strategies are necessary:

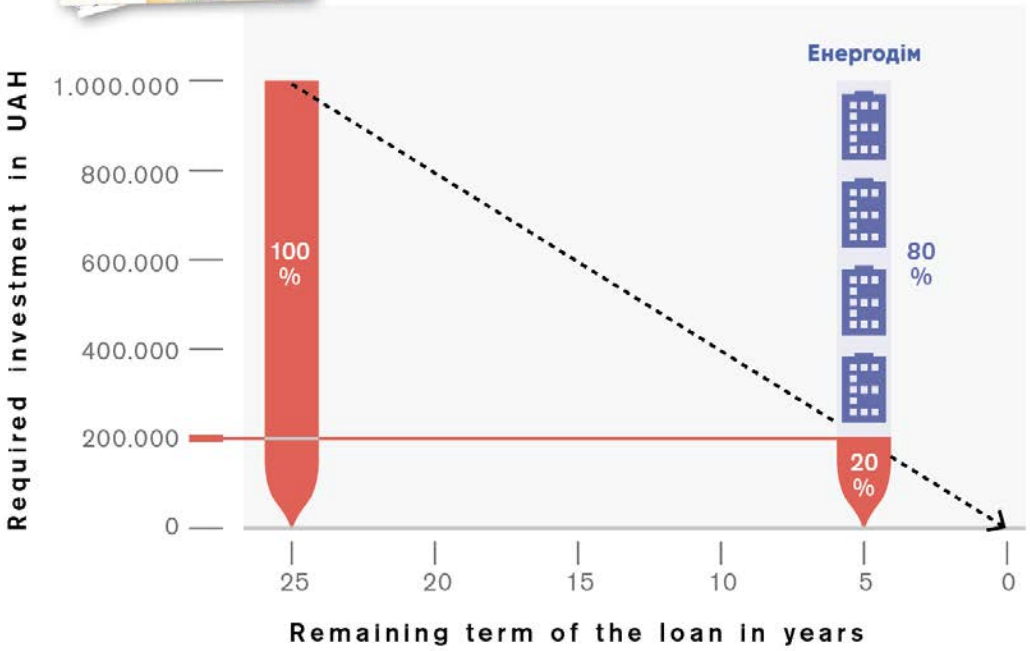
- **State support programmes** such as EnergoDIM and the emerging GreenDIM can reduce the share of costs borne by residents. Co-financing rates of up to 70% have been documented in successful projects.
- **Targeted subsidies and grants** from international donors are needed to cover the long payback horizon and to avoid exclusion of low-income households.
- **Innovative financing models**, such as energy performance contracts (EPCs) with utility providers or shared-savings schemes, could distribute risks and benefits across multiple stakeholders.
- **Awareness campaigns and technical advice** are essential to build trust among residents. Many homeowners underestimate long-term energy savings; professional guidance can help translate technical indicators into understandable financial implications.

Additional incentives could include early-adopter bonuses, partnerships with energy providers for shared-savings models, or municipal support schemes that bundle several buildings to reduce transaction costs.

Conclusion

The economic analysis shows that energy-efficient modernization of Series 94 buildings is **technically effective but financially challenging**. Without substantial subsidies and donor support, most households cannot afford investments with payback periods of three to four decades. To accelerate modernization, policies must therefore focus on **shortening the payback horizon to less than ten years**, through a combination of financial incentives, tariff adjustments, and efficient construction management. Ultimately, energy modernization should not be judged by payback time alone. It also contributes to **social resilience, reduced CO_2 emissions, and improved living comfort** – benefits that extend beyond individual households and justify public investment.

Sample calculation of the amortisation of the costs of energy-efficient modernisation



The diagram illustrates the relationship between modernisation costs and the payback period of investments in energy-efficient refurbishment. In the example shown, an investment of 1 million UAH would require 25 years to be recovered through energy savings. Since such a timeframe is not feasible for most residents, state subsidies cover up to 80% of the modernisation costs, reducing the reasonable loan repayment period to about five years.

