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RESILIENT RECOVERY *IN UKRAINE:*

housing and common spaces renovation during and after war

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I would like to say thanks to my mother, Iryna, who continues to live in Ukraine, for all the support you give to me even being so far. Дякую, мамо. за те що ти завжди поруч зі мною не дивлячись на відстань між нами.

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Thanks to XTU Architect for their professional and mental support and for believing in me as a professional.

ABSTRACT

This thesis investigates the role of architecture in supporting the resilient recovery of Ukrainian cities, with a focus on social housing and communal spaces as key elements of community life. It addresses the urgent need for reconstruction caused by ongoing war-related destruction, proposing a framework that integrates safety, resilience, sustainability, and cultural relevance. Through analysis of the needs of Ukrainian population and international post-war precedents, the work identifies effective strategies for combining energy efficiency, heritage preservation, and participatory design.The study arrives with a design proposal demonstrating interventions suitable for both wartime and long-term development. The project contributes to the discourse on architecture as a tool for social recovery and sustainable urban transformation.

CONTENT

Україна – це не просто територія, це наша віра, наша культура, наша свобода.
– Михайло Грушевський

Ukraine is not just a territory — it is our faith, our culture, our freedom.
– Mykhailo Hrushevsky

INTRODUCTION

The destruction caused by the ongoing war in Ukraine has led to damage to a large part of residential and public infrastructure, which requires the involvement of urgent recovery methods, including the recovery of communities and their adaptation. The thesis proposes a comprehensive and adaptive framework for the reconstruction of social housing and common spaces, focusing on safety, resilience, sustainability, and cultural relevance. It aims to serve both emergency needs and long-term development goals.

Given the massive destruction and constant displacement, the thesis examines the transition from reconstructive efforts to integrated and adaptive spatial strategies. Using case studies from Ukraine and international post-war precedents, the work identifies effective models of transformation that combine energy efficiency, cultural heritage preservation, and participatory design.

The thesis concludes with a design proposal that reflects the potential of interventions that can be implemented during wartime and transformed into long-term solutions. The project seeks to contribute to the broader discourse on architecture as a tool for healing and sustainable urban development.

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Please note that statistical data on the extent of destruction, the number of refugees and internally displaced persons, etc. quickly becomes outdated due to the ongoing full-scale war in Ukraine. Given the constantly changing situation on the ground, it is important to note that mentioned sources in this thesis can reflect part of the true picture and may not accurately reflect the current situation in the moment of reading.

Oct. 2022. Ukraine
Source: kibri_ho/Shutterstock.com

Resilient recovery in Ukraine: housing and common spaces renovation during and after war

MAIN GOALS AND OBJECTIVES

This thesis aims to analyze the current situation in Ukraine caused by armed conflict, identify new needs and propose a way to adapt and restore society to the new conditions using a housing renovation as a way of community resilience.

Urgency of recovery

The war in Ukraine has had a critical impact on the built environment, raising questions about community resilience. Ukraine faced with a massive housing destruction with a past years of the ongoing war. Housing recovery must be addressed through strategies that provide pathways to sustainability. It highlights the need to develop approaches that combine speed and flexibility with inclusivity and a forward-looking vision.

Main specifics in war and post-war context

The main priorities, especially in wartime, are safety and protection. Every person must have access to protective structures to save their lives. Another important requirement is speed of response and recovery. Adaptability plays a significant role in addressing different scenarios, projects, facilities, and community needs.

It is important to note that psychosocial comfort has a major impact on human well-being. Therefore, it is important to consider that spaces should promote social recovery and mental health. In the context of the new Ukrainian reality, where the number of people in need of special conditions is growing rapidly, the issue of ensuring inclusiveness and accessibility for vulnerable groups arises.

01

CONTEXT:
WAR AND THE LIVING ENVIRONMENT

Father and daughter in front of a building destroyed by a russian missile.
Kharkiv, Ukraine

Photo: Aleksey Filippov/UNICEF

WHY THE TIME TO RECOVER IS NOW?

The war in Ukraine raises issues of housing affordability, logistics, access to local resources, and the vulnerability of critical infrastructure and civil defence. It is important for future reconstruction strategies to understand the economic, demographic and environmental implications. At the same time, threats arising from climate change are becoming increasingly relevant, and the issue of urban resilience is becoming more acute.

Any destruction caused by war or natural disasters creates temporary planning and the need to immediately meet the urgent needs of the population. Thus, a compromise between quality and speed often arises in the reconstruction process. At the same time, each crisis reveals deeper problems that affect the sustainability of the built environment: the ability to respond quickly, adapt and recover from natural disasters, and be prepared for future challenges.

The above are challenges that arise in connection with the reconstruction of Ukrainian cities. This dissertation offers a personal view of reconstruction that takes these challenges into account and analyses them in order to propose new approaches and principles for transforming the living environment.

A sea of people on foot and even in wheelbarrows trudged over the remains of a destroyed bridge to cross a river and leave the city.
Irpin, Kyiv region, March 6, 2022.

Photo: Oleksandr Ratushniak

REFUGEES' SITUATION

Experiencing myself beeing an Ukrainin refugee I agree with the hypotese that there is an existing possibility that after the end of the war and the opening of borders, men whose families have gone abroad and assimilated in other countries will rejoin their families. It is also possible that adult refugees will return to Ukraine, but their older children will remain abroad. This will exacerbate the demographic crisis that Ukraine was experiencing even before the war. (Drozdov & Partners, New living environment, 2023).
The non-return of forcibly displaced peoples poses a serious threat to the post-war economy and Ukraine's recovery as a whole, as the lack of human resources will be a significant challenge in all sectors. Experts estimate that annual losses for Ukraine's economy if refugees do not return will range from 2,5% to 7,7% of pre-war GDP. It considers to be signoficant loses and unfortunately Ukraine will lose magor part even concider optimistical scenarious. (Mykhailyshyna, Center for Economic Recovery, 2023)
Both internally displaced persons (Diagram 1, Classification of forced migrants) abroad and citizens in Ukraine expect rapid changes after the war ends, so this will be a serious challenge for the state, and it is necessary to act now. The post-war reconstruction of affected regions must happen rapidly to ensure that people have a place to return to. However, beyond the physical rebuilding, it is equally important to restore quality of life by improving living conditions and aligning the urban environment with European standards. One of the key factors that can encourage people to come back is the possibility to find well-paid work in their professional field. As many industrial enterprises and institutions have been closed or destroyed, some people will also require access to retraining programs. In this context, the creation of new jobs with fair working conditions and competitive salaries becomes essential for the return and reintegration of forcibly displaced persons.

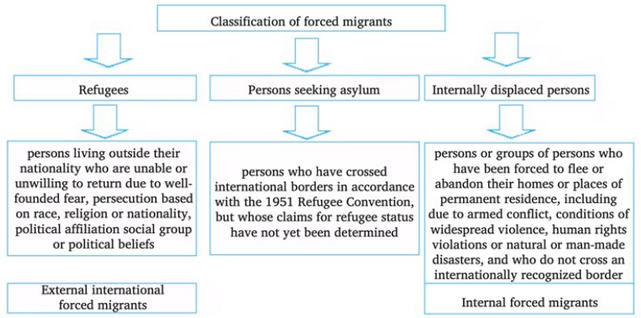


Diagram 1, Classification of forced migrants
Source: Miliienko, O. Internal migration and displaced persons in Ukraine, 2023

Forced displacement

The full-scale invasion of Ukraine has led to nearly 20 million people being displaced, according to the UN Refugee Agency. This constitutes a massive forced migration, with a significant portion of Ukraine's population affected. The situation is complex, with people displaced both within Ukraine and as refugees in other countries. According to various studies, the current number of Ukrainians who have left for European countries since the start of the full-scale invasion of Russia is about 6,9 million, where approximately 92%, resided in Europe (Germany, and Poland took in the highest number of Ukrainian refugees) (UNHCR, April 2025). The situation is quite dynamic, and this data changes periodically due to various circumstances and events. However, in addition to migrating abroad, Ukrainians are also moving within the country. Data on internal migration is illustrated in Fig.1 by the International Organisation for Migration (IOM), Ukraine Displacement Report, October 2023.

The data shows that Ukrainians most often migrate from frontline territories, mainly due to the presence of hostilities and the loss of housing as a result.

Having analysed statistical data and based on my own experience as a Ukrainian refugee, I can conclude that there is a problem with the reintegration of displaced persons both within Ukraine and beyond its borders. The issue of returning people requires a comprehensive approach that combines social, economic and spatial aspects. One of the key conditions for return is the availability of housing that can provide a sense of stability and security and facilitate the restoration of social connections.

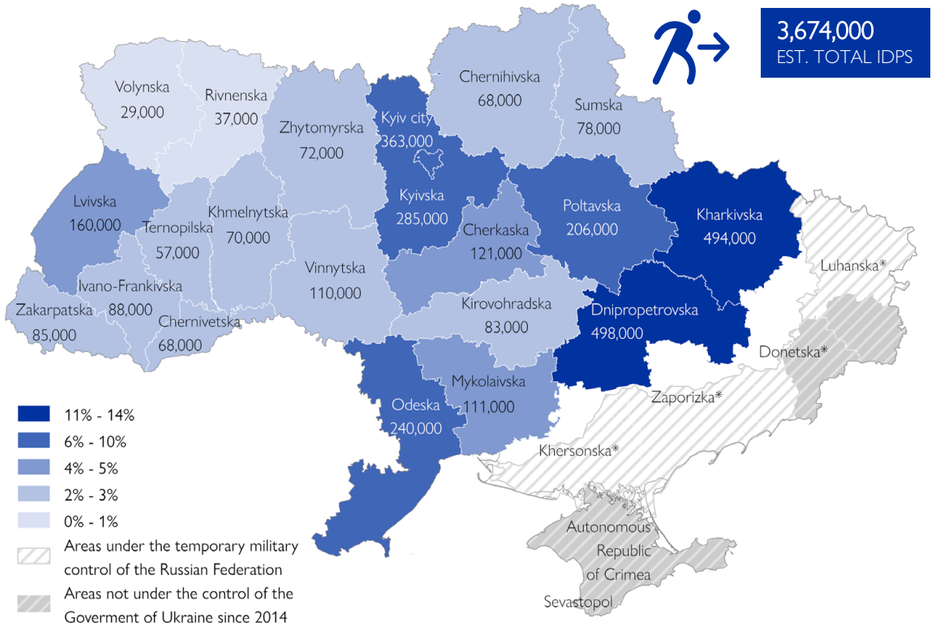


Fig. 1, Estimated IDPs presence by oblast of displacement
Source: International Organization for Migration (IOM), Ukraine Displacement Report, October 2023

Mental heath and well-being

The consequences of war are most often assessed in terms of economic losses, infrastructure destruction, and the number of injured and dead. However, war, first of all, has a catastrophic impact on people's health and well-being. The problem of protecting mental health and general well-being in Ukraine has become especially relevant after the start of Russia's full-scale war against Ukraine. Participation in hostilities, being in front-line zones, constant rocket and artillery shelling, and life under occupation — all these factors increases the vulnerability of the population to psychosocial stress.
The state of psychological health of the population of Ukraine, as determined by subjective expert assessment, is evaluated as critical and average, according to the findings of a study conducted by the Gradus Research Company. According to estimates by experts from the Ministry of Health, about 50% of the population of Ukraine will need psychological assistance. Of these, about 4 million will have moderate or severe mental health disorders. The World Health Organization has concluded that the vast majority of individuals confronted with emergencies, disasters, and wars experience psychological distress, which, in the majority of cases, exerts a long-term impact and very slowly decreases over time (the psychological consequences of war, in particular, post-traumatic stress disorder) will affect the mental state of Ukrainians for at least 7–10 years. The prospects for post-war recovery in Ukraine, according to researchers, largely depend on the level of emotional solidarity of citizens and the spread of a culture of psychological health in society.(Chepurko & Sobolev, 2023)

In connection with the above, the question arises: What methods are effective for increasing the well-being of Ukrainians? And how can architecture help to cope with this?

Photo: Pavel Klimov, Mariupol, Ukraine, April 3, 2022

Photo: Evgeniy Maloletka Mariupol, Ukraine, March 11, 2022

Photo: Zohra Bensemra, Borodyanka, Ukraine, April 7, 2022

Photo: Zohra Bensemra, Borodyanka, Ukraine, April 15, 2022

Photo: Pierre Crom/Getty Images, Kyiv, Ukraine, February, 2022

DAMAGE TO THE HOUSING STOCK DURING THE WAR

Russia invaded Ukraine at a small scale in 2014 and then at full-scale in February 2022. And due to now the end of this war is uncertain, and the price of the continued conflict is already immense. About 20% of Ukraine's territory has been occupied with the total infrastructural damages amounting to almost its GDP. (Nivievskyi, Gortyunov, Nagurney, 2024) Based on the assessment, co-authored by the UN under the technical lead of the United Nations Development Programme in Ukraine by 31 December, 2024, the total cost of reconstruction and recovery in Ukraine over the next decade will be U.S. $524 billion, which is equivalent approximately 2.8 times the estimated nominal GDP of Ukraine for 2024. Damages incurred over almost three years – from 24 February 2022 to 31 December 2024 – show that direct damage in Ukraine reached $176 billion (RDNA4, 2025). Key sectors impacted include housing (affecting more than 2.5 million households), transport, energy, commerce and industry, and education. It is important to mention that one of the sectors that was affected the most (Figure 2) and consequently needs reconstruction and recovery is housing. The extent of the destruction of the housing stock in Ukraine after February 24, 2022, exceeds the share of all new housing commissioned over the past seven years. Due to regular missiles attacks and the inability to assess the damage in the occupied regions, the share of destroyed housing will actually be much higher. (EY research, 2023).
As of December 2024, 13% of Ukraine's total housing stock has been damaged or

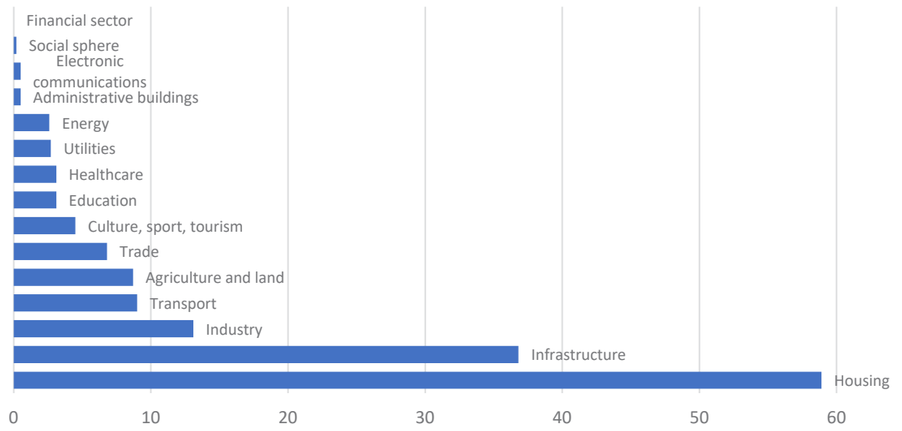


Fig. 2, Total damages distribution, as of January 2024
Source: Nivievskyi, Goryunov, Nagurney,, War-Induced Damages and Reconstruction in Ukraine, 2024

> (left) illustrative photos of destruction to housing stock in Ukraine

destroyed. In the energy sector, there has been a substantial increase in damaged or destroyed assets, including power generation, transmission, distribution infrastructure, and district heating, which has a connection and influence on the housing sector accordingly. The regions most severely affected by this destruction of housing stock include Donetsk, Kyiv, Luhansk, Kharkiv, Mykolaiv, Chernihiv, Kherson, and Zaporizhia. (Figure 3)

Despite the ongoing war, Ukraine is already rebuilding and has been able to reconstruct about 4.5% of its damaged infrastructure. (Nivievskyi, Gortyunov, Nagurney, 2024)

Achieving a balance between the current urgent needs for recovery and a sustainable path to development is a major challenge, which is why recovery and reconstruction efforts require joint and coordinated action.

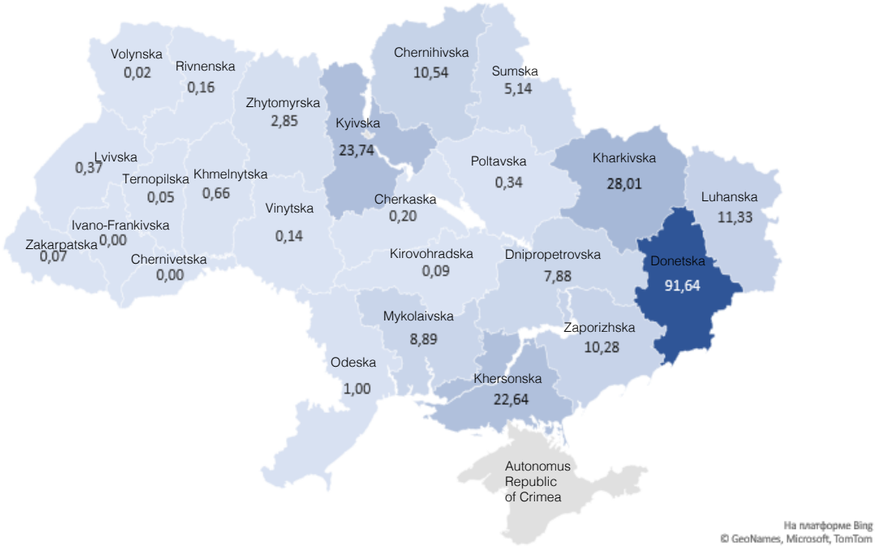


Fig. 3, Regional distribution of the number of destroyed or damaged housing stock, thousand units
Source: KSE, Report on damages, 2024

Unaffordable housing

The war led to a significant redistribution of the population, as a large number of people from the eastern, central and southern regions of the country (regions close to the line of combat or under frequent attack) were forced to be displaced to the western regions or outside the country. As a result, the western regions became overpopulated, while the eastern regions remained sparsely populated. This resulted in a significant increase in housing prices in the western regions and a decrease in the eastern regions. (Figure 4)
The ongoing destruction of the housing sector and infrastructure during the war has led to a shortage of housing options, which in turn has caused rental prices to rise due to limited supply. These factors have made Ukraine's housing sector increasingly inaccessible, especially for the country's socially vulnerable population. The population's income is decreasing, unaffordability of housing is growing, which makes the need for social rental housing even more urgent. According to the State Statistics Service, the average monthly salary in Ukraine in 2025 is 25,911 UAH (eq. 529,37 EUR). Meanwhile, the growing importance of renting creates additional challenges for affected households in finding affordable and sustainable housing options. Figure 5 illustrates the average percentage of salary spent on rent. Note that in some regions, the price of rent is decreasing due to extremely unsafe conditions, e.g. proximity to the front line.
As a result, housing is becoming increasingly inaccessible for the average Ukrainian.
The war has caused the biggest housing crisis in Ukraine, and the accompanying economic crisis has led to a decline in average income

Fig. 4, Average price (USD) of renting a one-room apartment as of October 29, 2025, with an increase over 6 months
Source: Self-elaboration with data from lun.ua (2025)

and impoverishment of the population. and against the backdrop of the migration of the educated population abroad, there is a need for quality management of the urban environment, employment, affordable housing and services to increase the competitiveness of Ukrainian cities, encourage people to stay and return to Ukraine, and reduce the burden on overpopulated regions. In summary, a new approach to housing construction, maintenance and ownership is urgently needed, based on fair and responsible management during reconstruction work. Sustainable and social development of housing construction in Ukraine must take into account the changing economic conditions in a country affected by war.

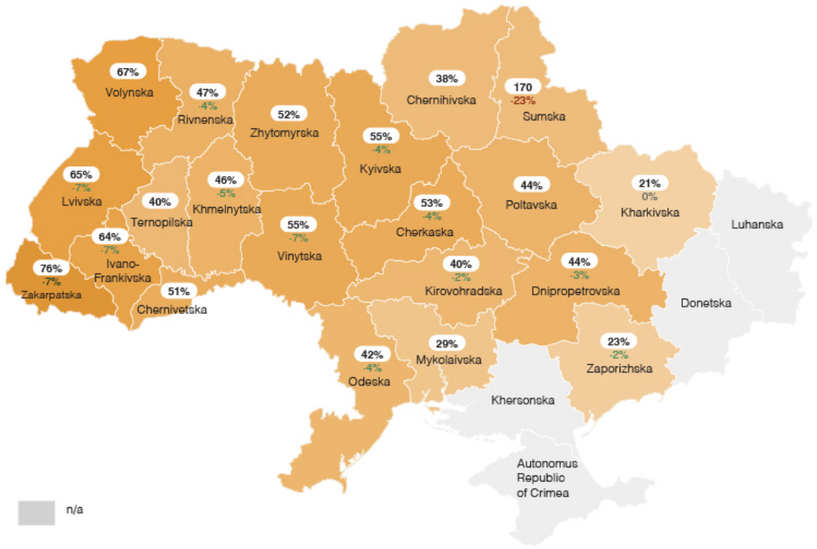


Fig. 5, Average percentage of salary spent on rent as of October 29, 2025, with an increase over 6 months
Source: Self-elaboration with data from lun.ua (2025)

Wheat plantations burnt after Russian airstrikes in Donetsk oblast, Ukraine

Photo: Miguel Medina/AFP/Getty Images

CLIMATE CHANGES AND THE WAR

The present situation is indicative of an impending crisis. In addition to the challenges created by the war, Ukraine is also dealing with the effects of global climate change. The war has exposed a number of challenges that the rest of the world is likely to face in the near future. These include displacement, infrastructure vulnerability, dependence on fossil fuel imports and resource scarcity.

The current global warming due to anthropogenic emissions is estimated to be between 0,8°C and 1,2°C since pre-industrial times, with an average increase of 0,2°C per decade. Despite achieving the goals of the Paris Climate Agreement by 2030 (i.e., limiting the average global temperature increase to 1,5°C above pre-industrial levels), sea levels are projected to rise by 0,26-0,77 cm, with every 10 cm posing a risk to 10 million people. As extreme weather events become more common, even in a scenario where global warming reaches 1,5 °C above pre-industrial levels by 2050 rather than 2030, almost one in four people could experience serious climate hazards related to heat stress, drought, floods or water stress, etc. in the next decade, which could affect their lives or livelihoods. (Bowcott et al., 2021) According to the findings of the international think tank IEP, by the year 2050, it is estimated that 1,2 billion people around the world may become refugees due to climate change and natural disasters. (Wang, Hsu, Li, & Gu, 2023) As a result a considerable number of territories are expected to become uninhabitable, while the remainder will necessitate substantial measures to adapt to the new climate conditions.
Figure 6 provides a visual summary of the potential climate changes expected globally and in Ukraine in particular.

Fig. 6, Possible of concequences of climate changes affecting Ukraine in particular.
Source. Self-elaboration based on global climate projections (Bowcott et al., 2021; Wang, Hsu, Li & Gu, 2023). Icons adapted from thenounproject.com under free license for non-commercial use.

Ongoing environmental and climatic changes in Ukraine

In some aspects, Ukraine is experiencing the effects of global warming faster than the global average. For example, the average temperature in Ukraine has risen by 1.4°C over the past 100 years (The Borys Sreznevskyi Central Geophysical Observatory) (Figure 7 illustrates the changes of temperature in Ukraine over the past 100 years) , while the global average difference has been only 1°C. All seasons in Ukraine have become warmer. According to the data of the Ministry of Environment for the last 30 years, the average summer temperature in Ukraine has increased by 1.3°C, the average winter temperature by 0.9°C, the average spring temperature by 0.9°C, and the average autumn temperature by 0.4°C.
The Borys Sreznevskyi Central Geophysical Observatory reports that 2024 was the warmest year on record in Kyiv, with an average annual temperature of +11.4°C, exceeding the climate norm by 2.4°C. Every month in 2024 surpassed historical averages, with February and September showing the most dramatic deviations at 5.7°C and 5.2°C above normal, respectively.
By 2100, the average annual temperature in

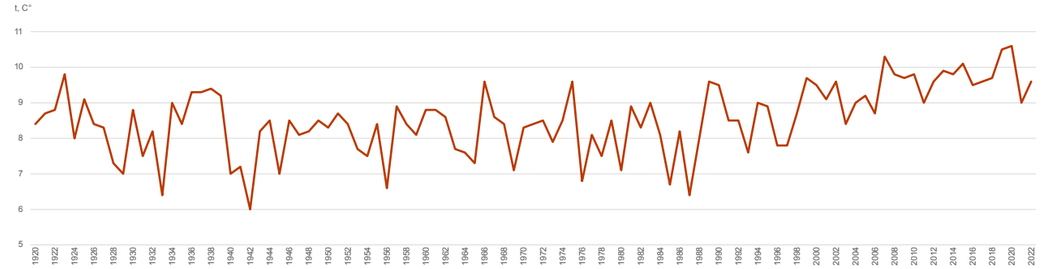


Fig. 7, The changes of temperature in Ukraine over the past 100 years (1920-2022)
Source. Self-elaboration based on data from The Borys Sreznevskyi Central Geophysical Observatory.