6 Conclusions and recommendations

6.1 Results of the study

This study confirms that the rehabilitation of war-damaged serial housing in Kryvyi Rih must begin with the **restoration of basic functionality and structural safety** and only then proceed to **modernization**. The pilot interventions at **Ukrainska 55** and **Birkuna 8** demonstrate that a phased approach—emergency stabilisation, structural reinforcement (including selective dismantling), and medium- to long-term upgrades—can be implemented under wartime constraints and provides a **transferable method** for similar buildings across Ukraine.

From a **technical** perspective, both pilots validate a toolkit for large-panel Series-94 buildings: rapid visual triage to prevent progressive collapse; temporary propping and bracing; selective removal of unstable sections; and **hybrid reinforcement** (e.g., steel framing with targeted composite strengthening) where original prefabricated elements cannot be reinstated. These steps restore **habitability** to undamaged sections and create a stable platform for subsequent works. The case experience also shows how early technical decisions (e.g., leaving a one-panel-wide spine for stiffness after partial dismantling) determine feasibility, cost, and speed at later stages.

From a **modernization** perspective, the pilots link structural recovery with energy, safety, and inclusivity outcomes. Where building envelopes are insulated, **non-combustible systems** (mineral wool) and **correct window positioning** in the future insulation plane improve performance and fire safety. The installation of **Individual Heating Points** (with weather-compensated control) is essential to realise savings from envelope upgrades, while roof preparation for **PV and backup power** increases resilience against grid instability. **Shelter strategies**—upgraded basements or modular debris shelters—provide realistic civil-protection gains where full blast-resistant retrofits of residential blocks are neither feasible nor proportionate.

From a **legal and organisational** perspective, the study highlights that fragmented ownership and the limited legal capacity of homeowner entities (OSBBs, legacy ZhBKs) remain key bottlenecks. Effective implementation depends on (i) clarified representation and contracting powers, (ii) codified emergency procedures when full owner consent is impracticable, and (iii) practical governance formats at project level. The **steering structure** established around Birkuna 8 illustrates a scalable way to align municipal authorities, homeowners' representatives, contractors, and implementing partners, increasing accountability and shortening decision cycles.

From a **financial** perspective, the pilots show substantial technical potential for savings (order of 37–54% in heat demand after envelope and system upgrades) but **long payback periods** under current tariffs and market prices. The observed gap between **normative** cost estimates and **market-based** procurement (often 30–70%) argues for **dual-track cost control** and **rolling estimation** to maintain transparency for donors and feasibility for municipalities. Blended finance – sequencing **household-level** support (eRecovery) with **building-level** programmes (VidnovyDIM, EnergoDIM/GreenDIM) and donor co-financing – will be required to de-risk investments and avoid **double funding**.

From a **social** perspective, acceptance hinges on clear, trauma-informed communication; realistic expectation management; and **capacity building** for OSBBs that goes beyond technical topics to include financial literacy, loan procedures, and transparent reporting. Residents' participation is not a courtesy add-on but a **structural precondition**for reliable implementation in multi-owner buildings.

In sum, the pilots provide **evidence and methods** that are directly reusable:
(1) prioritise safety and functionality; (2) embed energy, inclusivity, and civil-protection gains in the same project logic; (3) equip homeowner entities and municipalities with the legal and managerial tools to act; (4) manage costs with market-aware instruments; and (5) institutionalise participation. Taken together, these results position **Ukrainska 55** and **Birkuna 8** as **case studies** whose lessons can inform a **scalable reconstruction architecture** for Ukraine's serial housing stock.

6.2 Methods for emergency measures / The first steps to be taken

When a munition hits a building or explodes nearby, the first responders on site are the **State Emergency Service of Ukraine (DSNS)**. Their primary role is to rescue people trapped in the rubble, extinguish fires, and secure dangerous debris. Once life-saving operations are completed, the focus shifts to **preventing secondary collapse** and to stabilising the building for subsequent rehabilitation.