Ukraine is projected to rise by 4.7 °C under RCP 8.5 and by 2.5 °C under RCP 4.5 (World Bank, 2021), with the highest rates of temperature increase expected during the winter season (USAID, 2016). Additionally, the seasonal changes are also anticipated, the spring and summer months are projected to become warmer and the country's subtropical zone is likely to expand (World Bank, 2021). The usual climate zones of Ukraine will also be completely replaced by hotter and drier ones by this period. Furthermore, water resource experts warn that Ukraine could be facing an acute water shortage by around 2050 (UNICEF, 2025). These climatic changes mean that Ukraine's population is already experiencing certain climate threats, such as floods, droughts, rising sea levels, heat stress and water scarcity.

UKRAINE OCCUPIES LESS THAN 6% OF EUROPE'S LAND AREA, BUT BECAUSE OF ITS SIGNIFICANCE FOR MIGRATORY SPECIES AND GEOGRAPHIC DIVERSITY, POSSESSES 35% OF ITS BIODIVERSITY.
- Secretariat of the Convention on Biological Diversity

As of 2025, Ukraine faces extensive and long-lasting environmental and climatic consequences directly linked to the ongoing war. Beyond the destruction of critical infrastructure, the country is experiencing a significant environmental crisis characterised by the widespread degradation of ecosystems and habitats. Military activities have led to the contamination of air, soil, and water resources through the shelling of chemical plants, fires at oil storage facilities, explosions of chemical tanks, and damage to maritime infrastructure in the Black Sea. (War Worsens Climate and Environmental Challenges in Ukraine, 2025) According to Ukraine's Ministry of Environmental Protection, approximately 20% of Ukraine's natural areas have been negatively impacted by the ongoing invasion, including 812 protected sites covering nearly 0.9 million hectares (Figure 8 illustrates damage to protected areas). This includes areas within the Emerald Network, a European nature protection network, and wetlands protected under the Ramsar Convention. The war has resulted in the destruction of habitats for endangered species and the loss of valuable ecosystems. This situation poses severe threats to ecosystems and food security, particularly due to land contamination from landmines and military operations. Forests have been extensively damaged, with over 59,000 hectares burned as a result of shelling and missile attacks, representing roughly one-third of the country's forest fund (Operational Headquarters for Fixing Ecocrimes, 2025). The destruction has resulted in the release of nearly 67 million tonnes of hazardous substances into the atmosphere, contamination of soils covering over 14 million hectares, and pollution of water bodies by thousands of tons of industrial waste (Ministry of Environmental Protection of Ukraine, 2025). The ecological consequences include long-term risks to biodiversity, exacerbated by the

loss of aquatic life following environmental disasters such as the destruction of the Kakhovka Dam in 2023, which caused severe flooding and habitat loss in the northern Black Sea region (Institute of Marine Biology, National Academy of Sciences of Ukraine, 2025).

The destruction of residential and commercial buildings (many of which contain asbestos and other hazardous substances) as well as of infrastructure, industrial facilities, and energy installations has resulted in enormous waste management problems, increased air, water, and soil pollution, all of which pose serious threats to public health and various ecosystems, but also hamper reconstruction. (RDNA4, 2024)

Additionally, ongoing shelling and occupation impede environmental monitoring and remediation efforts, complicating the assessment and management of hazardous pollution. Simultaneously, environmental degradation intensifies Ukraine's vulnerability to climate change. The war-related damage amplifies exposure to climate stresses, including altered weather patterns, increased temperature extremes, and resource scarcity. Large areas have become uninhabitable or require substantial adaptation, while many citizens face displacement partly due to deteriorating environmental conditions. The fragmentation and contamination of natural territories have been demonstrated to compromise the country's resilience to ongoing climatic challenges.

In summary, the environmental and climatic impacts of the war in Ukraine represent a major ecological challenge with far-reaching effects on ecosystems, public health, and the sustainability of reconstruction efforts. Addressing these challenges through integrated and sustainable architectural and infrastructural planning is crucial for effective long-term adaptation and resilience in Ukraine's post-war future.

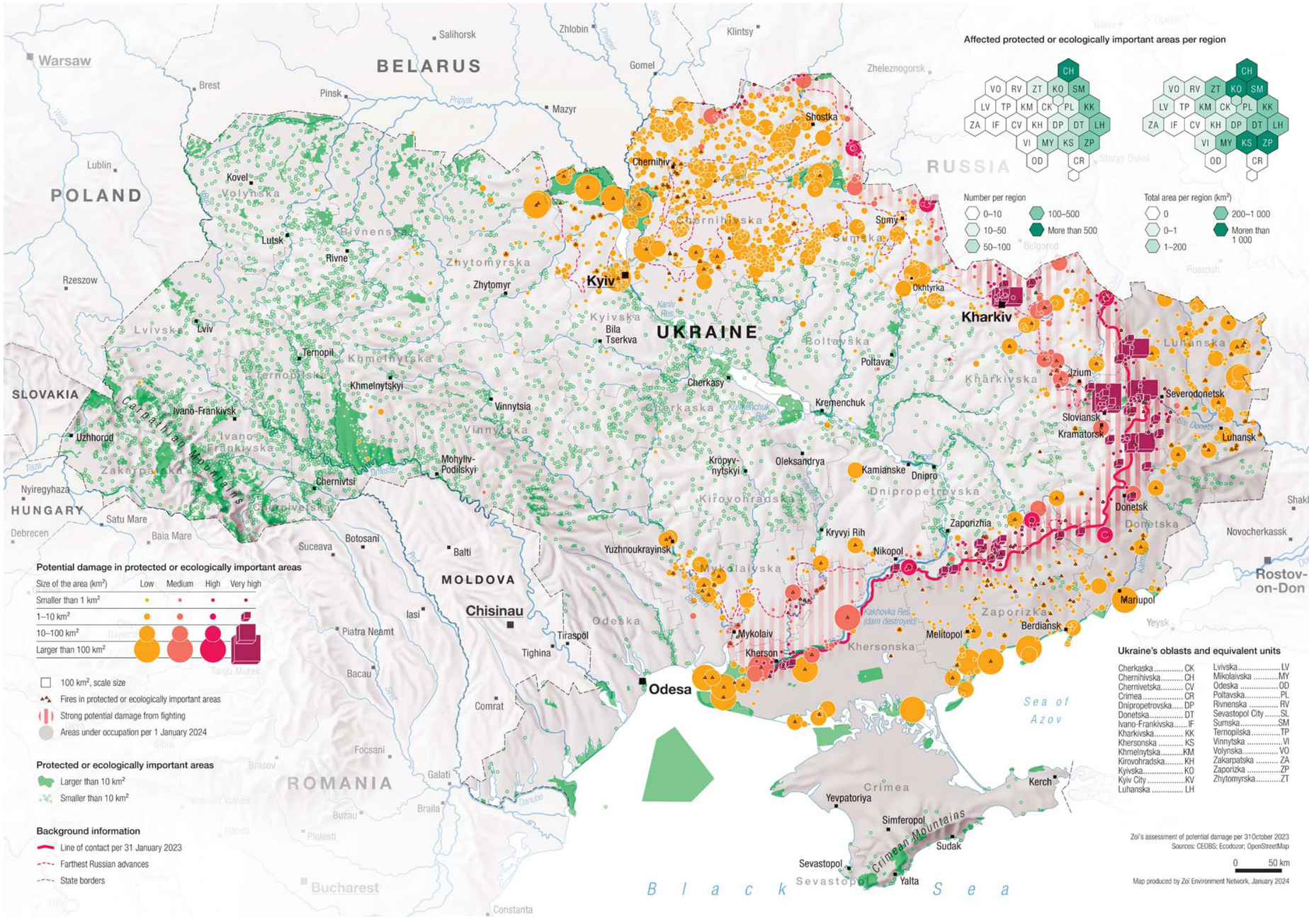


Fig. 8, Map damage to protected areas.
Source. Ukraine conflict environmental briefing by Conflict and Environment Observatory and Zoï Environment Network, ceobs.org

02

INTERSECTING EMERGENCIES: WAR AND CHALLENGES

UKRAINIAN CHALLENGES IN REBUILDING

Ukraine's post-war recovery faces many complex challenges. The main problem is not only the large-scale destruction of residential and public buildings but also systemic weaknesses in the very typology of construction, energy consumption, and structural systems.
Most Ukrainian residential neighborhoods, especially in urban contexts, developed in close association with industrial enterprises as cities expanded during Soviet industrialisation (Fig.9) (Shevchenko, 2022). The dominant housing typology consisted of standardised concrete panel buildings (often called "panelka", "khrushchyovka"), which were replicated across Ukraine, especially from the 1950s through the 1980s, as part of mass housing campaigns (Shevchenko, 2022). These housing blocks were primarily constructed to accommodate factory workers on a mass scale, reflecting the Soviet policy of linking residential development to industrial growth (Ukraine – ERIH, n.d.). The need for rapid construction led to compromises in quality; concrete panel houses commonly lack proper insulation, and quality living spaces were known for low comfort and poor insulation (Avramova et al., 2024). The focus was on providing separate units at minimal cost, rather than on quality living spaces. These mass-produced housing districts, along with associated public and communal facilities, became a fundamental aspect of Ukrainian cityscapes, shaping the visual identity of urban fabric (Shevchenko, 2022).
During the war in Ukraine, the housing problem has become much more severe. Daily attacks by Russia on Ukrainian cities are causing significant damage to residential infrastructure, creating serious challenges for the civilian population, who are forced to seek safer places to live. So the consequence of this, many residential buildings are no longer safe, as they were not designed to withstand air or artillery attacks. In particular, Soviet prefabricated buildings, which make up a significant part of the housing stock, do not have sufficient protective features, such as reinforced shelters or bomb shelters. In addition, the insufficient number of shelters in residential areas jeopardises the safety of residents.

In response to the housing stock damage, concerning the building safety, in particular, the need for a comprehensive survey of buildings is arising, especially to assess their suitability for further use, the possibility of modernisation, and the improvement of safety levels. Options for replacing or reconstructing the most worn-out and dangerous structures should also be considered to ensure the safety and comfort of citizens in the new conditions.

The modern reconstruction of Ukraine is not just a process of returning to the pre-war state but an opportunity to create more sustainable, energy-efficient, and safer cities. The main challenges include outdated housing typology, high energy consumption, and the need to modernise structural systems. However, the potential for transformation is enormous: renewable energy, thermal modernisation, circularity, modern modelling tools, and new modular systems make it possible not only to rebuild housing but also to create an environment that will serve the interests of people and their safety in the long term.

Fig. 9, Typical residential mass housing neighborhood in Ukraine: (1) Kramatorsk, Donetsk Oblast, (2) Kharkiv, (3) Odesa.
Source. Artemco.livejournal.com, @northern.friend - facebook.com, usionline.com

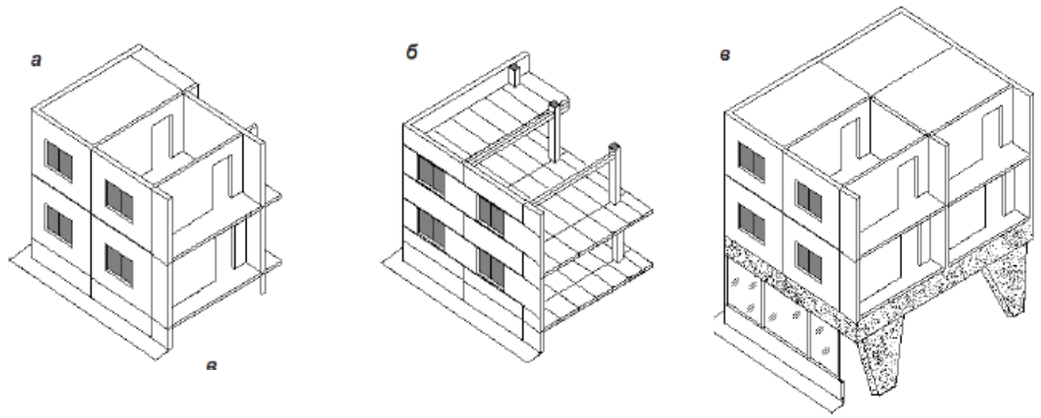


Fig. 10, Standardized concrete panel buildings - structural schemes: a) frameless; b) frame-panel; c) mixed.
Source. Karvacka, 2008

Fig. 11, Panel houses were damaged by missile strikes. (1) Odesa, (2) Kramatorsk.
Source. dumskaya.net, slovoidilo.ua

ONGOING UKRAINIAN RECONSTRUCTION EFFORTS

Reconstruction in Ukraine is not only about rebuilding infrastructure. It's about bringing life back to the affected communities, strengthening its resilience, and securing the foundations for long-term recovery. As shown in the previous chapter, the scale of destruction, particularly within the housing stock, requires not only physical restoration but also a coordinated, strategic, and transparent approach.
The step for it is to prepare a base for the reconstruction which would allow assessing and managing the further process. The national system for monitoring and managing reconstruction projects is still in its formative stage. Yet, as the war continues, new tools and institutional platforms are rapidly emerging to structure these efforts and ensure accountability. Initiatives such as the Ukraine Recovery Conference (URC) and the DREAM, digital management system, have become essential steps toward creating a more organised recovery process.
The immediate need for reconstruction is demonstrated in the results of an anonymous survey conducted by the DREAM platform, which assessed the perceptions and readiness of Ukrainian communities for recovery. With participation from over 400 communities, the findings indicate that 81,8% of respondents see restoration as necessary even during wartime, and 69,9% report being ready to begin reconstruction even during the war (Fig.12). These results highlight a significant point: Ukrainian communities are not waiting for the war to end — they are preparing for recovery now.
This preparation lays the groundwork for the next critical component of Ukraine's rebuilding process: institutional structures, conferences, and digital platforms for coordinating recon-

Fig. 12, Reflection of communities' readiness for a restoration process in Ukraine
Source: Restoration of Ukraine's regions: communities survey report, 2024

struction efforts. The following section gives an overview of these systems, including the URC, DREAM, and other national and international initiatives, and their role in shaping a transparent, collaborative, and future-orientated recovery process.

Ukraine Recovery Conference

The Ukraine Recovery Conference (URC) is an annual series of high-level international events dedicated to the swift recovery and long-term reconstruction of Ukraine following Russia's full-scale invasion. Each conference brings together governments, international organisations, financial institutions, businesses, local authorities, and civil society, unified in their commitment to strengthening Ukraine's resilience for as long as necessary. The URC series emerged in 2022 as a continuation of the earlier Ukraine Reform Conferences, adapting their framework to the new wartime reality and the urgent need for rapid recovery.
The key goal of the URC is to raise awareness and mobilise continued international support and investments for the recovery and rebuilding, reconstruction, reform, and modernisation of Ukraine. This includes providing emergency assistance for immediate needs, implementing rapid recovery projects, and creating attractive conditions for businesses to unlock the private sector's investments in Ukraine as well as for local communities to fully share in the recovery and civil society to actively engage in the reconstruction process.
The latest edition, URC2025, took place in Rome on 10–11 July 2025. It continued the previous conferences in Lugano, London, and Berlin. Italy, hosting the event, reinforced its commitment to the "Four Berlin Dimensions": business, human capital, regional recovery, and EU integration. Retaining this format at the Rome Conference ensures continuity and fosters a permanent process to support Ukraine's recovery, reconstruction, and modernisation, also by fully leveraging and valuing the experience, expertise, and capabilities acquired by Ukraine.
The URC2025 was focused on the following four thematic dimensions:

- Business Dimension – mobilising the private sector for reconstruction and economic growth: reconstruction on the necessary scale requires the engagement of private capital, which is central to rebuilding Ukraine's economy and supporting long-term recovery.
- Human dimension – social recovery and human capital: Ukraine's recovery depends on mobilising human capital, fostering social cohesion, and addressing inclusiveness, with the aim of unleashing the potential of all citizens at home and abroad, particularly women and youth. Key challenges include the reintegration of internally displaced people, refugees, and veterans into civilian life. Collaboration among stakeholders, civil society, and the Ukrainian diaspora is vital to preserving and growing the nation's human capital for sustainable reconstruction.
- Local and regional dimension – recovery of municipalities and regions: local and regional actors are key to Ukraine's reconstruction. The conference emphasises the role of local self-governance and regional state administrations in recovery, financial access, and capacity-building.
- EU dimension – EU accession and related reforms: advancing European integration will help align Ukraine's policies and institutions with European standards and drive long-term economic and social progress.

While the URC provides a strategic international framework, a critical gap remains between national-level priorities and the everyday realities of Ukrainian residential environments, especially in the housing sector, which suffered some of the most extensive damage. The conference outlines principles of resilience, human-capital development, and regional empowerment; nevertheless, these principles become fully materialised only when converted into specific architectural and urban strategies at the community scale.

Platforms for reconstruction

There are two platforms dedicated to managing the reconstruction projects: DREAM (Digital Restoration EcoSystem for Accountable Management) and BRP (Big Recovery Portal). (Nivievskyi, Gortyunov, Nagurney, 2024)

DREAM is a comprehensive digital database and collaborative platform (Fig. 13) developed through the partnership of by the Ministry for Communities and Territories Development of Ukraine, the NGO coalition RISE, and international partners such as the UK, USAID, and GIZ. DREAM organizes key processes at all stages of public investment management, implementing global practices for preparation and the highest standards of transparency and accountability. Thanks to its open-access model, anyone, from anywhere in the world, can monitor the planning and implementation of public investments and use this information to reduce risks, create accurate reporting, and improve overall efficiency in the use of funds. Its primary goal is to enhance transparency, trust, and accountability in Ukraine's reconstruction and recovery efforts while mitigating corruption risks. (DREAM – Public Investment Management System, 2025)
Key features of DREAM:

- a centralized platform for planning, implementing, and monitoring public investment projects;
- real-time visibility of state and international funding allocation;
- support for Public Investment Management (PIM) reforms through the transparent and effective use of resources;
- collaborative development involving state institutions, NGOs, and international partners — highlighting a multi-stakeholder approach to reconstruction.

Using this platform, each stakeholder can track the entire reconstruction process and also propose their own projects. When exploring the platform, it becomes clear that housing reconstruction programs represent one of the leading categories in the listed initiatives (Fig. 14, 15). The platform also provides an interactive map featuring all proposed recovery cases (Fig. 16), which can be filtered by region or project type. Once a specific object is selected, the platform allows users to follow its progress — from cost estimates and construction stages to the final results (Fig. 17, 18).

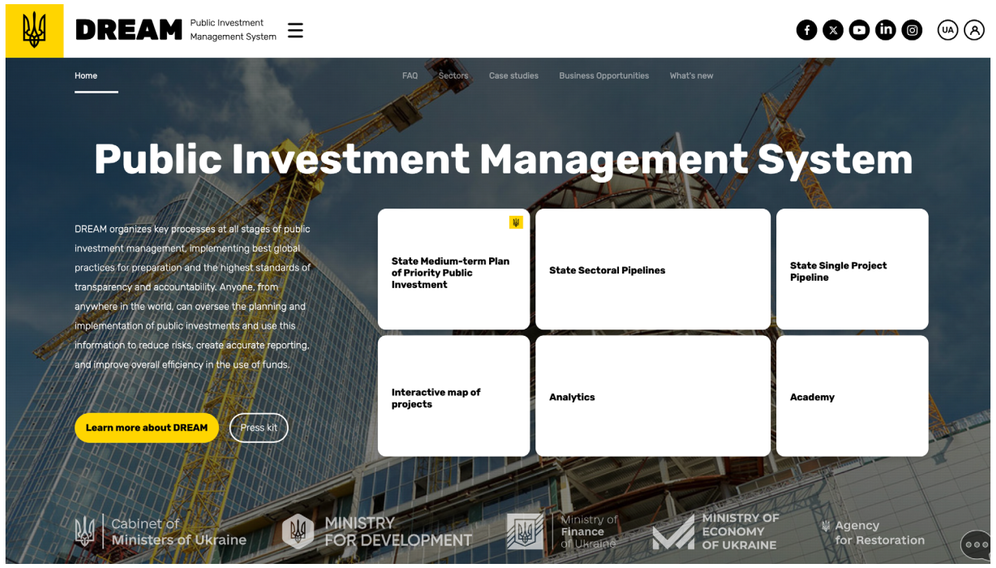


Fig. 13, DREAM platform
Source. https://dream.gov.ua

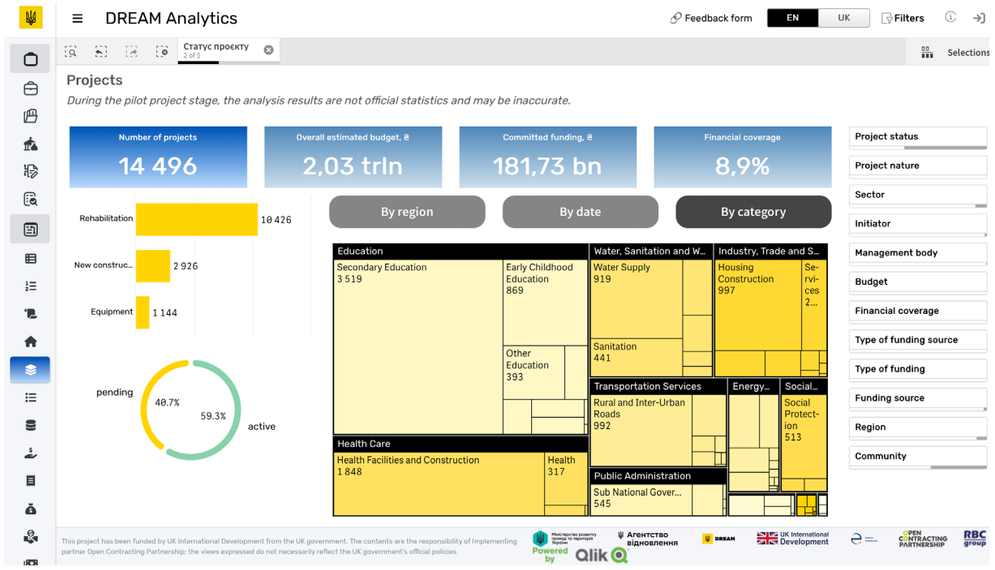


Fig. 14, Analytics of projects submited on DREAM.
Source. https://bi.dream.gov.ua/

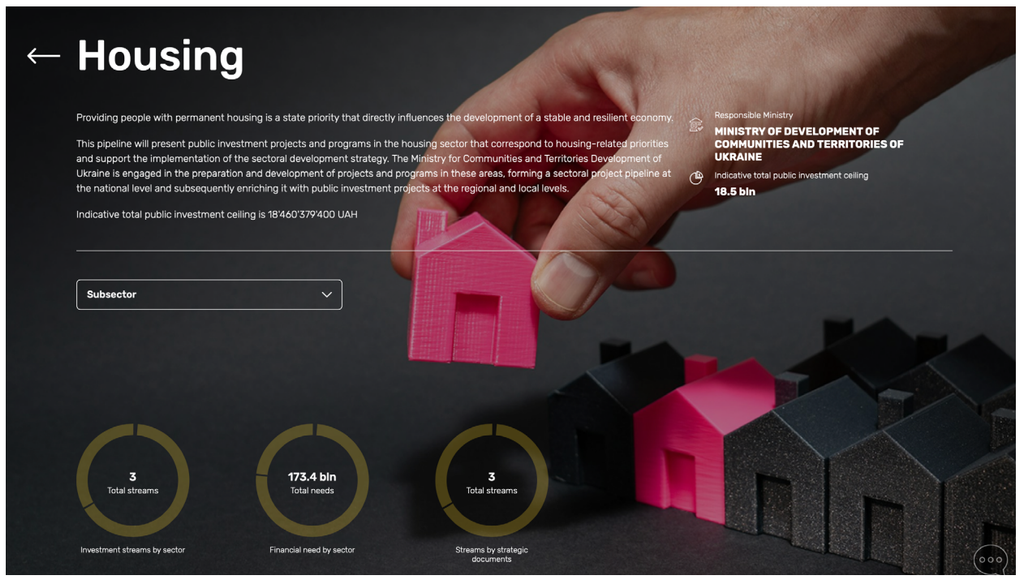


Fig. 15, Analytics of housing projects submited on DREAM.
Source. https://bi.dream.gov.ua/

Fig. 17, Map of projects submited on DREAM.
Source. https://dream.gov.ua/

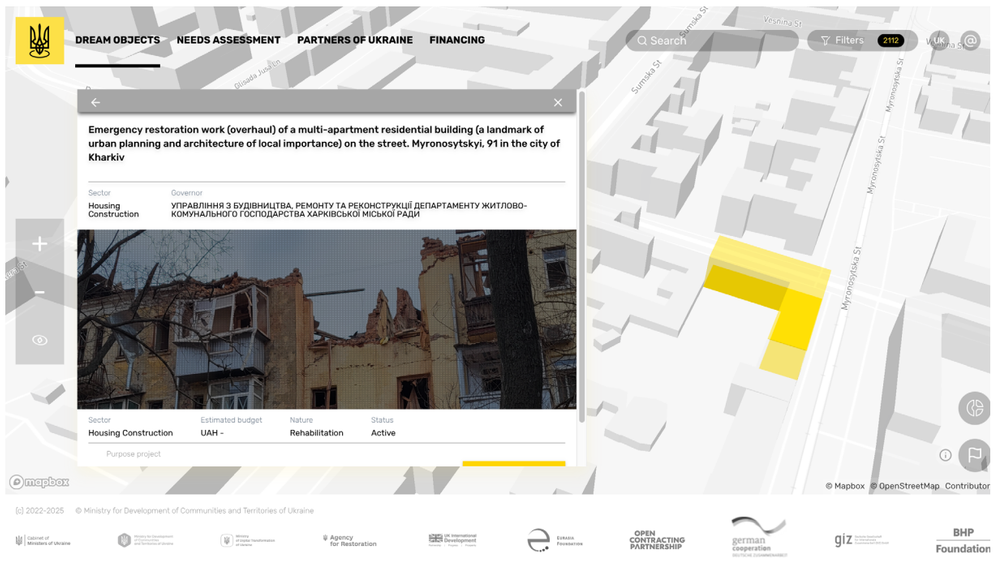


Fig. 18, Example of project submited on DREAM.
Source. https://dream.gov.ua/

The appear of DREAM demonstrates new Ukraine's approach to reconstruction: as an open, coordinated, and data-driven system. Regarding housing recovery, DREAM highlights the central role of housing in the broader recovery agenda. The platform not only demonstrates where the greatest needs lie, but also shows how transparent, modular, and adaptable solutions can be integrated into the national reconstruction framework.