Although every incident of destruction is unique, field experience has shown that emergency interventions follow a **general sequence of steps**. These steps provide a structured framework that balances speed, safety, and the need to prepare for later phases of reconstruction:

6.2.1 Preliminary visual inspection

A rapid visual inspection of the damaged building is essential to determine whether the structure poses an acute risk of collapse. Engineers assess whether **all utilities** (electricity, heating, gas, water) are disconnected, since damaged lines can worsen structural failure or cause secondary hazards. Walls are inspected for major cracks, visible tilting, or loss of vertical alignment. Floor slabs and beams are checked to ensure they remain in place on their supports. Where displacement or instability is

observed, **temporary support frames** must be installed immediately to prevent progressive collapse.

6.2.2 Implementation of priority measures

If critical risks are detected, **emergency stabilisation** is carried out. This usually involves the installation of temporary supports under floor slabs, bracing of walls, or reinforcement of staircases. Such stabilisation is often improvised using available materials – timber, steel props, or telescopic posts – and relies on the judgment and experience of engineers and rescuers. The absence of project documentation reflects the urgency of this stage: delays can result in catastrophic failure. This phase therefore places a **heavy responsibility on experts** and carries a **high degree of risk** for workers.

6.2.3 Comprehensive building inspection

Once the immediate danger has been controlled, a **systematic survey** of the entire building is undertaken. This diagnostic step includes visual and instrumental assessment of all structural components, façades, balconies, and staircases, as well as the state of technical systems (heating, water, electricity). The outcome is a quantified picture of overall and component-specific damage, expressed as percentages and degrees of impairment. This documentation becomes the **technical baseline** for subsequent planning.

6.2.4 Feasibility study

Based on the inspection results, a **decision is taken on the building's future**. The study considers technical feasibility of repair, financial costs, location, and residents' preferences. In some cases, the extent of damage, cost implications, or resistance from homeowners may lead to a decision against rehabilitation, making demolition and relocation the only viable options. The feasibility study thus acts as a **filter between repair and replacement**, ensuring that resources are allocated responsibly.

6.2.5 Reconstruction project

If rehabilitation is deemed feasible, a detailed reconstruction project is initiated. This includes **designing structural reinforcements** for damaged components, but also the integration of **modern requirements** that were absent in the original building. Examples are the installation of elevators, accessibility measures for persons with reduced mobility, or energy-saving technologies. In this way, reconstruction is not only about restoring lost function but also about **upgrading buildings to meet contemporary standards**.

6.2.6 Examination and approval

Finally, all project and cost documentation must undergo official **examination and approval**. This ensures that technical solutions comply with Ukrainian building standards and that cost estimates are accurate and justified. Only with such approval can reconstruction works proceed legally and with accountability to both residents and donors.

In conclusion, these six steps form a **structured emergency pathway**: from rapid rescue, to temporary stabilisation, to full technical diagnosis, feasibility decision, and detailed reconstruction planning. By embedding this sequence in national practice, Ukraine can ensure that rehabilitation not only prevents further loss of life but also lays the groundwork for sustainable modernization.

6.3 Methods and recommendations for residents' participation

The rehabilitation of multi-storey residential buildings in Ukraine is not only a technical and financial undertaking, but also a **collective social process**. In a system where nearly all apartments are privately owned, no rehabilitation can succeed without the **active participation of residents**. The pilot projects in Kryvyi Rih underline that functioning and empowered homeowner associations (OSBBs) are central to this process. At the same time, the projects also revealed that many OSBBs, as well as ZhBKs, lack the legal capacity, financial knowledge, or organisational skills to manage complex reconstruction tasks.

Strengthening residents' capacity for informed decision-making, collective action, and transparent communication is therefore an indispensable precondition for scaling rehabilitation. The following recommendations are derived from the pilot experience and international best practices:

6.3.1 Awareness and education

Residents must first understand why rehabilitation and modernization are necessary, what benefits they bring, and how costs can be shared. Awareness campaigns, training sessions, and workshops are effective tools to explain complex technical measures—such as thermal insulation, installation of Individual Heating Points, or accessibility upgrades—in language that is accessible to non-specialists. By raising awareness, scepticism can be reduced and willingness to cooperate increased.

6.3.2 Financial assessment

Before applying for any programme, OSBBs should conduct a transparent financial assessment of the building. This includes recording current energy costs, modelling the savings potential of modernization measures, and comparing these with estimated investment needs. Such an assessment allows residents to see the long-

term value of investments in clear, monetary terms and helps build trust in the decision-making process.

6.3.3 Loan application process

Navigating the procedures for loans and grants from Ukrainian programmes (*VidnovyDIM, EnergoDIM*) or international donors is a challenge for many OSBBs. It is therefore essential to provide simple **step-by-step guides**, templates, and advisory support. These should explain eligibility criteria, necessary documentation, and repayment options. Professional legal and financial advice is critical to reduce risks and ensure compliance.

6.3.4 Project planning

Residents must be able to see that rehabilitation is not improvised but carefully planned. OSBBs should therefore prepare **comprehensive project plans**, covering damage assessment, technical design, budget estimates, and timelines. Such planning avoids conflicts between short-term emergency measures and long-term modernization—for example, ensuring that windows replaced after a missile strike are installed in the correct plane for later insulation.

6.3.5 Cost-benefit analysis

To convince residents, numbers must be translated into **real terms**. Simple cost-benefit analyses should show how much a household currently spends on heating, how much could be saved annually after modernization, and how long it would take to recoup investments. Tools such as visual charts or case comparisons from other OSBBs can make the benefits of collective action more tangible.

6.3.6 Partnerships

OSBBs should be encouraged to partner with **energy consultants, NGOs, and engineering firms** experienced in housing rehabilitation. Such partnerships provide access to expertise, strengthen credibility vis-à-vis donors, and help professionalise the associations. Cooperation with civil society actors can also help to mediate conflicts and build social cohesion in damaged communities.

6.3.7 Monitoring and reporting

Transparency is key to trust. OSBBs should establish systems for **monitoring energy consumption** before and after modernization and report results back to residents. Regular updates—through meetings, newsletters, or digital channels—help to prevent misinformation and strengthen accountability.

6.3.8 Community engagement

Rehabilitation should be framed as a **collective project**. Organising resident assemblies, community clean-up days, or workshops on shelter use can strengthen social ties and create a sense of ownership over the process. This is especially important in war-affected neighbourhoods where displacement and trauma may have weakened community bonds.

6.3.9 Lessons learned workshops

At the end of each rehabilitation project, structured workshops should bring together residents, municipal staff, contractors, and donors to reflect on successes and shortcomings. Lessons learned can then be transferred to other OSBBs and municipalities, ensuring continuous improvement and capacity building across the housing sector.

6.3.10 International reporting and networking

Finally, pilot projects should not remain isolated local experiences. By reporting results through professional conferences, donor platforms, and media, OSBBs and municipalities can share knowledge nationally and internationally. This increases visibility, attracts further funding, and helps embed Ukraine's housing rehabilitation within broader European networks.

In summary, residents' participation is a **structural requirement** of housing rehabilitation. It requires capacity building at multiple levels: legal empowerment, financial literacy, technical understanding, and community organisation. The pilots in Kryvyi Rih confirm that without empowered OSBBs, no sustainable solution is possible. Conversely, where residents are informed, organised, and supported, even heavily damaged buildings can become **models for recovery** that combine emergency stabilisation with modernization and long-term resilience.