Big Recovery Portal (BRP) is other online portal for a recovery process that collects a data of recovery projects, provides analysis of relevant public expenditures, and engages citizens in monitoring projects quality and feasibility as well as construction supervision (Fig. 13). The goal of the project is to build an independent system of monitoring national budget expenditures and donor funds for Ukraine's recovery, to analyse these costs and to engage citizens in recovery monitoring. The project is financed by the European Union, and individual components by USAID, Prague Civil Society Center and KSE. All project participants are members of the RISE coalition. (Big Recovery Portal, 2025)

Key Features of BRP:

- collects detailed data on recovery projects nationwide, creating a comprehensive project database
- provides insights and analysis on budget spending related to recovery efforts.
- enables public participation in monitoring project quality, feasibility, and construction supervision promoting citizen engagement
- functions as part of an independent framework to monitor national budget and donor funds usage
- funding and support: Financed by the European Union with additional support from USAID, Prague Civil Society Center, and Kyiv School of Economics (KSE).
- part of RISE coalition: aligns with other initiatives aimed at transparency and accountability in Ukraine's recovery.

Housing projects make up the largest share of the BRP database, which once again confirms the urgent need to rebuild the country's housing stock (Fig. 21). Similar to the DREAM platform, BRP allows users to track the status of each project and assess potential implementation risks (Fig. 22, 23) throughout the reconstruction process.

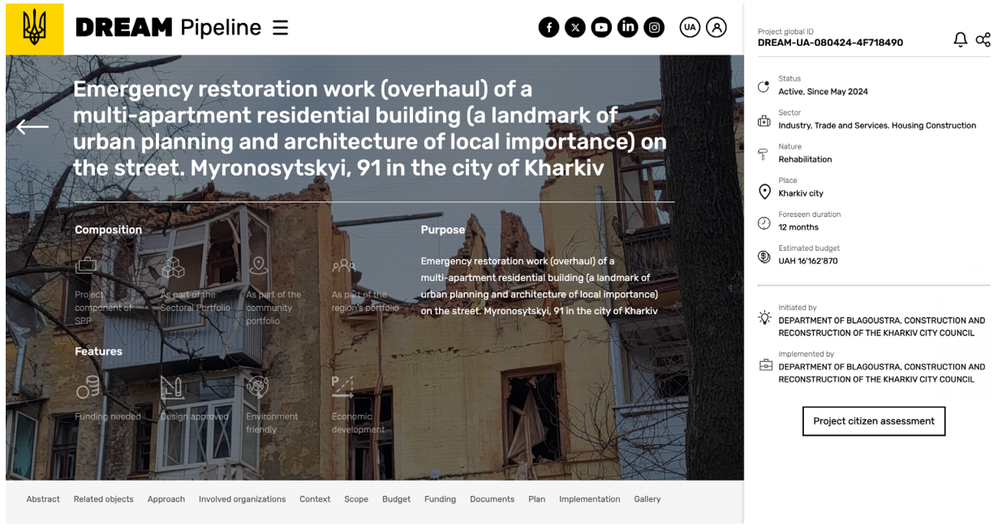


Fig. 19, Example of project submited on DREAM.
Source. https://dream.gov.ua/

Together, DREAM and BRP form a crucial part of the emerging digital ecosystem for Ukraine's reconstruction. These platforms show that recovery processes are increasingly shaped by openness, accountability, and public participation. Both platforms highlight the urgent need to restore the housing stock, which makes the focus of this thesis not only relevant, but also aligned with the current national priorities.

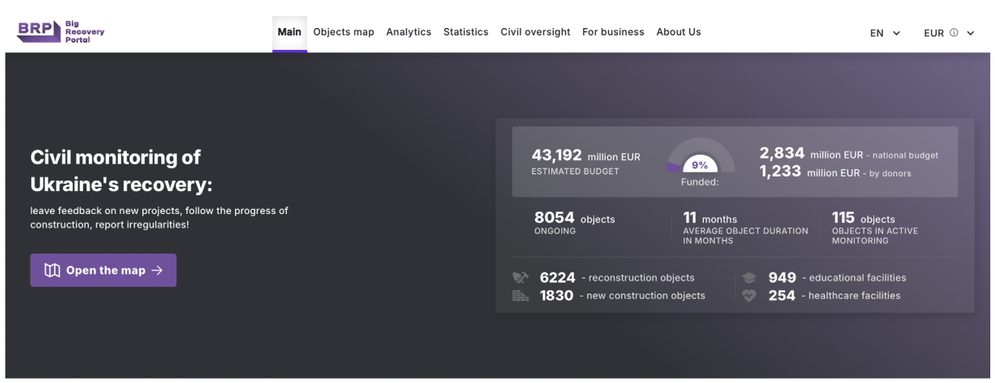


Fig. 20, Big Recovery Portal
Source. https:// brp.org.ua

Fig. 21, Recovery dynamics and project typology on Big Recovery Portal
Source. https:// brp.org.ua

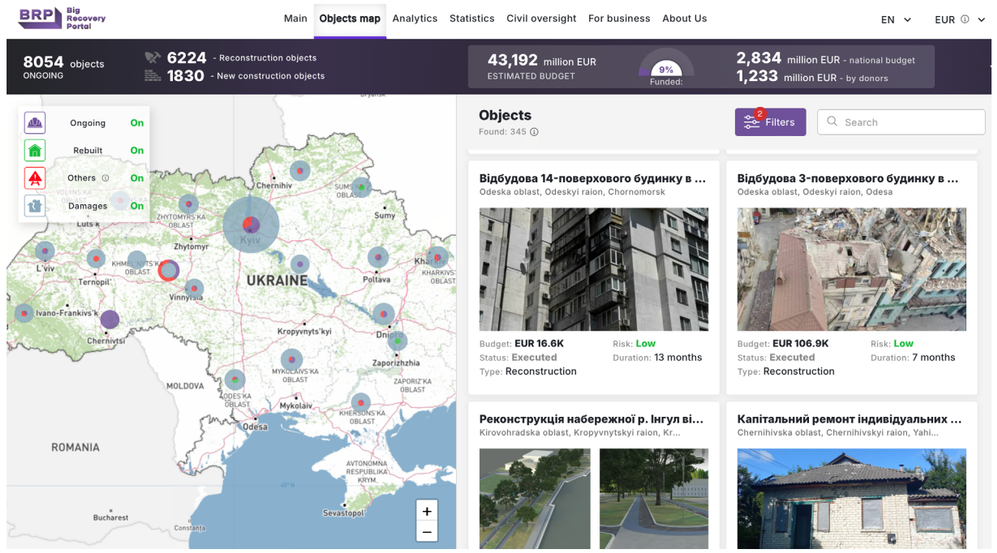


Fig. 22, Map of projects submited on Big Recovery Portal
Source. https:// brp.org.ua

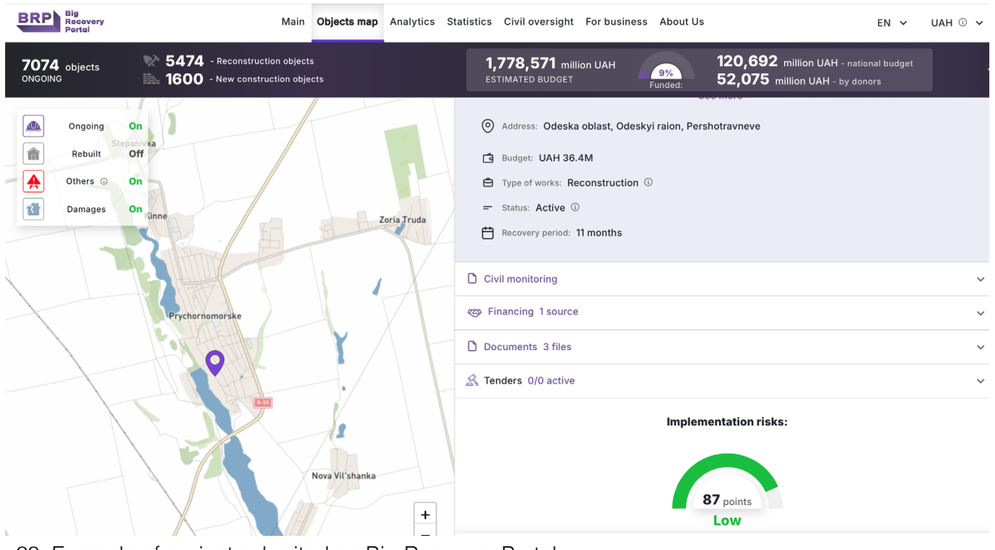


Fig. 23, Example of project submited on Big Recovery Portal
Source. https:// brp.org.ua

INTERNATIONAL EXPERIENCE

Approaches in reconstruction

In order to determine the right path for reconstruction in Ukraine, it is important not only to assess the current situation but also to analyse international experience that can help Ukraine minimise risks and reduce the number of mistakes in the reconstruction of destroyed cities. Such an analysis could serve as a foundation for understanding the main scenarios, prospects, and mistakes that had been made for Ukraine's post-war reconstruction.
The works of American architect Lebbeus Woods became well known in the context of post-war reconstruction, as he proposed his vision for the restoration of cities destroyed by war. Most of these experimental projects, which were never implemented and received a tonne of criticism, concerned the restoration of damage suffered by the city of Sarajevo after the Bosnian War in the 1990s. However, regardless of the failure and rejection of his concepts, Woods proposed a new approach to the reconstruction of cities damaged during the war. His architectural approach was based on an analysis of the experience of cities that were destroyed during World War II and then rebuilt, as well as the architect's personal vision. According to this, Woods identifies three basic principles that designers, architects, urban planners, and managers should follow when developing strategies for the reconstruction of a city destroyed or damaged by war. (Petrovska & Zapototskyi, 2024)
So The First Principle lies in restoring what has been lost to its pre-war condition. The idea is to restore «normality», where the normal is the way of living lost as a result of the war. The concept considers the war as only an interruption of an ongoing flow of the normal. The Second Principle involves demolishing the damaged and destroyed buildings and constructing something entirely new. This «new» could be something radically different from what existed before or only an updated version of the lost pre-war normal. Its application is very expensive financially, at least. While these two concepts support the desire of residents to restore, the question arises in examining the priorities and how they ignore the consequences of the war and the destruction for those who suffered from it. It is important to honour the memory of those who were lost while helping people heal and move forward, so they can return to a "normal" life.
The Third Principle has a different approach compared to the previous two; it is that the damaged city must create a new one from the destroyed old one (Fig.24).The architect's idea was that the destroyed city would no longer return to its previous life and therefore could be completely rethought. The architect believed that the reconstruction of old buildings must enable new ways and ideas of living. The so-called «ordinary» buildings (primarily office and apartment buildings) are the most needed. Churches, synagogues, mosques, and other historically significant buildings that are essential to the city and its residents' cultural memory must also be preserved and restored.
The First Principle is nearly always appears justifiable. However, where there is nothing particularly noteworthy to restore, it makes little sense to apply this theory to everyday buildings. On the contrary, the housing and office sector, that survived destruction, must offer the daily areas needed for the «radical reconstruction» that will permit the new lifestyles. (Woods, 2011)

In conclusion, the conceptual theory proposed by Lebbeus Woods offers a framework for understanding the complexities of post-conflict reconstruction. Thus, his principles emphasize the balance between restoring "normality," renewal, and reimagining city-life through radical transformation. Even though Woods' theories were mostly theoretical, they continue to stimulate reflection on how cities can rebuild not only their physical environments but also their collective identities and ways of life after conflict.

Based on these ideas, the next step is to look at real examples of post-war recovery. These cases show different approaches — from complete restoration to creating something entirely new — and can help define which strategies might be the most relevant for Ukraine's own path of rebuilding.

European experience

What mistakes can Ukraine learn from? — a question that comes up when you think about recovery and resilience, because time is crucial and a quickly depleting resource in these circumstances. How can international experience facilitate the restoration in Ukraine? Answering the question above, the example of the restoration of Warsaw, Poland, comes firstly as a well-known precedent. After 1944–1945, Warsaw was almost completely destroyed. Overall, the city was destroyed by 84%. At the same time, according to approximate data for July 1945, of all existing residential and non-residential buildings (about 25 500), 58,4% were completely destroyed, 14,1% were severely damaged and required reconstruction, and 27,5% were less damaged

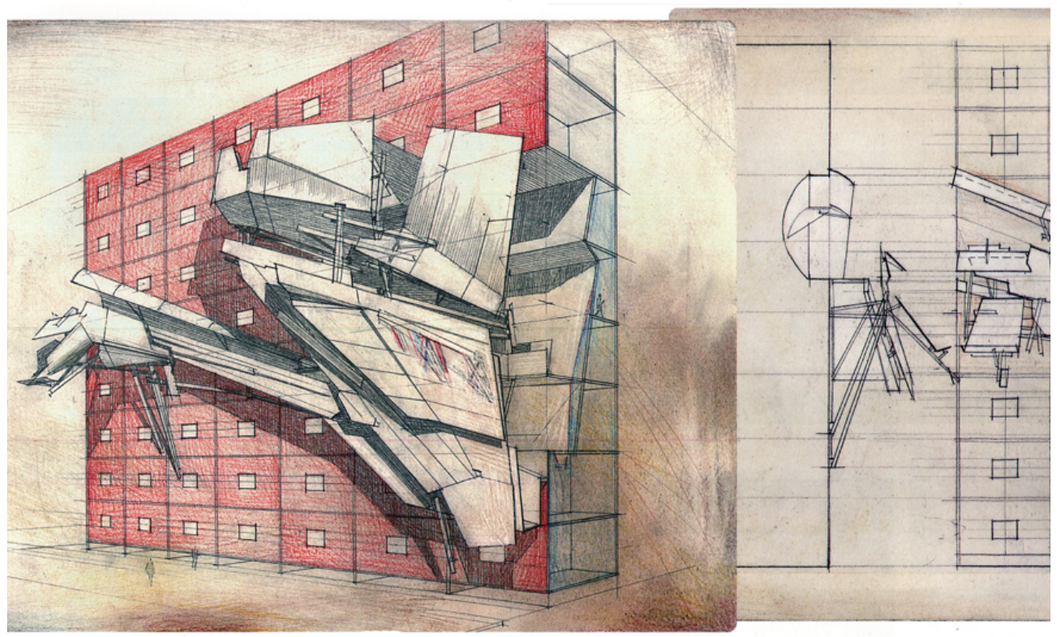


Fig. 24, A typical residential building that has been rebuilt with new kinds of spaces for inhabitants to use after experiencing significant damage in some areas. The principle behind reconstruction is to bring together people's experiences of the destruction into required architectural and social changes.
Source. Lebbeus Woods lebbeuswoods.wordpress.com

and required moderate repairs (Piątek, 2020). Plans to rebuild Warsaw began to be drawn up even before the city was liberated from German troops and the extent of the destruction was assessed. After the liberation of the city and a preliminary assessment of the destruction, discussions were already underway about when to start rebuilding, how to do it, and whether it was necessary at all. (Petrovska & Zapototskyi, 2024) The reconstruction was carried out through the Warsaw Reconstruction Office, which coordinated the projects. Even the rubble of destroyed buildings was used for construction, which was recycled into bricks or concrete (Warsaw Point, 2023); it helped to create a new building material known as “rubble concrete”, which was utilised in numerous postwar constructions (Fig.25).The main challenges in rebuilding included a lack of resources, political control by the Soviet authorities, and the need to balance the authenticity of the historical environment with modern needs.The form of the restored capital city of Warsaw was to be subordinate to its function. At the same time, the city was restored to its previous historical appearance. However, under the direction of the authorities, many of the destroyed buildings and streets were transformed into something completely new (Petrovska & Zapototskyi, 2024).

The other example of post-war reconstruction highlights the case of Bosnia and Herzegovina, Sarajevo (the war lasted from 1992 to 1995). According to UN estimates, during the siege of Sarajevo, virtually all buildings in the city suffered damage to varying degrees, with at least 35,000 buildings (both residential and non-residential from various historical periods) destroyed. As a result of the war, many residential areas were destroyed, and hundreds of thousands of people became internally displaced persons. Significant property rights issues arose: houses were seized by other people, and numerous disputes arose over the legality of ownership (Serano, 2015). After the war ended (1995), the city authorities of Sarajevo were faced with the task of restoring not only the damaged physical and impoverished social fabric of the city, but also the functional

Fig. 25, Men work to clear the Warsaw of rubble in 1947, there are sorted bricks behind.
Source. Photograph: Alfred Funkiewicz / Museum of Warsaw

and structural components characteristic of the capital. The main focus was on the first two problems. Even before the end of the siege, urbanists and city planners, including John Rowland, arrived in Sarajevo. After assessing the damage to the urban environment, they proposed integrated reconstruction concepts aimed at changing the physical fabric in such a way as to prevent future conflicts in the use of public spaces by city residents. The main idea of the plan was functional zoning and a clear separation of industrial, residential and recreational areas. However, the city’s reconstruction took place without an overall comprehensive reconstruction plan (Piplas, 2019).

«VARIOUS COUNTRIES AND INTERNATIONAL ORGANIZATIONS DONATED MILLIONS OF DOLLARS TO RECONSTRUCT SARAJEVO. THE AUTHORITIES SPENT THE MONEY ON REPAIRING THE DAMAGED INSTALLATIONS, BUT THEY DID IT WITHOUT ANY VISION FOR THE CITY. THE LATEST COMPREHENSIVE PLAN FOR SARAJEVO DATED BACK TO 1983, AND IT WAS A 30-YEAR PLAN. NOBODY BOTHERED TO AMEND IT AFTER THE WAR, THOUGH.»

— Dr Haris Piplas — an urbanist and author of the book Non-aligned City: Urban Laboratory of the new Sarajevo

In general, efforts focused on rebuilding the religious and historical buildings of the old city of Sarajevo in their original form (Aquilué & Roca, 2016). In general, a significant proportion of projects to rebuild architectural monuments in the historic centre, restore and repair residential buildings, and rebuild Sarajevo’s critically needed infrastructure were brought to life thanks in part to international financial support. Financial assistance for the city’s reconstruction was provided by various UN agencies, non-governmental organisations, the European Union (EU), the International Monetary Fund and the World Bank, the governments of Middle Eastern countries, the Japanese government, and others (Petrovska & Zapototskyi, 2024).

Overall, Warsaw’s post-war reconstruction became a strong symbol of resilience — transforming destruction into renewal and bringing back the city’s form and spirit. It showed that rebuilding can both preserve memory and open the way to a new beginning. Where the post-war reconstruction of Sarajevo has shown that the reconstruction process is quite complex and that without a clear plan for a comprehensive reconstruction plan, it is difficult to achieve the desired results, as the chaotic reconstruction plan of the city and lack of coordination have left their mark on it to this day.

An analysis of international experience in rebuilding cities destroyed during wartime could be useful for Ukraine in terms of preventing risks and repeating mistakes, as well as choosing the best reconstruction concept. The post-war reconstruction of Ukraine’s war-torn territory is a complex process that can be influenced by many factors and will not work without the involvement of effective development concepts. According to the recovery plans, Ukraine develops three phases of recovery: urgent response, medium-term recovery and long-term modernisation with a focus primarily on restoring social and critical infrastructure, as well as housing (Ukraine Recovery Plan, 2022). In addition to rebuilding housing and infrastructure, Ukraine will focus on comprehensive economic reconstruction, which is needed for an improvement in the quality of life of the population in the post-war period.

03

RETHINKING THE LIVING ENVIRONMENT

RETHINKING THE LIVING ENVIRONMENT

The ongoing war has exposed the vulnerability of Ukraine's urban system. The lack of resources, population displacement, and the constant military threat pose significant challenges to cities and towns, threatening their capacity to sustain economic vitality, ensure safety, and maintain overall well-being (UN-Habitat, 2023). These circumstances necessitate a critical reassessment of urban development strategies, including a revision of expansion policies and the establishment of mechanisms for economic and political autonomy in peripheral neighbourhoods. Many of these typical micro-districts, developed during the Soviet period, are now neglected and lack the infrastructural and financial resources required for sustainable regeneration (Babenko & Kharitonova, 2022). At the same time, Ukraine's renewal should also prioritise the rebuilding which was considered before the full-scale invasion, such as the creation of a green framework — an interconnected system of open and recreational spaces that guarantees equal access to nature and leisure for all residents (European Commission, 2020). These spaces act not only as ecological and social infrastructure but also as anchors of psychological resilience, offering places of rest and recovery during prolonged instability.

For Ukrainians, home has always held a meaning that extends far beyond physical shelter. It is tied to identity, culture, and continuity. In the current context, the idea of returning home is no longer only about safety — it is equally about restoring life, dignity, and emotional grounding. Losing one's home means losing familiarity, memories, and daily routines, while rebuilding it represents a pathway back to normality.

Rethinking the living environment therefore requires more than urban or ecological strategies — it demands a renewed focus on the housing sector as the core element of resilience. The war has shown that without safe, adaptable, and supportive living environments, neither communities nor cities can fully recover. This makes the reconstruction of the housing stock not simply one of many tasks but a foundational condition for Ukraine's broader recovery. In this context, restoring and transforming the residential environment becomes a central architectural challenge.

Challenges and Opportunities

With a focus on housing, Ukraine is confronted with several key questions:

- What steps should be taken to transform Ukrainian cities into environments that people will genuinely want to return to in order to resume active lives?
- What should renovated and newly constructed housing look like?
- What socio-economic strategies can be applied to the organisation of housing projects in ways that foster community integration and development?

Beside the question of what a modern Ukrainian neighbourhood should look like is central to the transformation of post-war reconstruction, the war has exposed deep structural vulnerabilities — ageing housing stock, monofunctional residential areas and the marginalisation of peripheral neighbourhoods. These challenges require a shift from expansion to regeneration of cities, where neglected areas are transformed into multifunctional, socially diverse and environmentally connected environments. Housing regeneration could be understood as a multi-level process that combines technological innovation, environmental responsibility, adaptivity and inclusiveness.
Building on the previous ideas about rethinking the living environment, several ideas rooted in the re-evaluation of Soviet-era urban planning can be reconsidered today, as a primary house stock in Ukraine (Shevchenko, 2022). Although many of these neighbourhoods face structural and social challenges, they also contain spatial qualities and latent potentials that can support contemporary regeneration strategies. In particular:

- vast recreation spaces: soviet district planning often reserved extensive green areas and parklands, which today can become valuable ecological and social assets if properly restored and integrated into a renewed urban fabric (Meuser & Zadorin, 2015).
- upgrading and re-use: the existing housing stock holds significant potential for energy-efficient retrofitting and material reuse, helping reduce construction waste and embodied carbon (Pomponi & Moncaster, 2017).
- void as resource: underused open spaces and vacant plots can be strategically repurposed to stimulate new urban development, such as community gardens, modular housing, or public facilities (Lydon & Garcia, 2015). In addition to this, destroyed land plots during the war can be rethought and retrofitted.
- social diversity: introducing mixed-income housing and inclusive public spaces enhances social cohesion and resilience (Talen, 2012), which could facilitate rapid healing of the Ukrainian community.

These are all challenges and opportunities are creating a vector for a future image of housing and public spaces in Ukraine and its adaptation to scenarios during and after the war.

Rethinking the living environment, its possibilities and potential is impossible without understanding how these places are perceived by the people who live there. The living environment is not just about structures, green areas or potential for modernisation. It is, above all, about the daily experiences of every Ukrainian. What are their habits, what losses have they suffered, and what do they expect? That is why it is so important in the reconstruction process to ask people questions, listen to their needs, and understand their emotional state. Each person forms their own picture of reality: what is safe for them, what causes discomfort, and what, on the contrary, gives them a sense of stability. Architectural solutions cannot be separated from these experiences.
Although I was unable to conduct a large-scale survey, I still had the opportunity to talk to several people and get their feedback. And while this is only a small part of a broader spectrum of voices, it allows us to see what lies behind the statistics and analytics — living experiences, fears, habits, and expectations. This is where I want to start the next section.

THROUGH THE EYES OF CITIZENS

This section provides examples of questions that form the basis for a comprehensive survey of residents, as well as one in-depth interview conducted to identify the key needs of residents regarding their living environment after the war. The interview provides insight into what is important to people today, how they perceive reconstruction, and how architecture can respond to their needs and experiences. Taking into account not only the quantitative and qualitative analysis of destruction and material losses, but also research into the perception of the reconstruction process, the willingness of residents to participate in this process, and the identification of the most important needs and psychological state of the population.Therefore, it is advisable to conduct structured surveys in areas where the reconstruction process is ongoing. The collected data will allow for a comprehensive assessment of the current situation and the identification of the main directions for further project work, taking into account the socio-psychological aspects and priorities of the community.

The key objectives of the structured survey and interview are to:

- Assess residents' perceptions of the current housing environment and their priorities following the war.Identify the main physical, social, and psychological needs of the population during the recovery process.
- Evaluate the willingness of community members to participate in renewal initiatives.
- Understand the influence of architectural design and urban space qualities on feelings of safety, dignity, and hope among inhabitants.
- Incorporate community perspectives and collective experiences into future sustainable reconstruction strategies.

The interview questions were designed based on the synthesis of research on post-war reconstruction and my own experience. The methodology includes a mix of open-ended and closed questions to capture both quantitative and qualitative data, reflecting best practices for assessing subjective experiences and collective needs in recovery settings. Pilot interviews helped refine the questionnaire structure and confirmed the relevance of the selected blocks (general information, housing, common spaces, views and participation) to Ukraine's post-war recovery priorities.

An example of a survey is presented below.

Sample survey for assessing community needs

- **BLOCK 1**: GENERAL INFORMATION
  - How old are you? (under 18 / 18–25 / 26–35 / 36–49 / 50–65, 66+)
  - Gender?
  - Which city/village are you from?
  - Where do you currently live (city and type of dwelling — flat, house, dormitory, shelter, etc.)?

- **BLOCK 2:** HOUSING
  - Where did you live before the full-scale invasion? What did you appreciate most in your home before the war? (e.g., layout, light, view, feeling of safety, community around)
  - Do you still continiue to live in Ukraine? Why?
  - Did you have to evacuate or live in another city? What were the differences in living conditions?
  - Has your house undergone changes or destruction due to the war? If so, how has this affected you emotionally and practically? Please describe.
  - What makes you feel safe at home? (e.g., reliable shelter, solid walls, neighborhood, silence, community support)

- **BLOCK 3**: COMMON SPACES
  - Which types of public or shared spaces did you use most often before the war (parks, courtyards, libraries, markets, etc.)? Why were they important to you?
  - Has your attitude toward these spaces changed since the war began?
  - Have you started using shared/public spaces more or less since the war began? What influences this change?
  - Did you have "safe" common spaces where you felt protected during air raid sirens or shelling?
  - Which qualities do you think are most needed in common spaces today? (e.g., protection, warmth, access to electricity/internet, visibility, social contact, nature)
  - Have any shared spaces in your city changed or been adapted during the war? What was helpful or not?
  - Have you had any experience interacting with your neighbors or community in shared spaces during the war? How did it affect you?
  - How would you like to see common spaces after the war? What main need acording to you they need to cover for ex. perception of safety, memorable space?

- **BLOCK 4**: VIEWS AND PARTICIPATION
  - Can you describe what a home means to you today? Has your understanding changed since the war?
  - What does your ideal home look like in the future? What do you pay attention to first: comfort, energy efficiency, safety, other factors? What spaces are most important for you? (e.g., kitchen, balcony, entry zone, safe room)
  - Have you ever participated in co-design or discussed plans with architects, local authorities, or NGOs?
  - Would you be willing to attend a workshop or community meeting to discuss renovation ideas? If so, how exactly? What could motivate you?
  - Do you think architecture can influence feelings of safety, dignity, and hope?
  - Do you know avalible initiatives about restoration in Ukraine? Have you contribute to some of them? If yes, how?
  - Can you recall a space (even a temporary one) that gave you a feeling of hope or peace during the war?
  - If you would like to leave an additional comment or share a story, please write here: (optional)

A pilot interview was proposed to ten individuals residing both in Ukraine and abroad. However, in the final outcome, only five participants responded to the questions, and just one of them provided detailed, in-depth answers. The responses from this participant are presented below.

Veronika, *makeup artist*
age: *24 years old*
from: *Kharkiv, Ukraine*
current location: *Paris, France*
status: *refugee*

“

— My name is Veronika, I’m 24 years old and my home city is Kharkiv. Currently I live in a private house, which I rent in Paris.

Before the full invasion I have lived in the centre of Kharkiv, in a rental apartment with the view on the garden near the building, and the horizon of my beloved hometown. Each time leaving the house and walking down the streets I probably was looking like a tourist, with my head up, I was admiring every detail of our beautiful historical architecture, admiring every detail I knew and finding a new one each time. I have always been the biggest admirer of my city with its graceful old buildings, old opera house, the sound of cars driving through the old cobblestone on the main street, green spacious parks and art on the streets.

*On 24th of February my city was the first one to be attacked by russians, so **I was forced to leave** with a deeply broken heart. I spent a few months living in another area of Ukraine later, however, my mother has been living in Paris for a long time and was begging me, in tears, to come to Paris. Of course, it was impossible to resist, so I have come to Paris. The difference was very drastic— starting from the atmosphere, culture, and ending with buildings.*

*First year **I’ve spent living with my mother and her husband in a single room apartment**, which was approximately **20m²**. It was pretty difficult, because the only space I’ve had for myself was my bed in the corner of the room and a table, with a chair, where I could do my remote job. In general, I was very surprised, how small were the living spaces in Paris, especially after I have learned that some people live in apartments less than 10m². In Ukraine, I would say that the apartments,in majority, are much more spacious and always have a heating system inside.*

***The building, where I used to live with my parents before was particularly destroyed** by two drones. Our apartment was flooded, thus there is a big mold problem inside now, all electricity was disabled, all the windows inside have exploded and doors have been dislocated. Apartments upstairs have burnt and the ceilings have fallen down, there were several victims of that drone attack. My father’s wife was at home with a dog that evening, however she is very lucky to have good reflexes, so she escaped the apartment just before the tragedy has happened. So neither her nor the dog have suffered. When I found about about what happened I was painfully upset, and really worried about where my dad, his wife and the dog will live now. They were forced to move to his friend’s house, because our apartment was not suitable for living anymore. Only in the matter of seconds, my dearest childhood memories of that house, our apartment, has turned to ashes, moldy rocks, cardboard instead of windows, and shattered glass on the floor.*

*What makes me feel **safe** at home is, in the first place, reliable **shelters**, strong and thick walls, and the location of the house. For example, if the house is «hidden» between two buildings I feel much safer.*

My city is concidered to be very green, lively, cultural, and student oriented. I would say that the parks have been a calling card of my city, and were definitely in the top of my favourite places.

We have a few big markets in Kharkiv and one of them had been considered as another very signature place. It’s name was «Barabashovo» market, and it was so big, that without knowing how to navigate there, you could easily get lost between all the little shops, where you could find probably any item that can cross your mind. One day during the war, hearts of all local people have been cracked once more, when missiles stroke the market, leaving numerous victims, dead, and injured, ruining lives, destroying and burning people’s life works.

*There was as well a big amount of historical orthodox churches in my city, and cultural buildings, museums which we, people of Kharkiv, are very proud of. A lot of them, as well, had been destroyed, exploded, some burnt to the ground, caused by **massive missile attacks intended exactly to demolish our culture**, our history as a nation.*

***A lot of my memorable places**, such as malls, restaurants, bars, museums **have been heavily damaged or exploded during the war**, and mainly have been targeted when a big amount of people was inside. Since then, **people started fearing to go to usual public spaces, so now, Ukrainians are trying to adapt to the conditions of the war and are organising public places in most safe ways possible** (covering glass windows with cardboard, making shelters nearby with quick access for anyone, organising concerts/ movie screenings in underground parking lots).*

After the war, of course, there will be an enormous amount of memorable, historical places, which will need to be restored, after endless attempts to ruin our culture and history.

Speaking of shared spaces, I believe that even after the war, they should be built with a thought of that our evil neighbor might try to attack us again one day, thus maybe be built with thicker and stronger walls if possible, with a big easy accessible shelter underneath.

Home for me now — is a place where I can always come back, feel safe and cozy, my «personal fortress», however Kharkiv, will always be the only home in my heart, despite of how dangerous it is there now.

*Of course, **during the war, my perception oh home, homeland has changed a lot**. Now I understand, that **having a home**, being able to live in/visit your hometown i**s a big privilege**, because you never know what is coming next with time. I’ve recently realized that even while choosing an apartment in Paris, I subconsciously analyze the location of the building (how exposed it could be for flying missiles), and how protected/surrounded by other buildings it is.*

My ideal home is definitely spacious, has thick walls, strong base of the house, reliable roof, but also cozy inside, with a balcony with the view on a garden. It should also be energy efficient of course, well-heated when it’s cold, and have no mold.

I think attending a workshop or community meetings to discuss renovation is an excellent idea. In this way everyone can brainstorm and find great resolutions by summing up the biggest concerns about safety, convenience of the buildings/common spaces together.

As a person, who is deeply proud of my hometown’s architecture, I can say, that it absolutely affects feelings of dignity, pride. Architecture can add so much charm and energy into the city, it can change the whole atmosphere. Of course, seeing damaged or destroyed memorable, historical buildings and common places being renovated, would give a huge feeling of hope for people’s hometown, country, as well, as more reliable, stronger buildings would make us, Ukranians, feel much safer.

I, unfortunately, do not know any renovation initiative, as an organisation in Ukraine, however I know there are a lot of people taking initiative to their hand and doing their best to renovate the destroyed parts of every city, and I am endlessly proud about it. ”

The interview results (Annex 1) reveal a redefinition of what home and public space mean for people living through the war. Home is no longer perceived primarily as a material or architectural entity but as a fundamental source of protection, emotional stability, and continuity. Many participants experienced the loss or damage of their homes, which led to a deep sense of rupture, as housing is closely linked to memories, family history, and a sense of identity. Even for those whose dwellings remained intact, the value of material comfort has shifted toward psychological security and the ability to preserve a sense of normality. Across different regions and living conditions, there is a shared awareness that complete safety is unattainable, and daily life is shaped by layered uncertainties — physical, emotional, and social.
Common spaces, which once supported social interaction, recreation, and access to basic services, have also undergone a major transformation in perception. While they previously contributed to well-being, learning, and community cohesion, many people now experience fear and discomfort in public environments, especially those with crowds or limited protection. At the same time, the importance of social contact, emotional support from neighbors, and access to information has increased, indicating that public spaces remain essential but must be reimagined through the lens of safety, adaptability, and psychological comfort.
Housing needs expressed by participants highlight a strong desire for environments that prioritise protection, energy resilience, functional layouts, and emotional grounding. Whether through reconstructing destroyed homes or maintaining existing ones, people emphasise the importance of comfort, reliability, and the ability to restore a sense of everyday life. Although participation in decision-making processes has been low, there is a noticeable readiness to engage in reconstruction efforts — provided that these processes are transparent, meaningful, and linked to real outcomes.

Overall, the interviews demonstrate that post-war housing and public space reconstruction must integrate physical safety with emotional resilience, strengthen community networks, and rebuild trust through participatory approaches. The emerging priorities reflect not only the need to restore built environments but also the need to support people's psychological recovery, belonging, and long-term stability.

THROUGH THE EYES OF PROFESSIONALS

To deepen the understanding of current challenges and potentials within Ukraine's restoration process, it was essential to explore not only the views of residents but also the position of professionals directly involved in reconstruction initiatives. Therefore, I conducted conversations with architects and researchers from XTU architects who are actively engaged in designing housing projects for Ukrainians who lost their homes or were forced to relocate. Their practical experience within the Ukrainian context offers valuable insights into the strategic, technical, and regulatory obstacles shaping today's rebuilding efforts.

During these discussions, several recurring themes emerged. One of the most pressing issues highlighted by the professionals concerns the timing of reconstruction. According to them, the urgency of providing housing during wartime often leads to rapid, emergency-driven decisions: "When you do everything in urgency, you think it's temporary… but those buildings will stay." While such interventions respond to immediate needs, they risk becoming long-term structures built without sufficient quality, planning, or consideration of future demands.
Another critical challenge concerns the rigidity and outdated nature of Ukrainian building norms. As Annelies Bal, an architect at XTU architects, noted, "Ukrainian norms are outdated; they are often contradicted." Moreover, contradictions of building codes are complicating the adoption of modern, safe, and energy-efficient methods.
The issue of material reuse was raised as both a possibility and a challenge. While selective recycling of building debris is explored in Ukraine, it remains complex due to the presence of hazardous materials. This makes reuse expensive and often unsafe.
At the same time, professionals highlighted that reconstruction offers opportunities for innovation. References were made to post–World War II France, where entire cities were redesigned: "It created possibilities… but when things are built in emergency, they are not well done." Therefore, Ukraine must avoid repeating the mistakes of rapid, uncoordinated rebuilding.
A recurring theme was the importance of social analysis and community-oriented design. Technical reconstruction cannot be separated from human needs: "You need to understand what people want… otherwise you get badly created buildings that cause social problems." The priority for most Ukrainians today is safety but, as noted during the conversation, "When there is still war, you cannot have a fully safe place, and you cannot live every time in the basement."

Overall, the insights from professionals reveal that reconstruction in Ukraine must balance urgency with long-term thinking. As Alix Chiret, Sustainability Consultant in XTU architects, concluded, "It's all about equilibrium: doing something fast, but also doing it well." Sustainable recovery will require updated norms, institutional flexibility, better coordination with European standards, and a deeper understanding of social and psychological needs.

SAFETY

The issue of safety has become one of the key criteria in shaping contemporary residential architecture in Ukraine. The full-scale war has radically transformed the way Ukrainian cities perceive safety. What was previously an 'additional' or even invisible element of urban life is now becoming a central component of any recovery strategy. Safety can no longer be viewed as a technical addition to architecture — it has become a basic necessity that determines the functionality of the living environment in conditions of constant threat. At the same time, the issue of ensuring the safety of residents is not only about engineering solutions, but also about spatial logic, accessibility, user habits, and a new level of trust in the urban environment. For many Ukrainians, shelters have become part of their daily routes, and the choice of housing is a matter of a few minutes' access to a protected space. Therefore, in the design of modern residential buildings and neighbourhoods, it is impossible to separate everyday life from emergency situations — both scenarios must coexist in the same environment.

I want to devote this section to one of the most vulnerable aspects of the Ukrainian context — safety inside buildings and living spaces, where people spend most of their time during air raid alerts, night attacks or sudden shelling. Here, safety ceases to be an abstract concept and becomes a material characteristic of planning decisions, structural systems and the availability of shelters.

In order to take a systematic approach to the design of new residential typologies, it is necessary to present a classification of shelters and safe rooms, their functions, limitations and degree of protection. This typology is based on international guidelines for the design of shelters and safe rooms (FEMA, 2006), adapted to the Ukrainian context, where the choice of shelter type is determined not only by the architecture of the building, but also by real threats: from debris damage and blast waves to repeated massive attacks.

Based on the FEMA classification of shelters, two basic categories of shelters can be identified: Standalone and Internal shelters, as well as their subtypes: single-function, multi-function, individual and collective. Each type has its own spatial logic, structural requirements and behaviour during an explosive load. Together, they form a comprehensive picture that allows us to assess the feasibility of implementing various solutions in new residential construction.

In this context, Ukrainian building codes offer a clear classification system for shelters, which can serve as the basis for the formation of a new security architecture. According to DBN V.2.2-5:2023 'Civil Defence Structures,' all shelters are divided into several key types, differing in their level of protection, functionality, and ability to be integrated into residential complexes.

1. Siimple shelters — standalone protective structure, affordable and widely available, but provide a minimum level of safety.
2. Shelters — a protective structure, capable of withstanding shock waves, building collapses.
2. Anti-radiation shelters (ARS) — has functions of shelter, additionaly provide protection from radiation and hazardous chemical threats.
3. Dual-purpose facilities (DPF) — a type of shelter that functions as a car park, gym or common area etc. in peacetime and transforms into a protected space in times of danger.
4. Safe rooms - protective structure inside a building, can protect from a small attacks or falling of debris. It is not recognised as a protective structure in Ukraine.

Together, these typologies outline a range of possible solutions from the simplest safety rooms to technically complex underground shelters. They demonstrate that a home security system cannot be universal: its effectiveness depends on the urban context, the building's structural system, the availability of resources, and the actual level of threat. The diagram (Fig. 26) summarises this spectrum, allowing for a comparison of the degree of protection, accessibility, and potential for integration of each type into existing or new housing.

For Ukraine, where the housing stock is heterogeneous and the challenges are multi-level, such a classification becomes the basis for the formation of adaptive security strategies. It allows us to think not only in terms of forced response, but also in terms of proactive design, where protection is integrated into the architecture at the level of planning decisions.

In summary, rethinking the living environment is impossible without including security as a basic element of the project.

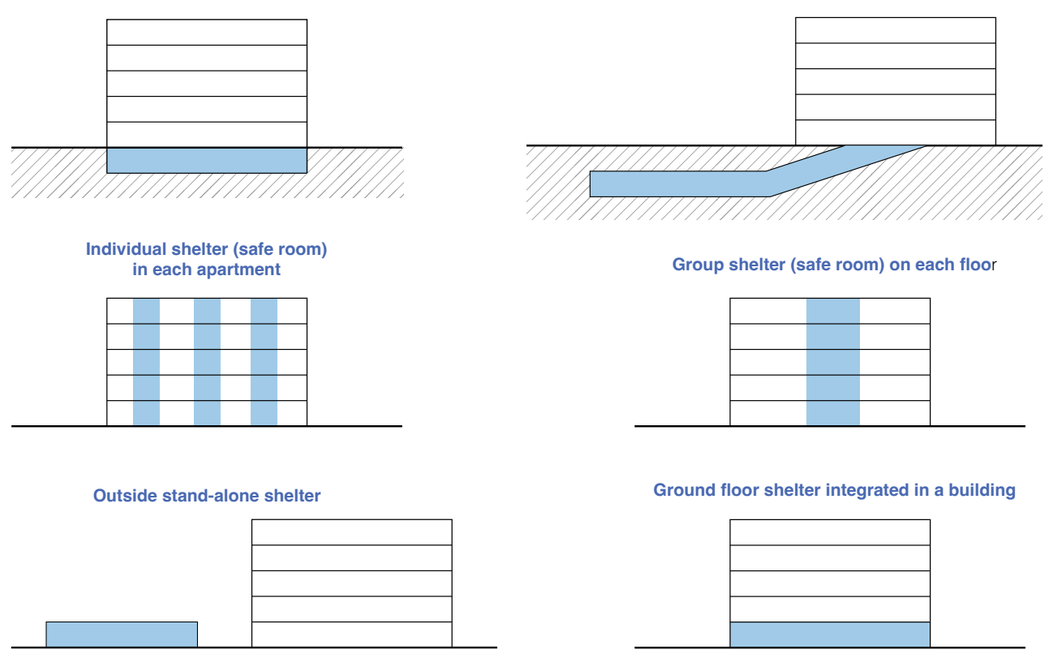


Fig. 26, Shelter typologies
Source. Self-elaboration

TRANSFORMATION *(THROUGH HOUSING)*

In the process of exploring the topic of transforming the living environment, it becomes clear that the further reconstruction of Ukraine cannot rely only on traditional linear model of construction. The scale of destruction, the shortage of material resources and environmental challenges require a rethinking of approaches to design and the use of materials. That is why assessing the potential of the circular economy is a necessary step in developing sustainable strategies for the restoration of the housing stock.

Circular economy in construction

Ukraine approved a carbon dioxide emission reduction strategy (LEDS 2050) in 2017, with a goal reduction of 70% by 2050. According to UNEP (UNEP, 2025), the construction sector is responsible for 34% of global CO_2 emissions, including both operation and embodied emissions associated with building and infrastructure construction. However, the full-scale invasion interrupted development under this strategy. Based on estimates by the Kyiv School of Economics, more than 236 000 residential buildings have been destroyed, which sharply increases the demand for new materials and structures. This creates the risk of a significant increase in the carbon footprint if standard construction approaches are used. In Ukrainian context reconstruction requires rethinking approaches to construction now, such as reducing the amount of material and energy consumption, increasing the life span of buildings and using renewable and recycled materials (UNDP, 2024; UNECE, 2025).
A considerable portion of emissions arrives from the production of new building materials such as cement, aluminium, and steel. Reusing structural steel has been demonstrated to offer major carbon savings: studies found that reusing steel can cut embodied CO_2 emissions by 74-79% compared to new steel (Journal of Architectural Engineering, 2023), where example (Stena Metall, 2024) reports emission reductions up to 98% when reusing beams rather than manufacturing new ones. The importance of establishing infrastructure for circular material use was formally recognized at the Ukrainian Recovery Conference in Lugano in 2022, where Ukraine's Ministries of Regional Development and Ecology, and the Confederation of Builders agreed to mechanisms for managing demolition waste. However, the morphology of the debris of buildings destroyed by hostile shelling differs from that of ordinary demolition waste. Much of the waste, including hazardous waste, ends up in landfills, which can lead to soil and groundwater contamination. Over 70% of roofs in residential and public buildings still use corrugated asbestos-cement (slate) sheets (Ministry of Environmental Protection & Natural Resources of Ukraine, 2023), yet there is no legal framework for its sorting and disposal. In Ukraine, as a state of 2023, over 450 000 tonnes of construction waste have been generated by war damage; yet, the recycling/reuse rate remains only about 6% of this total (Ministry for Communities, Territories and Infrastructure Development of Ukraine, 2024). In adition to this, the UNDP-led «Creative Recycling of Rubble» campaign reports over 600 000 tonnes of debris removed and partially transformed into secondary materials for reconstruction across multiple regions.
For Ukraine the transition to a circular economy in construction is not only an environmental necessity but also a strategic necessity for sustainable recovery. This approach is in line with broader European environmental strategies and ensures that reconstruction efforts contribute to long-term environmental and economic stability rather than replicating outdated, resource-intensive models. Post-war reconstruction provides an opportunity to rethink material cycles and construction practices through the lens of sustainability and resource efficiency. By integrating reuse, modular systems, and local production chains, Ukraine can reduce its dependence on imported materials, stimulate innovation, and create new economic value from existing resources. Ultimately, circular reconstruction can rethink not only how cities are rebuilt, but also how they sustain themselves environmentally, socially, and economically in the long term.