In summary, residents' participation is not an optional element of rehabilitation but a **structural precondition** for success. Empowering OSBBs with knowledge, financial tools, and professional support strengthens their role as active managers of collective property. At the same time, participation processes must be realistic: they must account for limited financial resources, post-war trauma, and varying levels of trust. By combining education, financial instruments, partnerships, and transparent reporting, rehabilitation projects can secure legitimacy and foster long-term ownership by the communities themselves.

6.4 Five Recommendations

The findings from the two pilot projects in Kryvyi Rih – **Ukrainska 55** and **Birkuna 8** – provide the basis for five sets of recommendations. These go beyond the case studies and point to **scalable approaches** that can inform the national recovery of Ukraine's serial housing stock. The recommendations are structured along the dimensions of technology, finance, management, communication, and upscaling.

6.4.1 Technical recommendations

The experience of the pilots demonstrates that technical solutions must balance **restoration of basic functionality** with **future-oriented modernization**. The following points are central:

- **Early structural triage.** Rapid visual inspections and standardised categorisation (minor damage, repairable, or total loss) are essential to prevent collapse and to allocate resources efficiently.
- **Hybrid reinforcement.** Where prefabricated elements cannot be replaced, a combination of steel frames, carbon fibre wraps, and other lightweight reinforcements provides stability, though fire protection must be integrated.
- **Resilient materials.** Exclusive use of **non-combustible insulation systems** (mineral wool) is recommended, particularly for façades, to mitigate fire risks and ensure compliance with European standards.
- **Energy modernisation embedded in rehabilitation.** Technical decisions during emergency works must anticipate later measures: for example, installing new windows at the outer edge of the façade to align with planned insulation layers.
- **Shelter strategies.** Neither basements nor buildings can be made bombproof, but **layered protection models**—simple basement upgrades and modular debris shelters—can be realistically integrated into rehabilitation projects.
- **Preparation for decentralised systems.** Even when not installed immediately, roofs should be reinforced for PV systems, basements insulated for future heat pumps, and cabling infrastructure pre-laid to avoid "throwaway investments."

6.4.2 Financial recommendations

Long payback periods (27–41 years) and major discrepancies between normative and market-based costs (30–70%) underline the need for adapted financing mechanisms:

- **Dual-track cost systems.** All projects should produce both normative and real-market estimates to ensure legal compliance and donor transparency.
- **Rolling cost estimation.** Budgets must be continuously updated to reflect wartime price volatility, with escalation clauses and buffers built into contracts.
- **Sequencing of programmes.** Coordination between household-level (*eRecovery*) and building-level (*VidnovyDIM, EnergoDIM, GreenDIM*) funds is vital to prevent double funding.
- **Subsidy models.** Payback periods must be reduced below ten years if modernization is to be socially acceptable. This requires blended finance with donor grants complementing state subsidies.
- **Innovative financing.** Energy performance contracts, shared-savings agreements with utilities, and municipal guarantee funds should be tested to distribute risk and mobilise private capital.

6.4.3 Management recommendations

The fragmented ownership situation in Ukraine calls for **robust management structures**:

- **Strengthened OSBB capacity.** Associations need training, legal empowerment, and access to technical assistance to act as competent contracting bodies.
- **Temporary trusteeship.** Where consensus cannot be achieved, municipal mandates or trustee arrangements should be introduced, with clearly defined scope and oversight.
- **Steering groups.** The Birkuna 8 project steering committee shows how municipalities, residents, contractors, and donors can coordinate decisions. Such groups should become a standard tool for large-scale rehabilitation.
- **Municipal role.** Urban administrations must be equipped to mediate between state programmes, donors, and residents—through technical staff, co-financing mechanisms, and oversight responsibilities.