The benefits of renovating the housing stock

The scale of destruction caused by the ongoing war has brought unprecedented challenges to Ukraine's housing sector.
In this context, renovation is a a tool for sustainable recovery to improve safety, reduce environmental impact, support social stability, and strengthen community resilience and not just an architectural intervention.
The following points outline the key advantages of focusing on renovation as a central strategy for recovery, demonstrating how it can directly contribute to rebuilding the housing sector in a more sustainable and human-centered way.

- Reducing CO_2 emissions and energy use:

The housing stock is relatively old: only 7% of the stock was built after 1991. A typical multi-unit building, therefore, is 30-50 years old and badly in need of repair and renovation. (UNECE, 2013) The current housing crisis makes this even more critical - with over 1,57 million housing units damaged or destroyed (Centre for Urban Research, 2023). Renovating existing buildings, especially by upgrading insulation, heating systems, and building envelopes, results in substantial energy savings and reduced greenhouse gas emissions. Transitioning to renewable energy systems at the building and district levels further strengthens Ukraine's energy independence and reduces reliance on external suppliers.

- Saving materials and preserving green areas

Renovation significantly reduces material consumption compared to demolition and new construction. Studies on circular construction show that refurbishment can cut material demand by 50–80%, depending on the building type and depth of intervention.

- Improving quality of life

Energy-efficient renovation directly enhances indoor comfort by stabilizing temperatures, reducing drafts, preventing mold, and lowering utility costs. Healthier and more comfortable homes have measurable effects on physical and mental well-being, which is essential for communities recovering from prolonged stress and displacement.

- Preserving social ties and diversity

Renovation avoids forced displacement, helping to maintain stable and inclusive communities. his continuity preserves social relationships, cultural memory, and local diversity — all vital for community resilience.

- Creating space for innovation and community involvement

Housing renovation opens opportunities for transparent, inclusive design with active participation from residents, while also encouraging the development of innovative construction, legal, and management solutions. Renovation becomes not only a technical process but also a social and cultural one.
Implementing near-zero energy buildings (NZEB) in construction can help to improve the poor performance of older buildings. European experience demonstrates that, with high-performance building envelopes and systems, significant reductions in energy use can be achieved at the neighborhood or district level.
For Ukraine, housing renovation is not only a technical necessity but a strategic lever for environmental recovery, social stability, and long-term resilience. It offers a way to rebuild not only structures, but communities and the foundations of sustainable urban life.

SUSTAINABLE RE-USE

In the context of Ukraine, where much of housing stock is made of standardized components (e.g., prefabricated concrete panels, steel frames), the potential for scalable reuse is considerable. Material banks could support recovery and renovation, especially in cities with high levels of destruction. Deconstructed buildings could serve as repositories for components needed in temporary housing, energy-efficient retrofits, or the infill of damaged urban fabric.

To the reasons of using material banks are:

- Sustainable reconstruction: Ukraine faces massive rebuilding needs — material banking could reduce waste, conserve resources, and cut carbon footprints in large-scale housing and infrastructure recovery.
- Cost efficiency: reusing materials already on-site or nearby can lower construction costs and supply chain dependencies during crisis response and rebuilding.
- Social impact: the process of rebuilding becomes participatory, where residents are active agents of recovery. The act of rebuilding together fosters collective resilience — social as much as physical.
- Integration into policy and design: applying material passports and circular design strategies within reconstruction policy and architectural protocols creates long-term resilience.

Material banks and circular practices in the renovation of the housing stock

One of the key challenges in Ukraine's post-war recovery will be the reconstruction of damaged housing stock under severe material, economic, and logistical constraints. At the same time, this challenge opens an opportunity to rethink how we treat existing materials and structures. The concept of material banks — systems for the recovery, storage, and reuse of building components — offers a practical and ecological strategy for large-scale renovation.
A material bank is a repository of building components salvaged from deconstruction or renovation. Rather than going to landfill, these materials are catalogued (often via material passports) and made available through marketplaces for reuse in new projects—maintaining material value and reducing environmental impact(UBE, 2024). Unlike demolition, which often leads to the loss of valuable materials, material banking focuses on "urban mining": extracting usable resources from buildings that are being dismantled or transformed. This includes bricks, steel elements, wood, insulation, windows, and even technical systems. These materials can be catalogued, tested, and reintroduced into new or renovated buildings — especially within the same neighborhood or city, which significantly reduces transport costs and emissions.
This approach hinges on Design for Disassembly — planning buildings to be deconstructed efficiently (e.g. using mechanical fasteners instead of adhesives) and on digital tools to track material data. By integrating the principle of materials reuse into the very fabric of construction, it greatly minimises construction waste. The core idea is to design buildings in such a way that their components can be efficiently disassembled and reused, thereby extending their lifespan and reducing environmental impact.
One exemplary initiative is Project BAMB (Buildings as Material Banks) in Europe, which demonstrates how treating buildings as repositories of reusable materials can support sustainable construction. By considering buildings as material banks, the industry can eliminate waste, reduce emissions, and enhance the overall value of components. This approach promotes a shift from the traditional consumption model to a more sustainable and resource-efficient system. It developed guidelines, pilot projects, material passports, and reversible building design strategies to integrate circularity in the built environment. Other case is Materialenbank in Leuven, Belgium — material banks are already integrated into municipal renovation strategies. There, local governments cooperate with social enterprises to recover materials from public buildings and make them available for reuse within a 50 km radius. These models show how circular construction can work not only environmentally, but also socially — by involving local labor, supporting low-income households, and reducing reliance on new, imported materials (Scoping the socio-economic performance of the EU proximity economy, 2024).

Approach implementing

To implement an approach of a Material Bank, several factors must be considered

- Building components:

selecting components that can be easily separated and reused without damage is essential. Planning for the effective recovery of materials involves designing connections and joints that facilitate easy dismantling. This approach ensures that materials retain their value and functionality for future projects.

- Construction waste minimisation:

by considering the end-of-life phase at the design stage, construction waste is significantly reduced. This approach aligns with the circular economy's goals of reducing resource consumption.

- Lifecycle planning:

incorporating lifecycle analysis in the design phase helps predict future material needs and potential reuse scenarios, guaranteeing that materials stay within the loop for as long as possible.
This approach of material banks could reduce long-term costs, minimize construction waste, and build local knowledge systems around sustainable materials. It also aligns with broader goals of European integration, as circular construction becomes a standard within EU urban and climate policy frameworks.

It is essential to acknowledge that not all materials can or should be reused indiscriminately. Structural integrity, contamination (particularly due to military activity), and compliance with Ukrainian building codes must be carefully verified. Therefore, the implementation of pre-demolition material listing is critical. This system helps sort components into categories for reuse, recycling, or safe disposal — setting the foundation for a more sustainable and resource-responsible reconstruction process.

Based on available research and sectoral assessments, a classification of reuse potential can be developed. This synthesis is based on data from the Ministry of Environmental Protection and Natural Resources of Ukraine (2023), UNDP (2024), the Kyiv School of Economics (2023–2024), and analytical materials by Drozdov&Partners (2024). Collectively, these sources highlight the heterogeneity of war-generated construction debris and show the need for structured reuse pathways tailored to the Ukrainian context.
The classification is based on building material components (Fig.27) and building element components (Fig.28). Both tables provide a classification of materials and elements commonly found in damaged residential buildings and their potential for reuse or recycling. Together, these typologies form a methodological basis for integrating circular practices into post-war housing recovery.
The table of material and component reuse potential demonstrates that a circular approach to reconstruction is technically feasible within the Ukrainian context. The classification highlights opportunities to reduce the volume of demolition waste, lower embodied carbon, and decrease dependency on imported con-

potential demonstrates that a circular approach to reconstruction is technically feasible within the Ukrainian context. The classification highlights opportunities to reduce the volume of demolition waste, lower embodied carbon, and decrease dependency on imported construction materials. Concrete, metals, masonry, and glass show particularly high reuse and recycling potential, while wood, plastics, and gypsum can still contribute to secondary production when processed appropriately. At the component level, structural steel elements, modular façade panels, and certain interior elements (such as doors or sanitary fixtures) offer a possibility for direct reuse.
By prioritising the reuse of materials and components, Ukraine can facilitate reconstruction while maintaining affordability, reducing environmental impact, and supporting the long-term resilience of communities. Embedding circular strategies into housing recovery frameworks addresses immediate post-war needs and sets the foundation for a sustainable and resource-efficient built environment.

Material type	**Share of construction waste**	**Reuse application**	**Limitations / Notes**
Concrete	~52%	Can be crushed into recycled aggregate for road repairs and foundations; can be processed into recycled cement for new concrete	Few processors in Ukraine (e.g., Olnova, Ariess Ukraine); advanced recycling technologies are costly
Glass	n/a	Fully recyclable in a closed-loop system; can be reused in insulation materials, ceramics, brick production, and agriculture	Requires careful sorting and cleaning to maintain quality
Gypsum	n/a	Fully and repeatedly recyclable; can be turned into new gypsum boards or used as fertilizer	Requires separation from mixed waste to maintain purity
Wood	~2%	Reusable for chipboard or biofuel briquettes	Often contaminated with paint or oils, limiting reuse
Plastics		Can replace up to 20% of material in pipes and 50–70% in window frames; potential use in insulation materials	Reuse depends on material purity
Masonry materials	~32%	Crushed brick, tiles, ceramics can be used as backfill or aggregate for non-load-bearing elements (paving slabs, panels, screeds).	Not suitable for structural concrete without additional processing
Metals	~4%	100% recyclable; structural steel can be directly reused, offering major carbon savings compared to recycling	Structural reuse requires quality assessment and certification

Fig. 27, Reuse of building material elements
Source. Self-elaboration

Building components	**Reuse application**	**Reuse conitions / Limitations**
Structural and envelope materials		
Concrete panels	Foundations, retaining walls, crushed into aggregate for new concrete mixes	Crack-free, tested for load-bearing
Clay bricks	Non-loadbearing walls, partitions, façade infills, paving	Clean, not frost-damaged
Natural stone	Facade cladding, boundary walls, landscaping	Intact blocks, no major fractures
Interior and finishing elements		
Wooden beams and floors	Flooring, exposed ceiling structures, furniture, insulation	Free from rot and pests
Doors and window frames	Interior reuse, furniture, restoration projects	Solid wood, no deformation
Parquet and hardwood flooring	Refurbished flooring, cladding, shelving, interior elements	Minimal wear, non-toxic finish
Steel components and rebar	Structure, recycled steel	Rust-free, structurally sound
Technical and utility components		
Steel components and rebar	Reinforcement for non-critical elements or recycled via existing metallurgy systems	Not corroded
Pipes and radiators	Heating systems, metal recycling, full reuse of components	Pressure-tested, not corroded
Façade and glazing elements		
Glass panels	Greenhouses, partitions, secondary façades	Undamaged, suitable dimensions thermal efficiency standards must be verified to ensure relevance
Aluminum profiles	Façade systems, recycled aluminum curtain wall systems, shading devices, modular construction	No oxidation, intact frame
Secondary use and recyclables		
Bitumen roofing	Road base, waterproofing	Not contaminated, free from asbestos
Ceramic tiles and sanitaryware	Secondary re-use, mosaics, public furniture	Unbroken, adhesive-free
Insulation materials	Outbuildings, temporary housing, temporary structures	Assessment for contamination (especially post-explosion or fire)

Fig. 28, Reuse of building element components
Source. Self-elaboration

Modular and prefabricated systems

Reconstruction in Ukraine requires solutions that are fast, adaptable, and scalable. demands building solutions that are fast, adaptable, and scalable. Modular construction and prefabricated technologies are well suited to this approach. They accelerate building timelines while providing flexible, future-ready systems capable of responding to evolving needs during and after the war.
Compared to traditional construction, modular systems can reduce construction time by 30–50% (NIBS, 2024), this speed advantage is crucial for addressing the urgent housing shortages faced by many Ukrainian communities.
The strength of modularity lies in its:

- Speed: factory-made elements minimize time spent on site;
- Flexibility: modules can be rearranged, expanded, or adapted over time;
- Future-proofing: buildings can evolve with changing needs by adding new modules or replacing outdated ones;
- Functional diversity: modular units can be configured into housing extensions, service spaces, communal areas, or protective structures.

In Ukrainian cities, modular systems can be deployed both to retrofit damaged housing blocks and to construct new, adaptive neighborhoods.

A modular reconstruction framework can include a diverse set of prefabricated components:

- Structural modules: Reinforce or replace damaged structural systems to improve stability, seismic resilience, and safety.

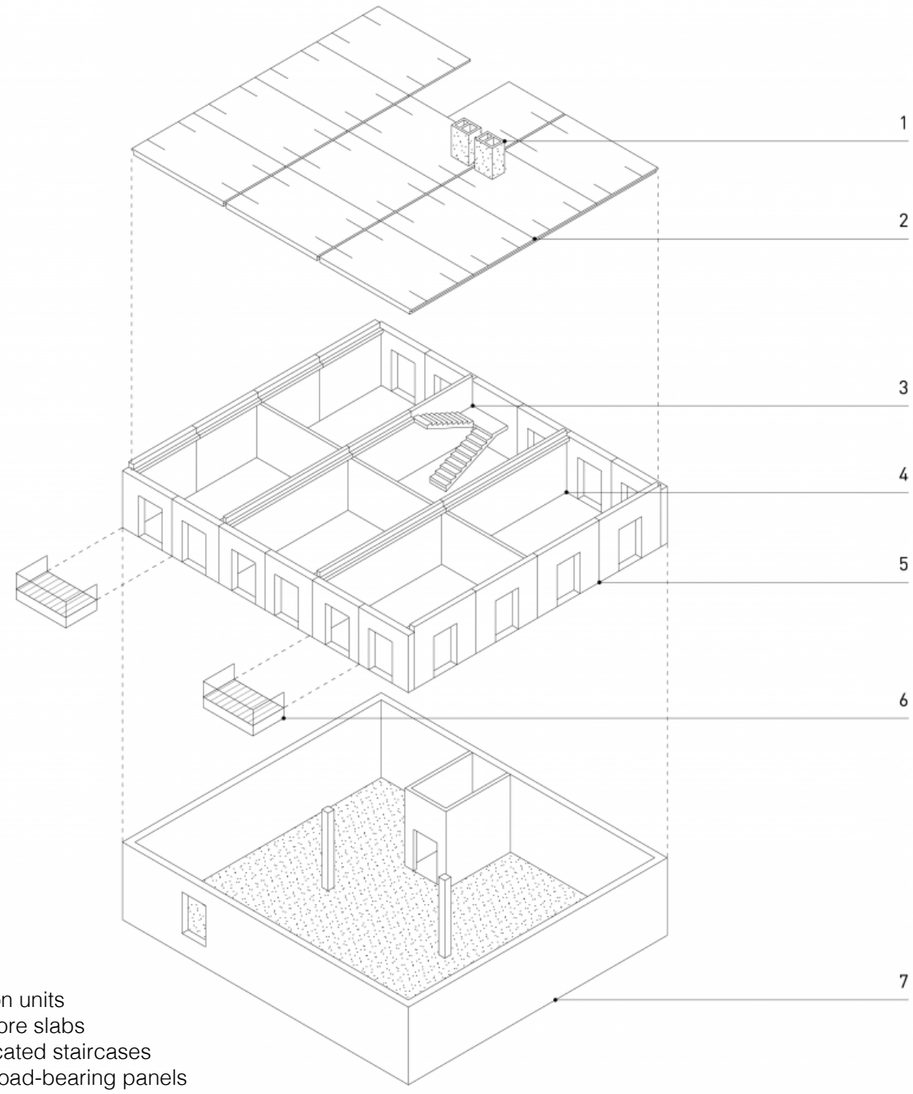
Insulation and building envelope upgrades: Improve energy efficiency and thermal comfort of existing structures.

- Exterior additions: Prefabricated balconies, staircases, and vertical circulation towers enhance accessibility and quality of life.
- Re-erection modules: Lightweight elements allow for rapid rebuilding of collapsed sections, easily assembled or disassembled as needed.
- Integrated bomb shelters: Protective modular units built into residential complexes ensure civilian safety and can serve community functions during peacetime.

Prefabrication is closely connected to modularity, and it focuses on industrial production of building elements. Its benefits include:

- Reduced construction time: factory product\ion and pre-integrated utility channels shorten on-site assembly.
- Consistent quality: controlled manufacturing ensures accuracy, durability, and compliance with seismic/ military-risk requirements.
- Reduced skilled labor needs: prefab assembly requires fewer highly qualified workers.
- High adaptability: components vary from whole building typologies to façade panels, window modules, balconies, and connection nodes.

Integrating modular and prefabricated systems into Ukraine's reconstruction process enables a shift from emergency rebuilding toward long-term urban transformation. These technologies make it possible to retrofit and extend the existing housing stock, accelerate reconstruction of destroyed buildings, and create sustainable, energy-efficient, and socially cohesive environments for the future. Important to mention, prefabrication technol- ogies are already being used in new house construction to quickly provide housing for Ukrainian refugees (Fig. 29-33).



1. ventilation units
2. hollow-core slabs
3. prefabricated staircases
4. internal load-bearing panels
5. external load-bearing panels
6. prefabricated reinforced concrete balconies
7. reinforced concrete cast-in-situ structures

Fig. 29, Building system scheme with using a prefab tecnology used for social housing in Lviv, Ukraine, Drozdov & Partners, Budova company
Source. Drozdov & Partners, https://drozdov-partners.com

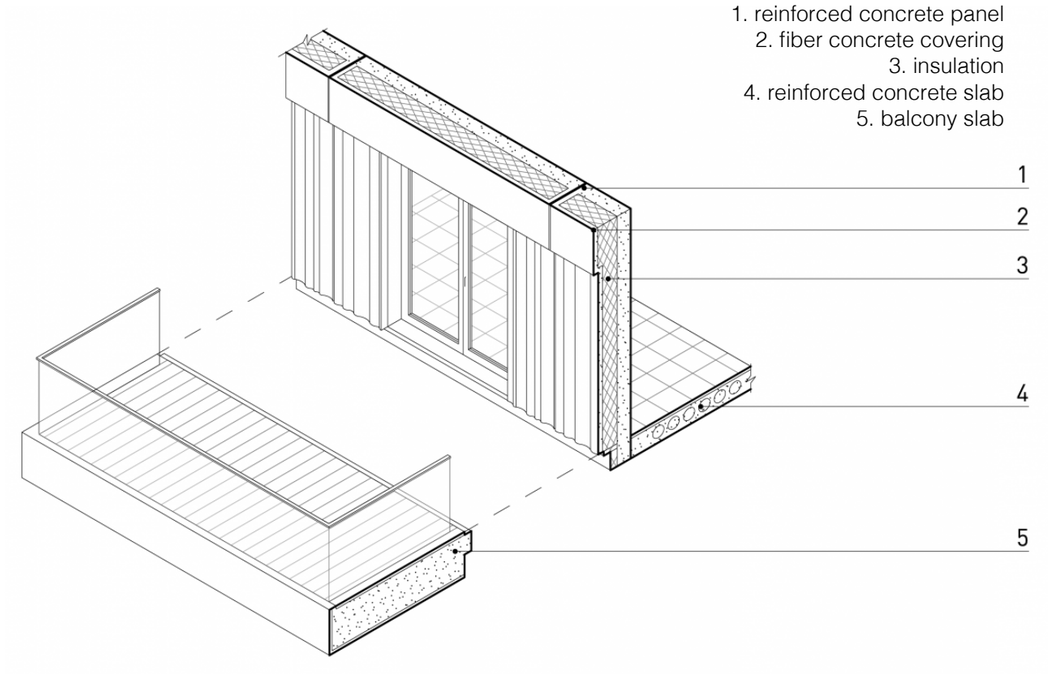
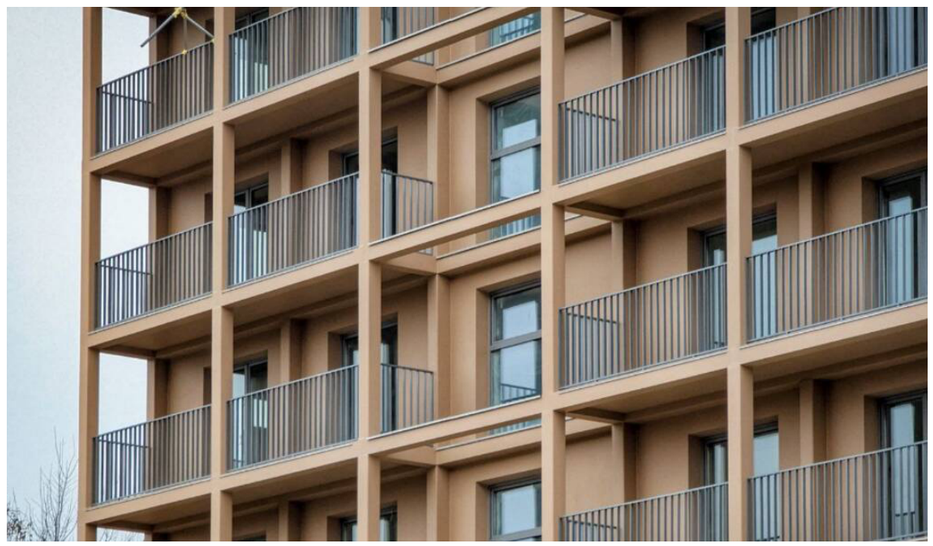


Fig. 30, Building system scheme with using a prefab tecnology used for social housing in Lviv, Ukraine, Drozdov & Partners, Budova company
Source. Drozdov & Partners, https://drozdov-partners.com

Fig. 31, Construction process of a social housing project in Lviv, the first pilot project of this format in Ukraine.
Source. Drozdov & Partners, https://drozdov-partners.com



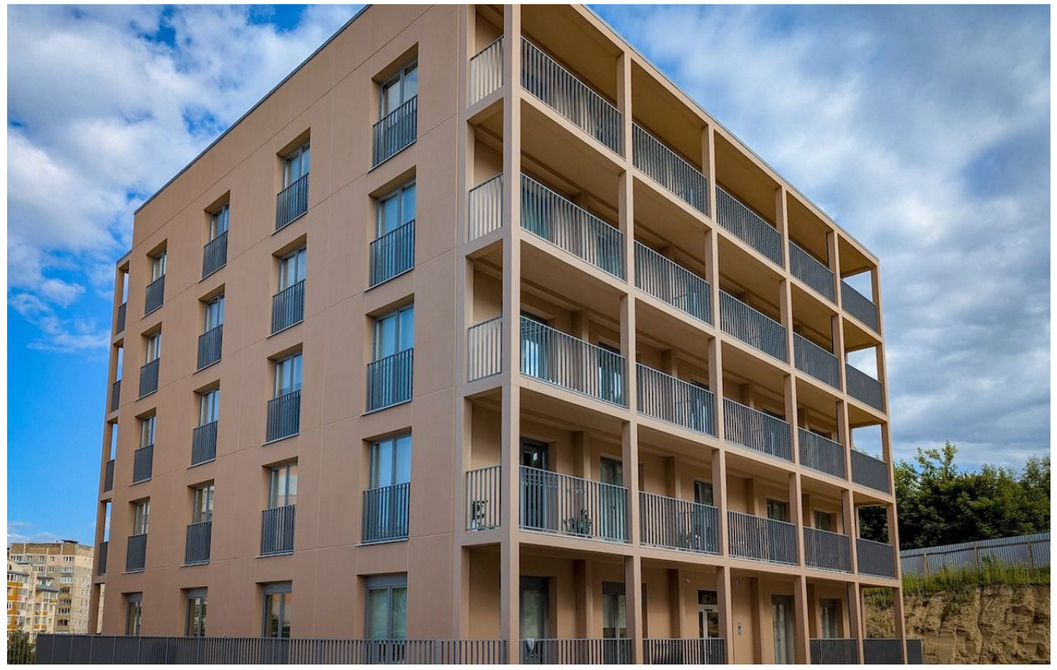


Fig. 32-33, A completed social housing project delivered in Lviv, Ukraine, Drozdov & Partners, Budova company
Source. Vladyslav Muravsky; NE:Urban

04

DESIGN PROPOSAL

Based on the analysis of the current housing situation in Ukraine, it becomes clear that post-war reconstruction must be understood not only as the physical restoration of buildings but as a broader adaptive process that integrates safety, sustainability, and community well-being. The vulnerability of the existing housing stock, combined with long-term demographic shifts, environmental threats, and the psychological impacts of war, reveals the need for new approaches that move beyond repairing the past. The residential typologies that dominate Ukrainian cities repetitive, standardised, and structurally similar (Fig.34-39), create both a challenge and an opportunity. Their wide presence across the country makes them a strategic foundation for scalable interventions. This means that a single architectural solution, if adaptable and modular, has the potential to be replicated across regions with different degrees of destruction, climatic conditions, and social needs.

The design proposal presented in this chapter builds on these findings. It aims to demonstrate how existing neighbourhoods can be transformed into safer, more resilient, and socially supportive environments through a combination of renovation, modular extensions, and the rethinking of common spaces. The project is conceived as a model of reconstruction that can evolve, expand, and adjust to both wartime constraints and long-term urban development goals.

34 37
35 38
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Fig. 34. Avdiïvka, Ukraine, 2023 *Photo: GETTY IMAGES*
Fig. 35. Odesa, Ukraine, 2024 *Photo: Dumska*
Fig. 36. Dnipro, Ukraine, 2023 *Photo: dp.informator.ua*
Fig. 37. Borodyanka, Ukraine, 2022 *Photo: Ales Ustinov*
Fig. 38. Kryvyï Rih, Ukraine, 2023 *Photo: Libkos*
Fig. 39. Kyiv, Ukraine, 2025 *Photo: Efrem Lukatsky*

THE RECONSTRUCTION STRATEGY

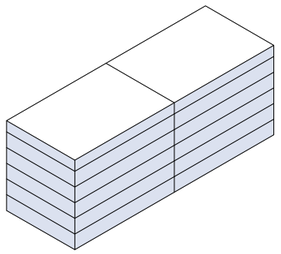
The reconstruction strategy is based on specific means, methods, and objectives for each building that is rebuilt or newly constructed. The destruction can be transformed into an opportunity, as it still requires intervention, giving us the chance to do better than before.

Since many of the damaged buildings share a similar repetitive structure, they can be grouped into three categories based on the way of the damage (Fig.41):
- First category: buildings composed of multiple blocks with damage to the first or last block.
- Second category: buildings composed of multiple blocks with damage to a middle block.
- Third category: buildings composed of multiple blocks with damage between two blocks.

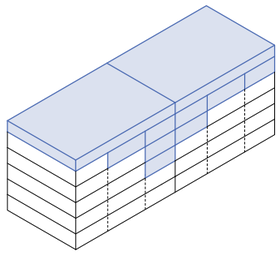
Within these three possible categories, the interventions can be classified into three subcategories (Fig.40):
- rehabilitation,
- reconstruction with repair of the existing structure
- new construction adjacent to the existing building.

All materials from the demolished structure should be recycled and reused wherever possible, the approach can be usud as in a table Fig.27-28.

rehabilitation



reconstruction with repair of the existing structure



new construction adjacent to the existing building

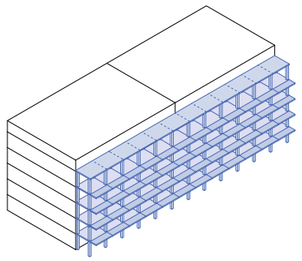


Fig. 40, Possible categories of interventions
Source. Self-elaboration

First category:**damage to the first or last block**

Second category: **damage to a middle block**

Third category: **damage between two blocks**

Fig. 41, Building destruction analysis
Source. Self-elaboration

Rehabilitation is applied to buildings that remain structurally stable and require primarily functional, thermal, or spatial improvements to meet contemporary standards.

Reconstruction with repair of the existing structure addresses cases where damage is more substantial: the structural frame can still be preserved but needs reinforcement, replacement of individual elements, or partial reconfiguration.

New construction adjacent to the existing building becomes the most transformative approach, used when the destroyed part cannot be restored and when an additional volume can improve spatial quality, density, or energy performance.This classification allows for a more adaptable reconstruction strategy, ensuring that interventions respond precisely to the condition of each building rather than applying a uniform solution. It also opens the possibility to integrate sustainable technologies, modular additions, and improved layouts directly into the renovation process. In this way, reconstruction is a chance to rethink the living environment, enhance resilience, and improve general well-being.

CASE STUDY

Kharkiv is the second largest city in Ukraine, and it stands out as an important industrial, historical, and cultural beacon for the country. Due to its proximity to Russia, at just 30 km from the city's centre, it has suffered immeasurable damages and losses as a consequence of the conflict.
Selecting Kharkiv as the case study is therefore not only a response to the scale of destruction but also to the city's strategic role in Ukraine's recovery. Its residential neighbourhoods represent a wide range of Soviet-era typologies that are repeated throughout the country, making it an ideal testing ground for a reconstruction model that can later be transferred to other regions. Moreover, the patterns of damage in Kharkiv clearly reflect the three categories identified in the reconstruction strategy, allowing the proposed intervention framework to be applied, compared, and evaluated in real conditions. Beyond these analytical and strategic reasons, my choice of this location also carries a personal dimension: many people I know come from Kharkiv. Understanding their stories and the profound impact the war has had on their everyday environments reinforces my motivation to work on a proposal that is not only methodologically sound but also emotionally grounded.
Within the Saltivka neighbourhood (Fig.42), North Saltivka is the most damaged part of the district and the closest to the Russian border, it has been selected to carry out this pilot intervention. The site encompasses various housing typologies and building uses with different degrees of destruction (Fig. xx), creating an opportunity for testing context-specific reconstruction solutions. This diversity allows the strategies developed for this particular location to be extended and adapted to other sites within Saltivka and the broader Kharkiv context. This scalability is one of the key strengths of the proposed housing pilot project. Additionally, this area has already been the subject of international interest, as it was examined in the Norman Foster Foundation's competition on housing reconstruction. Its inclusion in this broader discourse further underscores its relevance as a site for prototyping innovative, evidence-based approaches to post-war recovery.

Fig. 42, An aerial view of the Saltvka
Source. Google Earth

The urban structure of Kharkiv was formed in several historical stages, creating a heterogeneous and multi-layered urban fabric. The central areas retain compact perimeter development with continuous street fronts and high building density. Moving away from the centre, the urban fabric gradually opens up into large-scale residential developments from the Soviet period, where typical panel buildings are arranged in a free composition with large distances between blocks. This change in morphology creates a striking contrast between the historical density and the open structure of the peripheral microdistricts.

The spatial logic of the city is determined by the alternation of built-up areas and various types of voids. Planned voids include inner courtyards, green buffer zones, and public spaces integrated into residential areas. In contrast, unplanned voids consist of abandoned industrial areas, infrastructure gaps, and vacant lots that have arisen as a result of historical transformations. After 2022, a new category of spatial voids emerged: areas of destruction and disappeared buildings, most prevalent in the north-eastern part of the city (Nothern Saltivka).

In this study, the map (Fig.43) focuses on the flat projections of Kharkiv's buildings as a key layer for understanding the current state of the urban fabric. The distribution, density, and fragmentation of buildings reveal the basic morphological logic of the city, the contrast between the dense historical part and the open microdistricts, as well as spatial gaps.

Kharkiv's system of green areas forms an important ecological and spatial framework for the city, complementing and balancing its heterogeneous urban fabric. Green areas of various sizes, from large parks to local squares, are organised in the form of a network that permeates the city and provides ecological integrity, recreational opportunities and natural corridors for air movement.

An important part of this network is the agricultural areas that have historically formed on the outskirts of the city and within some residential areas. Private gardens, cottage communities, gardening cooperatives, and small farm plots create a mosaic of productive landscapes that complement the city's ecological system. During the war, these spaces have taken on new significance: as sources of local food production, places of temporary self-organisation, and sources of social and mental support.

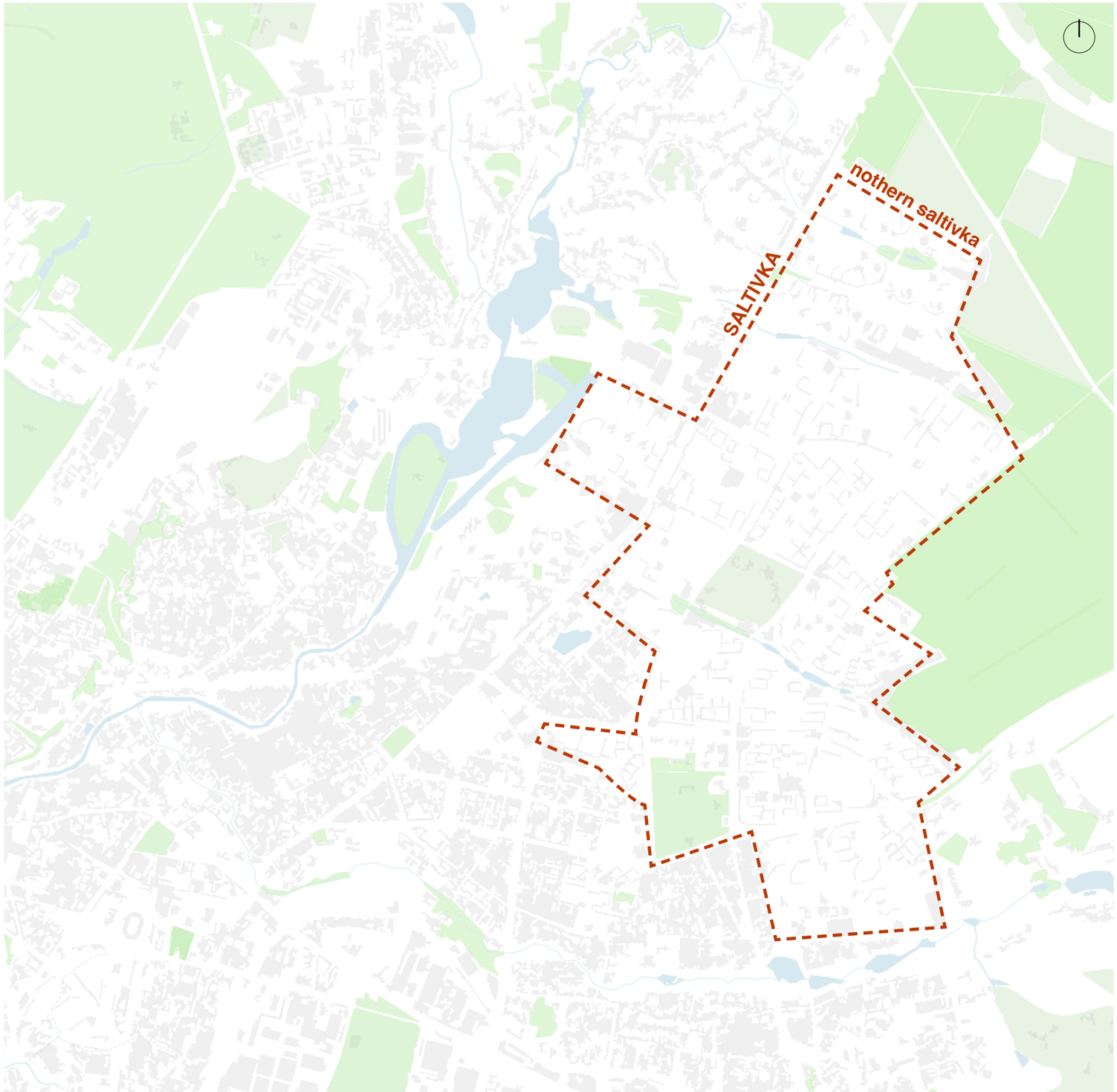


Fig. 43, Map of voids and green areas of Saltivka.
Source. Self elaboration based on google maps data

Saltivka is one of the largest residential areas in Kharkiv, formed in the 1980s in accordance with the principles of microdistrict planning. Its urban fabric is characterised by its large scale, open composition of residential buildings and clear functional organisation, which forms the unique morphology of the district.

The structure of the district is based on superblocks with free-standing 9-16-storey residential buildings, which are spaced far apart and oriented according to insolation and wind parameters (Fig.44). This model creates an open, airy development where buildings form not streets, but large courtyard spaces connected by a network of pedestrian walkways and green corridors. Morphologically, Northern Saltivka is characterised by low building density combined with very high population density, which is typical of late Soviet residential areas. The density of the area's buildings reflects a combination of the open spatial model of the microdistrict and a significant concentration of housing stock. Unlike the central districts of Kharkiv, where density is created by perimeter blocks, in Northern Saltivka it was formed due to the height and scale of residential buildings located on large plots with inter-quarter open spaces.

Green areas in Northern Saltivka play a fundamental role in shaping the ecological framework of the district. Inter-quarter spaces, green areas adjacent to buildings, and fragments of forest parks create a system of open spaces that compensates for the height of the buildings and provides recreational functions within walking distance. Branched green corridors connect the district with large natural areas in the north and with the city's green infrastructure, forming a coherent ecosystem.

At the same time, the peripheral areas of Northern Saltivka contain agricultural zones of agricultural land that form landscapes along the district's boundaries.

After 2022, Northern Saltivka suffered extensive destruction, which led to the emergence of a new morphology, a spatial fragmentation. Entire neighbourhoods with damaged (Fig.45) buildings turned into voids in the urban fabric, changing not only the physical but also the social and spatial connections of the district. The open nature of the development contributed to the scale of the damage, but at the same time, green spaces and large courtyards partially restrained the spread of destruction.

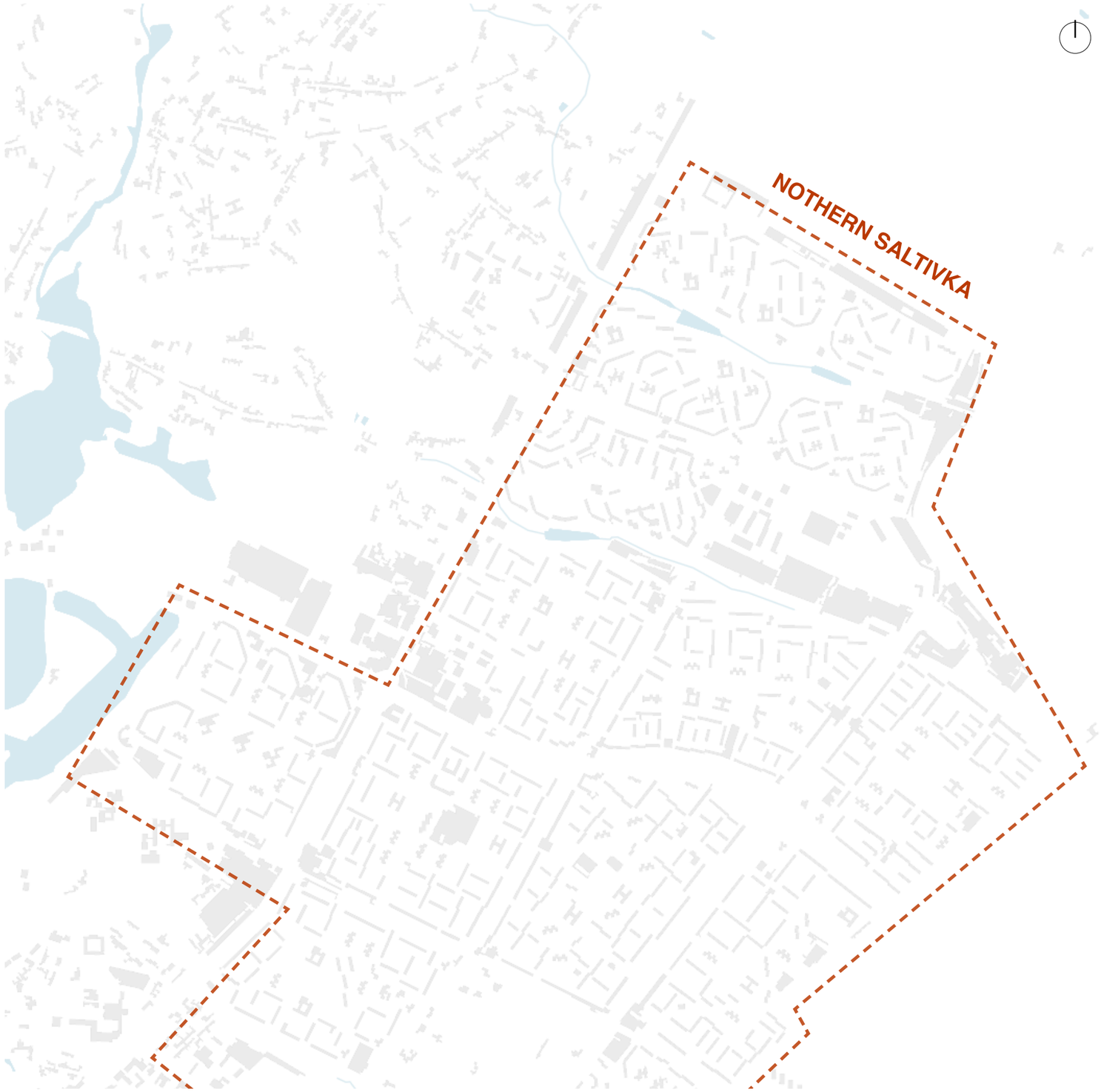


Fig. 44, Road network of Kharkiv, Ukraine
Source. Self elaboration based on google maps data

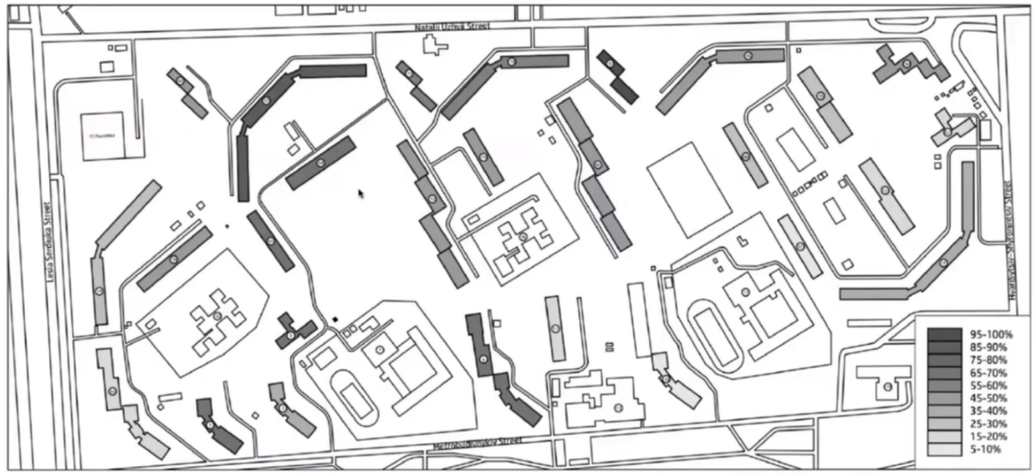


Fig. 45, Damages to the residential buildings in Northern Saltivka
Source. lecture of O. Kalmykov

Taking into consideration the condition of the Nothern Saltivka residential buildings, it becomes clear there is an there is an urgent need of renovation.

The residential building located at 82 Nataliia Uzhvii Street, Kharkiv, Ukraine, was selected to explore the reconstruction strategies mentioned in the previous chapter. In such a particular case the possibility to apply such direction as reconstruction of existing structure plus new construction adjacent to the existing building is under consideration.

Rationale for building selection

This particular building is chosen because it exemplifies the challenges and opportunities of reconstructing mass housing in Kharkiv. Its structural characteristics, repetitive typology, and position within a heavily damaged district (Fig. 45) make it ideal for testing the proposed design strategy. The building represents a broader category of Soviet residential blocks that appear across Ukraine, meaning that the solutions developed here can be scaled and adapted to similar structures nationwide. The building at 82 Nataliya Uzhviy Street reflects all the key features of this typology: modularity, seriality and structural economy, which allowed large housing estates to be built quickly. This building forms part of Kharkiv's Soviet-era architectural heritage; it is a type of project developed in 1980 and was replicated in 1984-1990. Specifically, the building belongs to the 162 series, a mass-produced housing typology originally developed in Kharkiv and widely implemented across the region.
The building is situated within a densely populated residential district inside the planned urban structure of North Saltivka. Surrounded by similar blocks, it forms part of a coherent neighbourhood fabric shaped by repetitive mass housing ensembles. The urban layout ensures direct access to public services, green areas, and community infrastructure (a characteristic feature of Soviet neighbourhood planning). Its position on the edge of North Saltivka also makes it a representative interface between severely damaged zones and areas with partial preservation.

Functional and architectural characteristics

The building was designed to accommodate the mass demand for housing through compact apartment units with efficient internal layouts (Fig.47-48). It consists of two identical, repeating blocks, producing a symmetrical and regular architectural composition. Each block contains sixteen residential storeys, reflecting the high-density approach characteristic of large Soviet housing districts.
The structure is defined by a functional and economically driven architectural language. It is rectangular in shape, built using a prefabricated panel system with minimal decorative elements (Fig.46). The building employs a load-bearing wall system constructed from transverse reinforced-concrete panels. These panels extend along the building's length, ensuring stability and structural rigidity. The stairwell walls are also prefabricated panels, functioning as additional load-bearing elements that support the vertical structural axis. The external façades, likewise made of prefabricated panels, create a uniform and homogeneous appearance typical of the series.

Enerrgy efficiency

According to data from the Kharkiv Housing Challenge competition (2024), the existing building structures demonstrate the following performance characteristics. The thermal envelope of the exterior walls currently achieves U-values in the range of 0.7–1.1 W/m²K, which accounts for approximately 50% of the total heating energy demand. Existing windows, typically plastic or timber frames with double glazing, perform at U-values of around 2.7–3.0 W/m²K, contributing to roughly 35% of current heat losses. The thermal properties of the flat roofs and floor slabs range from 0.6–1.0 W/m²K, representing the remaining 15% of the heating energy demand.

State of preservation and degree of damage

The state of preservation of the building is uneven and causes concern primarily due to the significant damage to one of its blocks caused by a rocket strike (Fig.49-50). A significant part of this block has collapsed (Fig.48), which calls into question the possibility of its com-

Fig. 46, Damages to the residential buildings in Northern Saltivka
Source. lecture of O. Kalmykov

plete restoration and would require deep structural intervention, including the reinforcement of load-bearing elements. This type of damage corresponds to the third category in the reconstruction strategy, cases where part of the building cannot be effectively repaired and requires new construction, located next to or in place of the destroyed part.
The other blocks of the building did not suffer significant damage. Given the age of the building and the materials typical of the 162 series, they need modernisation rather than restoration. Work on the undamaged sections will focus on improving energy efficiency: additional insulation of external walls, replacement of outdated windows with high-efficiency models, and modernisation of heating and ventilation systems, which will reduce heat loss and operating costs.

Aesthetic and architectural characteristics

The aesthetics of the building clearly reflect the principles of Soviet functionalism, such as restraint of form, rationality, and lack of ornamentation. The facades are made of concrete panels, creating a monotonous but uniform surface. The evenly spaced rectangular windows reinforce the regularity of the composition. The protruding stairwells create relief and make it easy to identify individual sections of the building, adding a slight visual contrast within the overall economical architecture.

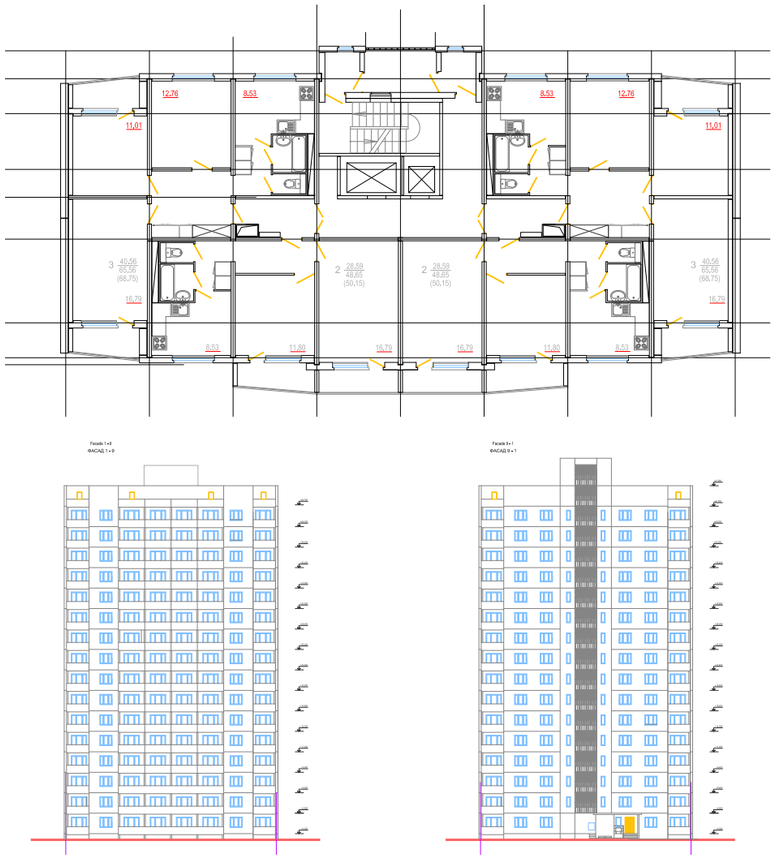


Fig. 47-48, Plan and facade of residential building at 82 Nataliia Uzhvii Street, Kharkiv, Ukraine.
Source. self eleboration based on data from Norman Forster competion

Fig. 49-50, Damages to the residential building 82 Nataliia Uzhvii Street. block 2
Source. lecture of O. Kalmykov

EXPLORING THE SOLUTIONS FOR INTERVENTION

It is important that the proposed solutions for interventions can be applied not only to a specific building or area, but are flexible enough to be adapted to other similar conditions. This allows the developed strategy to be transferred to different urban situations and scaled up to the broader context of Ukraine's post-war reconstruction.
Before determining the solution for the building itself, it is important to consider the spatial and social context in which it is located. In the case of the building at 82 Nataliya Uzhviy Street, it located on the edge of Northern Saltivka, is one of the tallest buildings in the area, and is directly adjacent to a large open area of agricultural fields. This location makes it not just a residential building, but a kind of "transition point" between dense development and open landscape.