6.4.4 Communication recommendations

Transparent and inclusive communication is both a **governance tool** and a **psychosocial necessity**:

- **Information formats.** Regular town hall meetings, workshops, and digital updates keep residents informed and prevent misinformation.
- **Trauma-informed communication.** Given the psychological impact of displacement and destruction, mental health professionals should be involved in outreach.
- **Clear distinction of decision levels.** Technical, financial, and administrative decisions must be communicated separately to avoid confusion and to strengthen trust.
- **Professionalisation of OSBB leaders.** Training in legal, technical, and communication skills is essential for chairpersons who act as mediators between residents and external actors.
- **Public visibility.** Projects should be reported in professional forums and media, making successes and challenges transparent and creating learning opportunities for other communities.

6.4.5 Recommendations for upscaling the findings

The Kryvyi Rih pilots are not isolated projects but **laboratories for national practice**. Their insights must be transferred systematically:

- **Expert workshops.** Bring together stakeholders from Ukrainian ministries, municipalities, OSBBs, and international donors to consolidate lessons.
- **Handbook development.** Produce a comprehensive manual covering technical, legal, financial, and organisational aspects of rehabilitation, to be distributed across Ukraine.
- **Integration into national programmes.** Findings should be fed directly into the frameworks of RDNA4, eRecovery, VidnovyDIM, EnergoDIM, and GreenDIM.
- **European alignment.** Position Ukraine's housing recovery within European initiatives such as the Green Deal and New European Bauhaus, ensuring long-term compatibility and funding access.
- **Dissemination platforms.** High-profile events such as the Lviv Urban Forum should be used to spread lessons early, complemented by digital platforms that allow peer-to-peer exchange between OSBBs.

In conclusion, the rehabilitation of **Ukrainska 55** and **Birkuna 8** provides a dual message: first, that restoring structural safety and habitability under wartime conditions is possible; second, that these interventions can act as **prototypes** for a national housing recovery strategy. By combining technical resilience, financial innovation, institutional reform, transparent communication, and systematic upscaling, Ukraine can turn emergency rehabilitation into a driver of long-term transformation.

7 Appendix

7.1 Contacts

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7.2 List of project reports referred to

Damage assessment of residential building vul. Ukrainska, 55 (Serhii Kurinniy)
15 August 2023

Damage assessment of residential building vul. Birkuna, 8 (Serhii Kurinniy)
15 April 2024

Identification of a prefabricated residential building in Krivyi Rih / Criteria catalogue
8 July 2024

Identification of a prefabricated residential building in Krivyi Rih / Decision paper
31 August 2024

Rehabilitation of Series 94 apartment buildings in Kryvyi Rih / Project report
8 November 2024

Fourth Rapid Damage and Needs Assessment (RDNA4), Government of Ukraine, EU, World Bank Group, UN, February 2025

7.3 List of buildings codes and laws referred to

Постанова Кабінету Міністрів України від 19 квітня 2022 р. № 473 «Про затвердження Порядку виконання невідкладних робіт щодо ліквідації наслідків збройної агресії Російської Федерації, пов'язаних із пошкодженням будівель та споруд».
Resolution of the Cabinet of Ministers of Ukraine No. 473 of 19 April 2022 'On approval of the Procedure for performing urgent work to eliminate the consequences of the armed aggression of the Russian Federation related to damage to buildings and structures.'
https://zakon.rada.gov.ua/laws/show/473-2022-п#n9

Постанова Кабінету Міністрів України від від 27 вересня 2022 р. № 1073 «Про затвердження Порядку управління відходами, що утворились у зв'язку з пошкодженням (руйнуванням) будівель та споруд внаслідок бойових дій, терористичних актів, диверсій або проведенням робіт з ліквідації їх наслідків та внесення змін до деяких постанов Кабінету Міністрів України».
Resolution of the Cabinet of Ministers of Ukraine dated 27 September 2022 No. 1073 'On approval of the Procedure for management of waste generated in connection with damage (destruction) of buildings and structures as a result of hostilities, terrorist acts, sabotage or work to eliminate their consequences, and amendments to certain resolutions of the Cabinet of Ministers of Ukraine'.
https://zakon.rada.gov.ua/laws/show/1073-2022-п#n2