Intervention strategy for the territory

Chosen approach is suggest interventions to remain minimal during the rapid response period, although at the same time to form the basis for the long-term development of the territory. Where even temporary or limited changes serve as the first step in a larger transformation of the area.
The environment determines how effectively a community can recover: architecture not only rebuilds physical structures, but also restores connections between people and the environment in which they live (Fig.51).

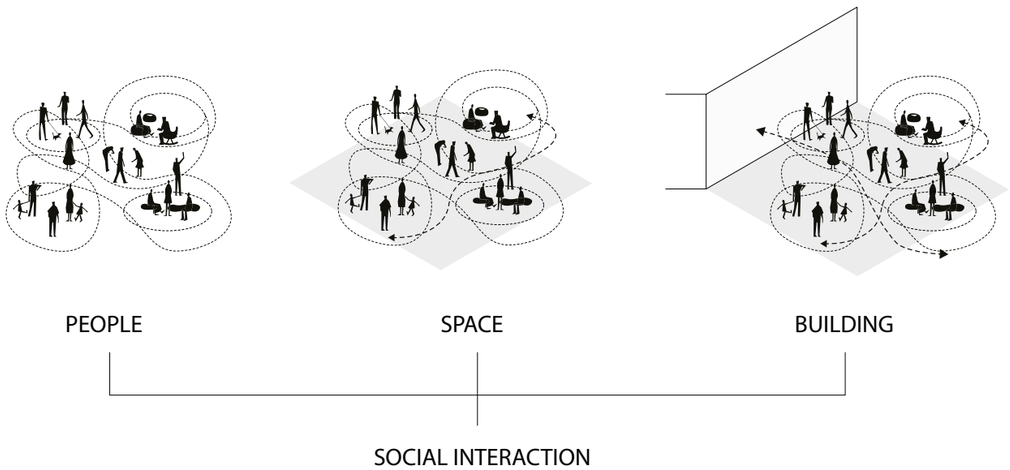


Fig. 51, Acts of recovery
Source. self elaboration

Microclimate and social anchoring

One of the key elements of territorial intervention is the use of water-permeable and water-active surfaces that function as a microclimatic tool. Such elements reduce the temperature in the summer, create local cooling zones, and make the space more comfortable to be in. At the same time, it functions as social anchors, forming a natural point of attraction where people can gather, interact, and spend time together.
The social aspect is particularly important in a post-war context: as the results of the needs analysis have shown, the restoration of social ties and the return of community is a key factor in the psychosocial recovery of residents.

Recycled elements

Another possible solution is the use of multifunctional elements made from materials obtained from the demolition of damaged buildings, in particular recycled concrete. This underline the importance of the circular use of resources in post-war reconstruction, and combines environmental friendliness with practical functionality.
Such elements can serve as urban furniture, help shape spatial boundaries and pedestrian routes, function as places for informal meetings, and at the same time serve as reminders of the material memory of the territory. Due to their flexibility and modularity, they can be easily adapted to different scenarios of use.

Vegetation and Green Infrastructure

Expanding green infrastructure is another key area of territorial intervention. Such solutions may include urban forests, biodiversity corridors, and other green spaces that can create shaded areas for recreation, provide natural noise barriers, and improve air quality.
Increasing the amount of greenery performs several critical functions:
- natural cooling of the territory;
- creation of a comfortable and safe microclimate;
- support for the emotional recovery of residents;
- creation of an attractive environment for daily use.

In addition, an extensive green network ensures the ecological continuity of the area, which is especially important for territories located on the border between urban development and open landscape. Increasing the amount of greenery works as a natural way to cool the area and create a comfortable microclimate. It creates a sense of security and tranquility, promotes the emotional recovery of residents, and makes the space attractive for everyday use.

The proposed territorial interventions demonstrate how minimal actions can initiate a broader and more sustainable urban transformation. By prioritising adaptable strategies that can be transferred beyond a single building or neighbourhood, the project establishes a framework that is applicable to other damaged areas and, ultimately, to the wider context of Ukraine's post-war reconstruction.
In the case of 82 Nataliya Uzhviy Street, the specificity of its location, positioned at the threshold between dense urban development and an open landscape, makes the site particularly responsive to interventions that reinforce the relationship between people, buildings, and their environment. Even minimal actions implemented during the rapid response phase are conceived as the first step toward a long-term vision for the territory.
The effective recovery requires more than rebuilding structures: it demands the reactivation of social life, the restoration of everyday routines, and the creation of spaces that support emotional well-being. Microclimatic improvements, recycled-material urban elements, and expanded green infrastructure collectively form a resilient system that responds to environmental, social, and psychological needs.
Overall, the intervention approach shows a crucial principle: post-war reconstruction must balance urgency with foresight. By integrating adaptability, circular material use, and ecological continuity, the proposed strategy addresses the immediate needs of residents but also lays the groundwork for a sustainable, and future-oriented urban recovery.

Functional redistribution and conceptual framework for a building

The next stage of the solutions focuses on developing an intervention strategy for a building that can be applied not only to the selected case study but also adapted to other damaged buildings within the broader context of Ukrainian post-war reconstruction. At the same time, this chapter examines the specific architectural and spatial interventions proposed for Building 82 on Nataliia Uzhvii Street, using it as a detailed example of how the general framework can be implemented in practice. Through this dual perspective (both universal and site-specific) the intervention strategy seeks to illustrate how designed solutions can support resilient recovery, improve living conditions, and contribute to long-term urban renewal.

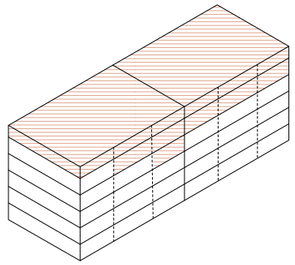
The studied building consists of two linear blocks, one of which was severely damaged by a missile strike what corespond to a first category of damage classification presented in this chapter. In line with the reconstruction strategy developed for the general urban context, the intervention for this building is articulated in three interconnected parts, each corresponding to one of the acts in the spatial performance of recovery: defining, healing, and enhancement (Fig.52) based on .

1. The preserved block represents the part of the building that remained structurally intact during the war. This section will be repaired, upgraded, and continue to function as residential housing.
2. The damaged block (where a substantial part collapsed) will be reconstructed, preserving all salvageable structural elements and recycling the damaged ones as part of the material recovery process.
3. The new extensions, added to the facades of the building, will complete the linear composition and provide extension residential units and communal spaces.

This transformation mirrors the conceptual framework of the project: the building itself embodies the journey from destruction to renewal,

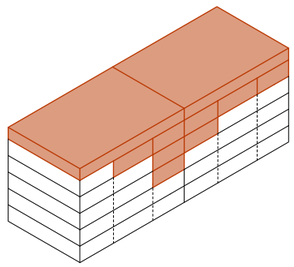
ACT I

DEFINING



ACT II

HEALING



ACT III

ENHANCEMENT

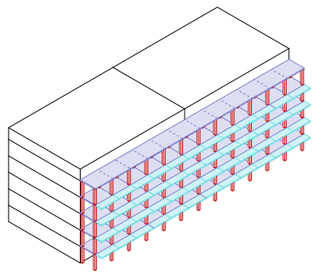


Fig. 52, Acts of recovery
Source. self elaboration

while its extension opens new possibilities for spatial quality, mental well-being, and community reconnection.

Thus, the proposed strategy can be applied to most damaged buildings. At the same time, its implementation depends on the actual technical condition of each object, since a preliminary assessment of structures is key to determining possible intervention scenarios. If a building cannot be restored due to the critical level of damage, materials from dismantled structures can be sorted and reused within local reconstruction cycles.

ACT I DEFINING

Before any architectural intervention can proceed, each damaged building must undergo a rigorous structural and technical assessment. This initial analytical phase is essential for determining the degree of destruction, identifying the integrity of load-bearing elements, and evaluating whether the structure can be safely preserved, partially restored, or must be entirely rebuilt.

In the case of the analysed building on Nataliia Uzhvii Street, 82, the project assumes that a significant portion of the structure can be preserved. The intact block remains structurally sound, while part of the damaged block can be stabilised and reintegrated after demolition of irreparable elements.

ACT II HEALING

Reconstruction of the existing structure
This act focuses on stabilising and upgrading all structurally preserved parts of the building, including both the intact section and the remaining fragments of the damaged block. The aim is to redefine the architectural foundation of the building and prepare it for further transformation.

Accessibility and energy performance
The reconstruction of the existing structure prioritises inclusivity and building performance. Key measures include:

ensuring full accessibility for people with reduced mobility through the introduction of ramps, accessible circulation routes, and upgraded vertical transport;
significantly improving energy efficiency by adding high-performance thermal insulation to exterior walls;
replacing outdated window systems with low-U-value, high-performance glazing;
upgrading heating, cooling and ventilation systems to reduce energy consumption and improve interior comfort. (Fig.53)
These measures bring the building into alignment with contemporary standards, reduce long-term operational costs for residents (a crucial factor in the Ukrainian socio-economic context).

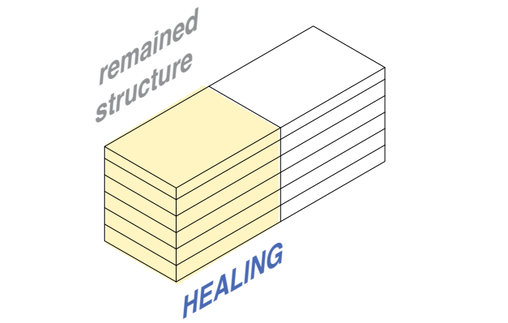


Fig. 53, Improving performance of the building
Source. Self elaboration

Reconstruction of the damaged block

Structural and Functional Reconfiguration
Given the extent of destruction, the damaged block requires a new structural system. Instead of restoring the old panel-wall structure, the reconstruction will use:
- a column-and-slab system for higher adaptability
- prefabricated façade panels incorporating natural materials, particularly timber, to improve thermal performance and add warmth to the architectural expression

Functional reprogramming
The reconstructed volume becomes more than housing. Its new configuration allows for:
- therapy centre supporting post-war mental recovery
- a coworking space (in collaboration with local NGOs and nearby schools)
- a public café and a multi-purpose hall at the ground floor

These functions activate the building socially and make it a destination rather than a passive residential block (Fig.55).
This new civic movement helps draw people back into the district, creating opportunities for interaction, support, and community rebuilding.

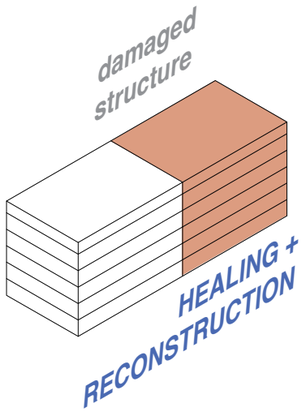


Fig. 54, Improving performance of the damaged block
Source. Self elaboration

Approaches to dealing with the destroyed structure
Four options were considered:
- complete removal of the damaged block,
- partial removal depending on load-bearing capacity,
- preservation of lower floors if only upper levels are destroyed,
- intentional conservation of fragments as memorial elements.

The chosen approach combines structural renewal with symbolic presence, allowing architecture to acknowledge loss while creating space for healing.

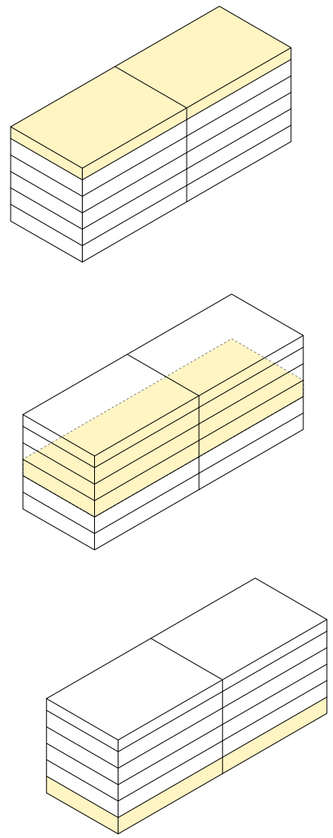


Fig. 55, Possible public floors localisation
Source. self elaboration

ACT III ENHANCEMENT

New Construction
As part of the new construction adjacent to the existing building strategy, extensions at both ends introduce:
winter gardens, what can increase usable residential area, create visual and physical links to greenery, offer protected microclimates that improve mental well-being and function as flexible living spaces or shared gardens. This strategy is widely used by Lacaton and Vassal architects.

Additional residential units
The extensions expand the building's housing capacity, providing adaptable and contemporary layouts. The communal floors could be introduced. Certain levels are dedicated to: recreation, everyday shared activities or/and cultural and leisure functions
These "community layers" increase vertical social interaction, distributing public life throughout the building.

Dual-use shelter design
The ground-floor shelter will be designed for double purpose: to provide safety during emergencies and to serve as a recreational or communal space during peaceful times.

Proposed solutions (Fig.56) presents a range of tools that can enhance the performance, flexibility, and spatial quality of housing in Ukraine. These include façade extensions, modular add-ons, winter gardens, communal layers, and structural upgrades which aim to improve energy efficiency, living comfort, and community interaction. However, not all proposed interventions can be fully applied to the analysed case study. Nevertheless, it is important to acknowledge these solutions within the research. They illustrate the spectrum of architectural possibilities and demonstrate adaptability for other buildings with different structural conditions. In this way, the intervention framework remains both flexible and scalable, capable of responding to the diverse realities of Ukraine's damaged housing stock.

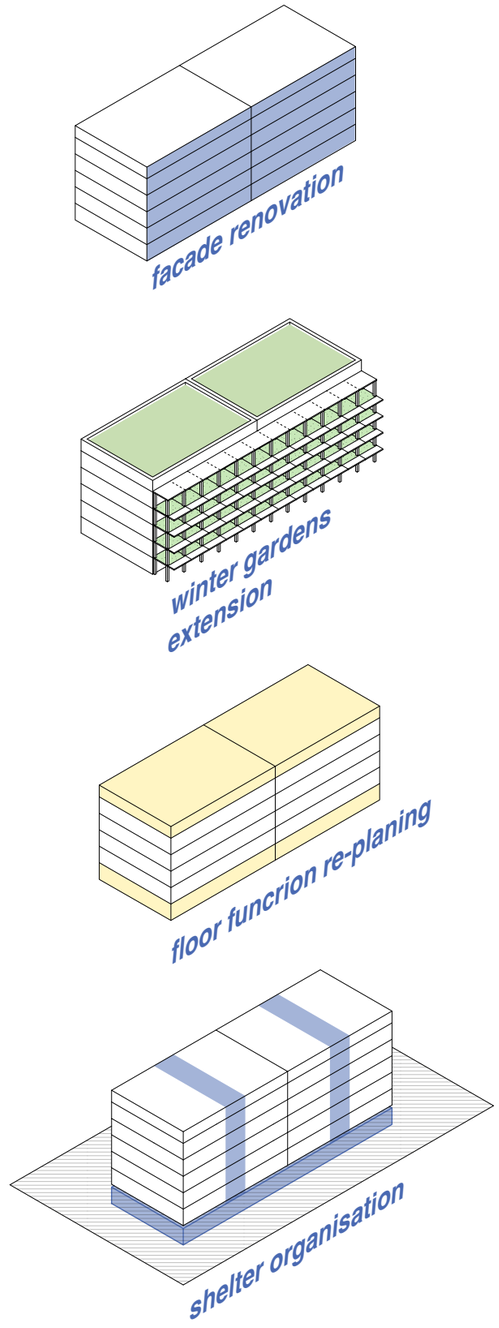


Fig.56, Possible intervention and extension
Source. self elaboration

APPLIED SOLUTIONS

This section is devoted to the development and justification of applied solutions integrated into the case study, which meet the modern requirements of sustainable urban development and the context of post-war reconstruction. The main goal is to create a sustainable, functional, and inclusive public space capable of effectively resisting environmental challenges and social tensions.
The proposed architectural, planning, and landscaping interventions are designed as a comprehensive response to a community resilience in Ukraine: the environmental challenges and social needs of the urban environment. The integration of sustainable materials, such as recycled concrete and wood, serves as the foundation for environmental sustainability. At the same time, special attention is paid to improving microclimatic conditions, for example, through the creation of urban gardens. From a social point of view, each solution aims to strengthen social interaction and foster a sense of community.

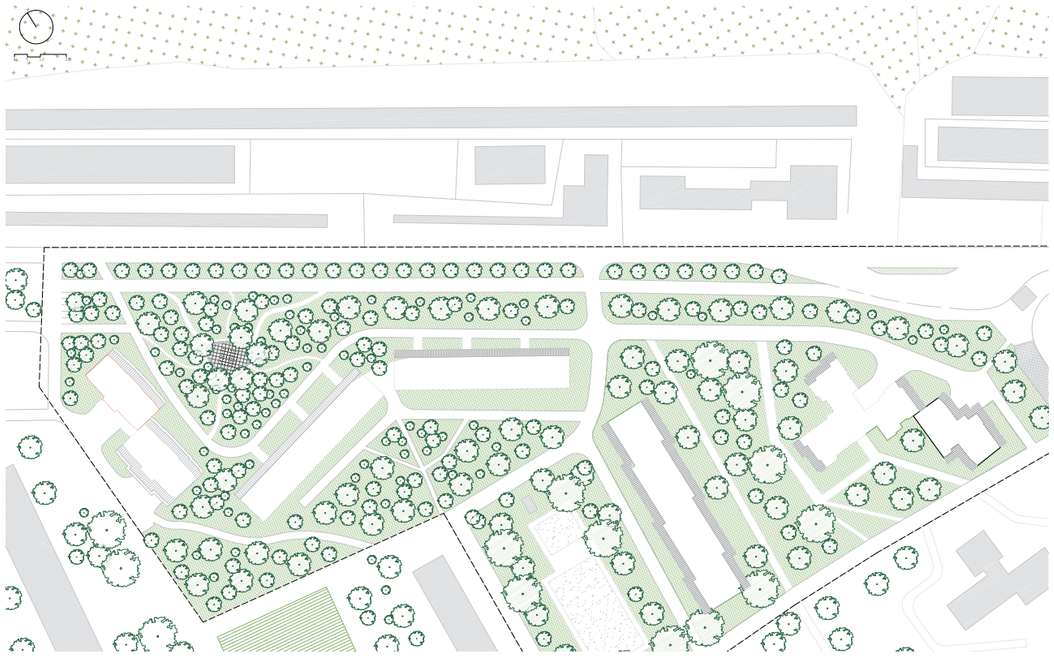


Fig. 57, Masterplan
Source. Self elaboration

The master plan (Fig.57) was developed using the principle of minimal intervention, aimed at enhancing the existing qualities of the space and creating an environment focused on community well-being. The strategy involves delicate work with the territory, where small but targeted interventions create conditions for social interaction, environmental stability, and emotional recovery of residents.

A key element in the organization of the space is a “dry” fountain (Fig.58), which serves as the central anchor of the public square (Fig.59) .It provides a comfortable microclimate, becomes a natural meeting point, and functions as a symbolic element of collective memory, shaping the identity of the renewed territory.
The space uses modular elements made of recycled reinforced concrete, emphasizing the idea of circular use of materials. These blocks perform several functions at once: serve as seating areas; form a sequence of spatial accents; create informal meeting points; emphasize the ecological

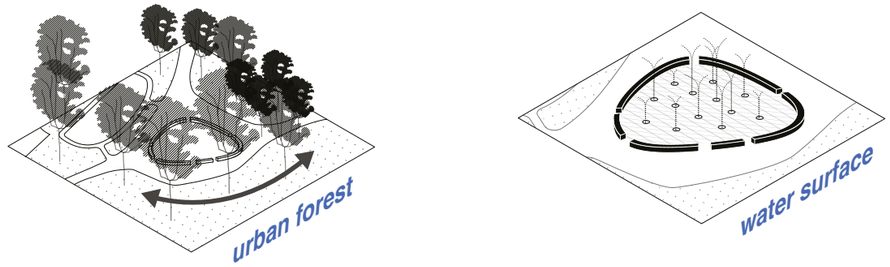


Fig. 58, Solutions for the area
Source. self elaboration

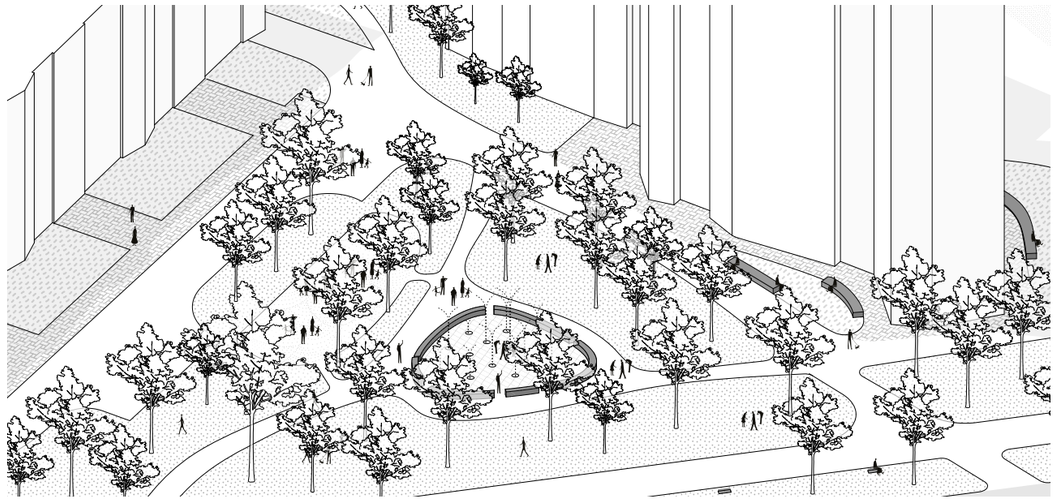


Fig. 59, Schematic view of the territory of case study
Source. Self elaboration

The renovation of a residential building that has suffered rocket damage requires a comprehensive and phased approach. The first step is to conduct a detailed engineering assessment of the condition of the structures, which will allow the level of damage, residual load-bearing capacity, and the possibility of further use of the preserved elements to be determined.
The proposed intervention strategy (Fig.60) is based on the principles of community resilience, circular renovation, and a safe and healthy living environment. Along with the technical restoration of the building, a system of winter gardens (see Fig. 62-63) will be integrated, improving energy efficiency and social interaction among residents.
Stage 1. Reinforcement and energy efficiency improvement of the preserved part
The first stage involves the modernization of preserved structural elements. Since the exterior walls of the building are made of panels (see Annex 2, Tabula tool), which are characterized by a low thermal insulation coefficient (U-value), their thermal modernization is a priority task.
This stage includes:
- reinforcement of panel joints,
- improvement of the thermal insulation characteristics of the shell,
- restoration of damaged engineering systems.

These measures ensure a basic level of safety, energy efficiency, and comfort in the dwelling.
Stage 2. Restoration of the destroyed part and creation of a common floor
The next step is the reconstruction of the destroyed part of the building. The project involves the integration of a common public level located between the existing structure and the new structural block.
This element performs several functions simultaneously:
- acts as a buffer zone, ensuring structural and microclimatic stability;
- creates space for social interaction, supporting the psychological stability of the community;
- serves as a memorial dedicated to residents who suffered during the rocket attack, integrating memory into the daily experience of living.

Stage 3. Additional structures: winter gardens as an autonomous system
The third stage involves the installation of additional structures — winter gardens mounted on separate prefabricated columns that do not create an additional load on the existing building.
Wintergardens could:
- improve thermal insulation and accumulate solar heat,
  create additional semi-public spaces for residents,
  form green microclimatic chambers that promote emotional recovery and social cohesion.