Law of Ukraine on Waste Management (promulgated by the Verkhovna Rada (VR), 2023, No. 17, Art. 75)
https://zakon.rada.gov.ua/laws/show/2320-20#Text

Civil Protection Code of Ukraine
https://zakon.rada.gov.ua/laws/show/5403-17#Text

DBN B.2.6-33:2018 Structures of external walls with facade thermal insulation. Requirements for design, installation
https://e-construction.gov.ua/laws_detail/3075201563413710205?doc_type=2

DBN B.2.6-31:2021 "Thermal insulation and energy efficiency of buildings"
https://e-construction.gov.ua/laws_detail/3075196638495507996?doc_type=2

DSTU CEN ISO/TR 52016-2:2022 Energy efficiency of buildings.
Energy requirements for heating and cooling, internal temperatures, visible and latent heat loads

7.4 List of interviews, presentations, and workshops (project phase 1)

22 October 2024
Berlin-Ukrainian Urban Expert Exchange, Senat of Berlin
"Rehabilitation of nine-storey residential buildings in Kryvyi Rih"
Prof. Dr. Philipp Meuser / Oleksii Markov

4 November 2025
Interview with **Tetyana Afanasyeva** on facility management for OSBBs, Lviv
Prof. Dr. Natascha Meuser / Prof. Dr. Philipp Meuser

14 January 2025
Intersec 2025 (Security Leaders' Summit), Dubai
"Security at the heart of design" (incl. presentation of the Kryvyi Rih project)
Prof. Dr. Philipp Meuser

30 January 2025
MistoBUD 2025 International Conference on Urban Infrastructure, Sustainable Development and Renovation, O.M. Beketov University of Urban Economy, Kharkiv
"Rehabilitation of war-damaged residential buildings in. Learnings from pilot projects in Kryvy Rih"
Prof. Dr. Philipp Meuser

11 June 2025
Lviv Urban Forum 2025, Lviv
Workshop "Strengthening urban resilience: Best practices of war-damaged residential buildings"
Serhii Franchuk / Prof. Dr. Philipp Meuser / Oleksii Markov / Oleksandra Averina

In preparation:

29 September 2025 until 3 October 2025
Ukraine Resilience Week 2025, Lviv
Workshop "A strategy for rehabilitation and modernisation. Learnings from the *Birkuna 8* pilot project in Kryvyi Rih"

13/14 November 2025
ReBuild Ukraine, Warsaw

7.5 Selected bibliography

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Iokheles', I.A. et al.: Seriia 84: Krupnopanel'nye zhilye doma i blok-sektsii: Illiustrirovannyi katalog (Moscow: TSNIIEP Zhilishcha, 1979).

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Malaia, Kateryna/Meuser, Philipp: Mass Housing in Ukraine. Building Typologies and Catalogue of Series 1922–2022 (Berlin: DOM publishers, 2024).

Meuser, Philipp/Mysak, Nataliia: 'Towards a New Housing System for Ukraine: Tackling the Challenges Before, During, and After the War' in Rubba, Anna/Du, Jua et al., ed., Design for Resilient Communities. Proceedings of the UIA World Congress of Architects Copenhagen 2023 (Cham: Springer Nature, 2023).

Onishchenko, U.N. et al. (ed.): Arkhitektura sovremennykh zhilykh domov dlya massovogo stroitel'stva: sbornik nauchnych trudov (Kyiv: KyivZDNIIEP, 1986).

Sedak, I. N./Dachno, V. P./Piskovsky, Ju. I./Ladny, V. E.: Architecture of the Soviet Ukraine (Moscow: Stroyizdat, 1987).

7.6 Poster for **Ukraine Resilience Week** (Lviv) and **ReBuild Ukraine** (Warsaw)