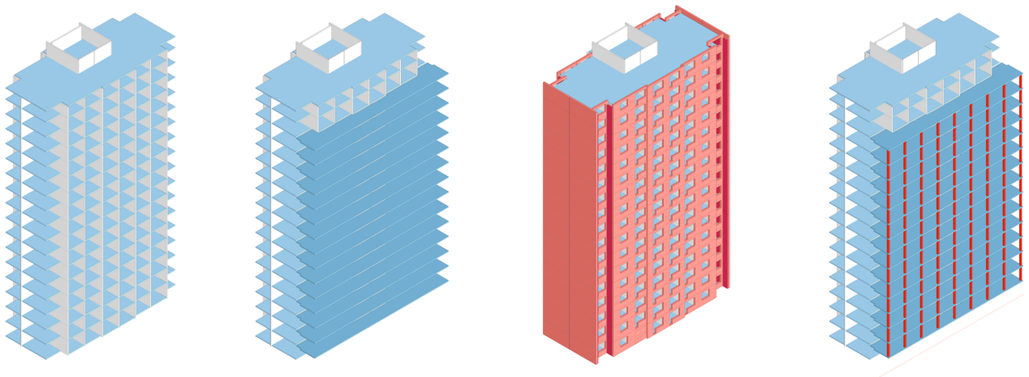
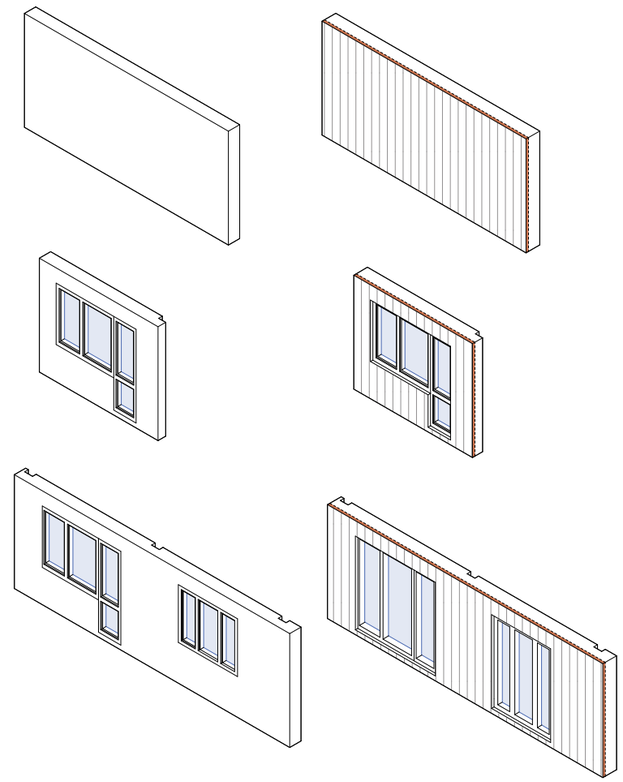


Fig. 60, Building strategie implementation, example of of the buiilding 82 Nataliia Uzhvii Street, Kharkiv, Ukraine.
Source. Self elaboration



According to the Tabula Web Tool, the thermal performance of the existing concrete wall panels can be significantly improved. The U-value of these elements, which typically ranges between 0.7–1.1 W/m²K, can be reduced to 0.30–0.19 W/m²K after renovation measures are applied (see Annex 2).

Fig. 61, Improvment insulation in walls and windows enlarging.
Source. Self elaboration

Integration of winter gardens into the renovation of a residential building

During the renovation, it was important to preserve as much of the existing layout as possible due to structural constraints, but the typical apartments presented are quite compact. This is how the idea of using winter gardens as a way to improve the quality of living without redesigning came about.
The diagram (Fig. 63) shows the application of the concept to a typical residential floor plan shows how winter gardens “wrap” the building from the outside, acting as an additional layer that does not change the internal logic of the layout. Winter gardens are located around the perimeter of the facade as autonomous volumes supported by separate prefabricated columns. This allows to avoid loading the existing structure and at the same time create a light, transparent extension of the living space. This approach integrates well with small apartments, which, thanks to winter gardens, gain additional micro-space without physical intervention inside.
What is the benefits of winter gardens here:
- Improved microclimate. These spaces create a natural buffer zone between the apartment and the street, which helps reduce heat loss and increases energy efficiency.
- More usable space without remodeling. For small apartments, even a few extra square meters can significantly change the quality of life. Winter gardens become a space for relaxation,

work, or a green corner.
- Psychological stability. Life after the trauma of war requires not only the physical restoration of buildings, but also the restoration of the inner comfort of residents. A green quiet zone, even a small one, has a strong therapeutic effect.
- Autonomy of construction. Since winter gardens do not interfere with the load-bearing structure, they can be implemented quickly and with minimal risk to residents.

Winter gardens naturally complement the idea of “minimal intervention” in the building. They allow you to modernize living space without changing the structure of apartments and increasing living space (Fig.62). This approach is widely used in renovation projects (e.g. Transformation of 530 dwellings by Lacaton & Vassal, Frédéric Druot, Christophe Hutin architecture).

During the design process, it was important to understand how the proposed extension in the form of winter gardens interacts with natural sunlight. The diagram (Fig. 64) shows that the new building envelope does not conflict with insolation requirements. On the contrary, it creates more balanced lighting and microclimatic conditions.
In summer, when the sun is high and the light falls almost vertically, the transparent volume of

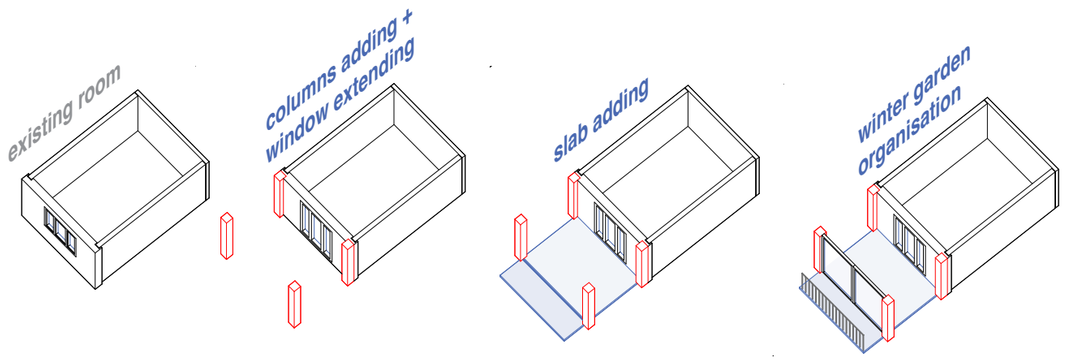


Fig. 62, Room improvment process
Source. Self elaboration

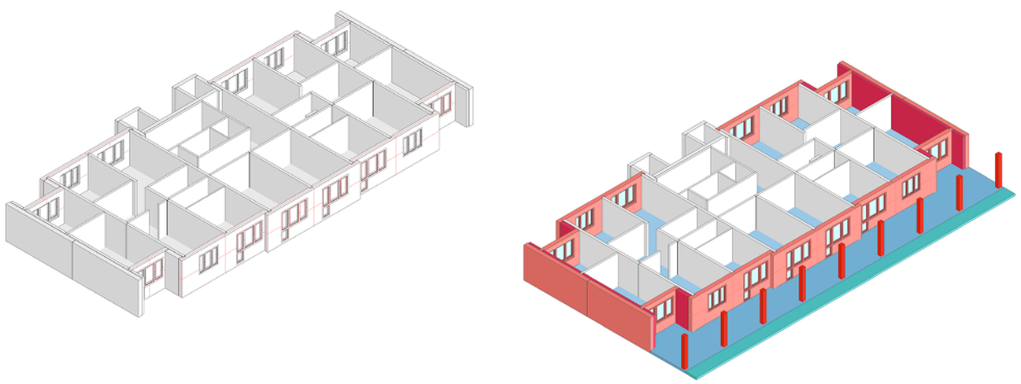


Fig. 63, Extention application on a typical floor.
Source. Self elaboration

the winter garden acts as a natural protective layer. Its protrusion creates soft shading, which reduces the risk of overheating of living spaces but does not interfere with uniform daylighting. In winter, the situation is completely different: due to the low angle of the sun’s rays, light easily penetrates inside, enveloping both the winter garden and the interior spaces of the apartment. Thanks to this, the building receives additional solar heat during the coldest period of the year, and the transparent buffer zone reduces heat loss, stabilizing the internal microclimate.
This combination of spatial form and natural climatic characteristics allows the winter garden to function as a passive temperature moderator. It does not violate insolation requirements but, on the contrary, enhances their effect, creating an environment in which heat and light interact with the architecture in a coordinated and harmonious manner. Thanks to this, the extension becomes not just an additional space, but an important element of sustainable renovation, which at the same time provides energy efficiency, visual lightness, and improved comfort for residents.

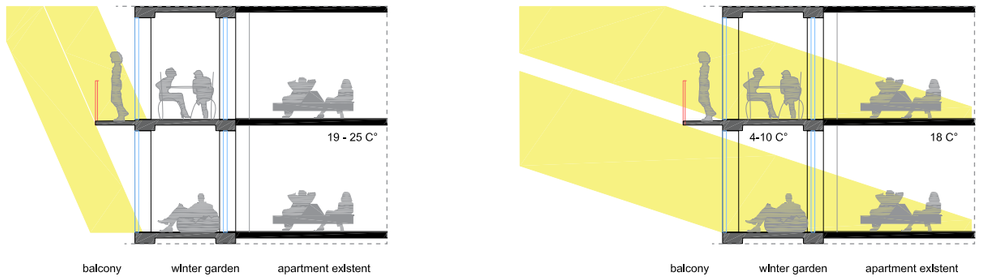


Fig. 64, Solar study of extention
Source. Self elaboration

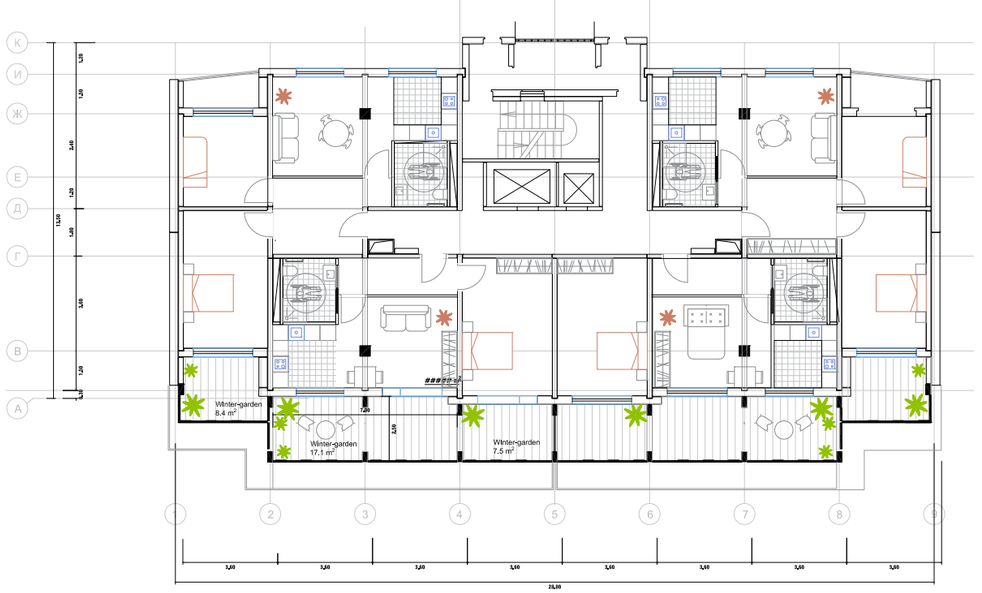


Fig. 65, Typical floor plan scheme
Source. Self elaboration

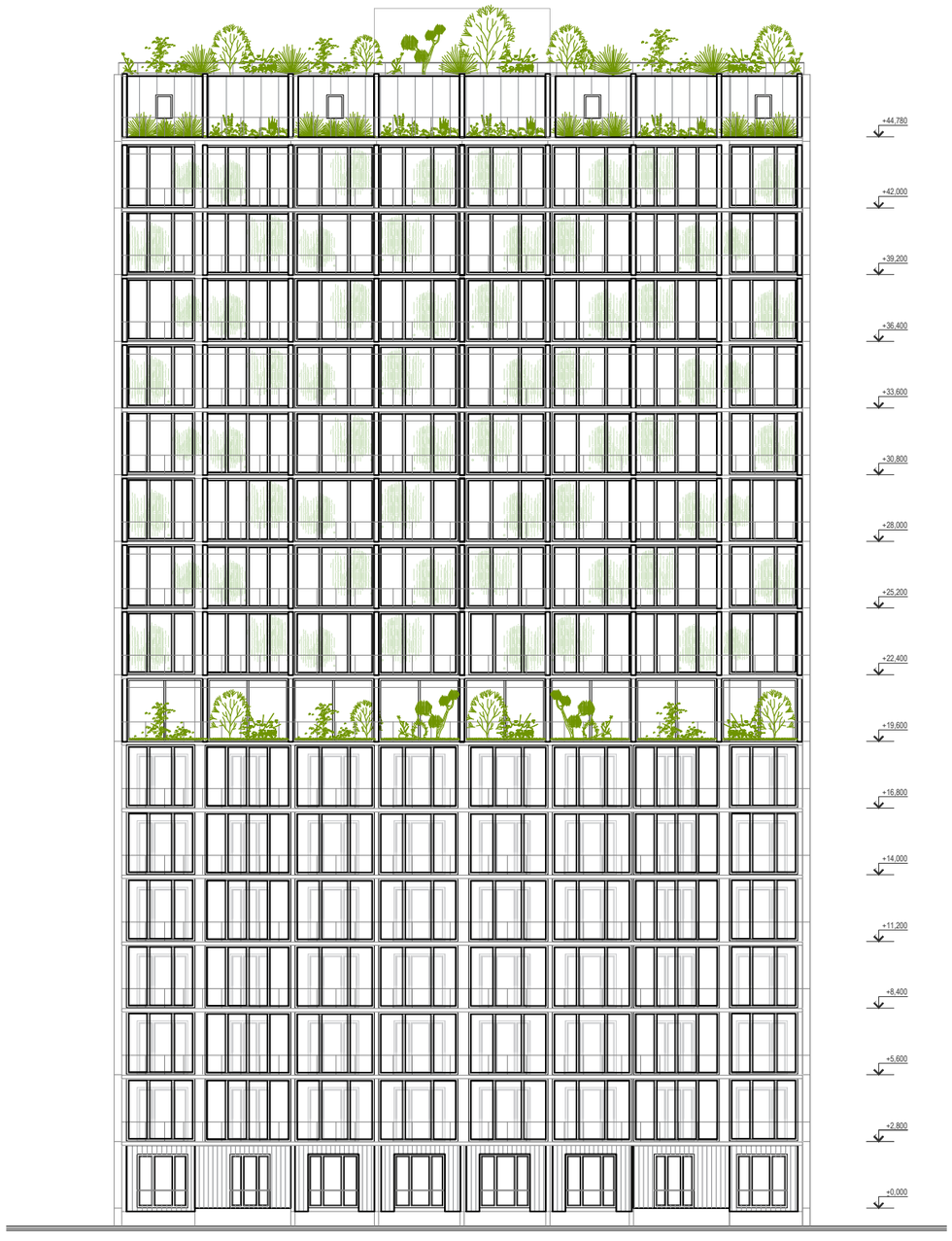


Fig. 66, Facade scheme
Source. Self elaboration

The restored building (Fig.65-67) has a renewed vertical structure for public distribution. The ground floor is dedicated to public functions and designed to establish an active connection between the building and the surrounding area, creating an open and accessible space for interaction.
Further vertical division occurs at the level where the remained part of the structure meets the new extension. This floor is conceived as a space of collective memory,a memorial that recalls the event that changed the lives of the residents. At the same time, it serves as a recreational environment: a place where residents can communicate, interact, relax, and find mental balance after a traumatic experience. This combination of memorial and social dimensions forms an important element of the concept of community resilience, making the space functional and therapeutic.

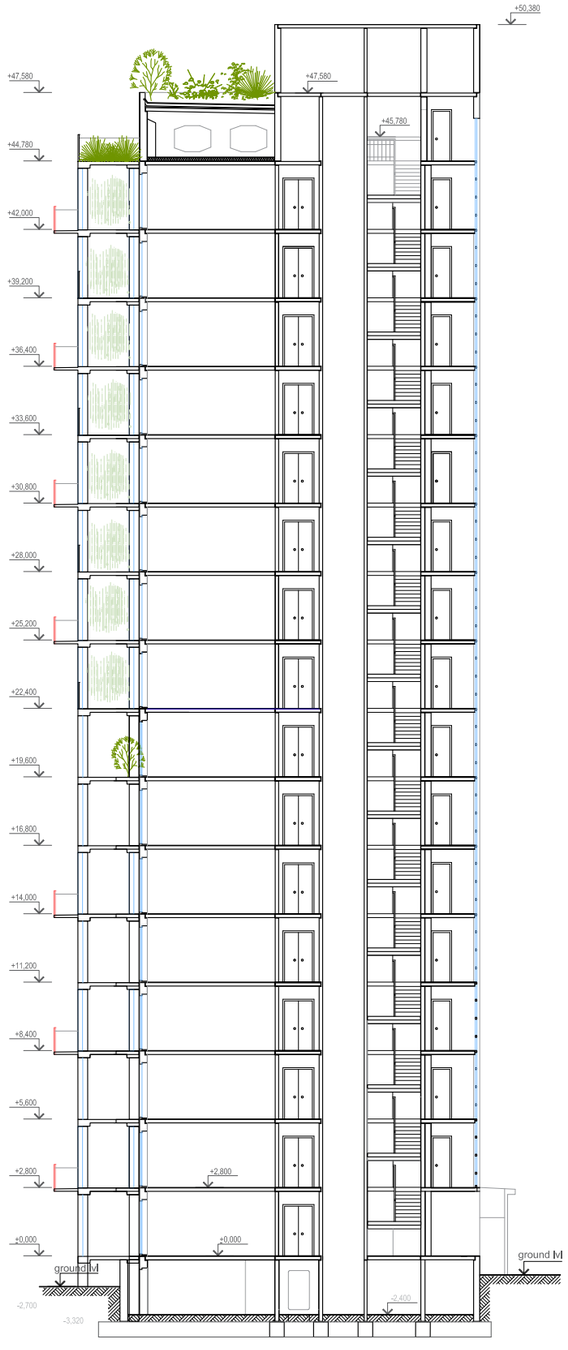


Fig. 67, Section scheme
Source. Self elaboration

CONCLUSION

This thesis grew out of an urgent question: what can architecture do when war destroys not only buildings but also people's way of life? In the case of Ukraine, housing has been one of the most affected areas, and it is through housing that we can best see how strongly war affects people's sense of security, stability and belonging. For me, it was important to consider reconstruction not only as technical restoration, but as a way to support communities and help people adapt to new conditions.

During the research, it became clear that reconstruction must be fast, flexible and, at the same time, forward-looking. In wartime, safety remains a priority which is access to protective spaces, structural reliability, and the ability to respond quickly. But at the same time, there is another, equally important need: spaces must support social interaction, inclusivity, and mental health. This is especially relevant today, when the number of people who need special conditions and additional support is constantly growing.

Based on an analysis of recurring housing typologies, I have proposed a methodology that can be applied in different parts of Ukraine. It combines various types of interventions, from rehabilitation to new extensions, and allows solutions to be adapted to the specific degree of destruction. This approach helps to preserve architectural integrity while creating a basis for more sustainable urban development.

The case of Kharkiv, namely the buildings in Nothern Saltivka, is an example of how this methodology can work in practice. The damaged part of the building provided an opportunity to rethink its functions and structure, adding new public spaces and creating conditions for social support. The preserved parts of the building were modernised, and new extensions expanded the housing stock, improved the quality of life and created more connections with nature through a winter garden and new façade solutions. At the territorial level, I tried to show that the restoration of a building is impossible without the restoration of the space around it. Green areas, urban forests, places for meetings and interaction, all this forms an environment that helps people return to normal life and feel part of the community.

In conclusion, the reconstruction of Ukraine requires a combination of three things: sustainable architecture for emergencies, preservation of memory, and a sensitive, contextual approach. Together, it allows to create spaces that meet people's immediate needs without devaluing their experiences, while also forming a foundation for the future.

BIBLIOGRAPHY

- Drozdov&Partners. (2024, November 23). New living environment. https://drozdov-partners.com/en/projects/new-living-environment
- Daria Mykhailyshyna (2023). Center for Economic Recovery https://ces.org.ua/shho-stimulyuvatime-ukraïnskih-bizhenczіv-povernutisya-dodomu-prognoz-ekonomistki/ (21 July 2025)
- International Organization for Migration (2023). Ukraine Displacement Report
- Miliienko, O. (2023). Internal migration and displaced persons in Ukraine: Governing policies and protections by the administrative courts. Social & Legal Studios, 6(3), 94-103. doi: 10.32518/sals3.2023.94.
- UNHCR, UKRAINE SITUATION FLASH UPDATE #81, (2025)
- Cherenko, L. M., Polyakova, S. V., Shyshkin, V. S., Reut, A. G., Krykun, O. I., Kogatko, Yu. L., Zayats, V. S., Klymenko, Yu. A., & Nat. Acad. Sci. Ukr., Inst. Demogr. and Soc. Research named after M.V. Ptukha. (2023). Quality of life of the population of Ukraine and the first consequences of the war:
- Real estate market research from EY Ukraine https://www.ey.com/uk_ua/newsroom/2023/03/doslidzhennya-rynku-nerukhomosti-pid-chas-viyny-vid-ey (22.07.2025)
- Fourth Rapid Damage and Needs Assessment (RDNA4), (2025)
- Nivievskyi, Oleg and Goryunov, Dmytro and Nagurney, Anna, War-Induced Damages and Reconstruction in Ukraine (May 17, 2024). Available at SSRN: https://ssrn.com/abstract=4831914
- Central Geophysical Observatory named after Boris Sreznevsky http://cgo-sreznevskyi.kyiv.ua/uk/diialnist/21213/9-pidsumki-shchedrogo-na-rekordi-chervnya-u-stolitsi
- Bowcott, H., Fomenko, L., Hamilton, A., Krishnan, M., Mysore, M., Trittipo, A., Walker, O., & United Nations. (2021). Protecting people from a changing climate: The case for resilience.
- Chepurko, H., & Soboliev, A. (2023, May 26). Ментальне здоров'я українців: виклики воєнного часу. Scientific Practice: Modern and Classical Research Methods. https://doi.org/10.36074/logos-26.05.2023.048
- DREAM – Public Investment Management System https://dream.gov.ua/
- Restoration of Ukraine's regions: communities survey report. DREAM Platform
- Big Recovery Portal https://brp.org.ua/
- Ukraine Recovery Conference https://www.urc-international.com/
- Wang, John & Hsu, Jeffrey & Li, Yang & Gu, Vicky. (2023). Confronting Current Crises and Critical Challenges of Climate Change. International Journal of Sociotechnology and Knowledge Development. 15. 1-17. 10.4018/IJSKD.318695.
- Docomomo Journal 67, 2022/02 - Liudmyla Shevchenko MASS HOUSING IN UKRAINE IN THE SECOND HALF OF THE 20TH CENTURY
- ERIH - European Route of Industrial Heritage (2025) ON THE INDUSTRIAL HISTORY OF UKRAINE https://www.erih.net/how-it-started/industrial-history-of-european-countries/ukraine
- Avramova, O., Oksana, H., Lesia, B., Mysyk, V., & Zakhozhai, Z. (2024). History of housing policy's formation and development in Ukraine. Edelweiss Applied Science and Technology, 8(5), 328–337. https://doi.org/10.55214/25768484.v8i5.1690
- Current housing crisis in Ukraine - Ukraine. (2025, February 23). ReliefWeb. https://reliefweb.int/report/ukraine/current-housing-crisis-ukraine
- Petrovska, A., & Zapototskyi, S. (2024). POST-WAR DEVELOPMENT STRATEGIES FOR UKRAINIAN CITIES: INSIGHTS FROM INTERNATIONAL EXPERIENCES. Ekonomichna Ta Sotsialna Geografiya, 92, 26–37. https://doi.org/10.17721/2413-7154/2024.92.26-37
- LEBBEUS WOODS. WAR AND ARCHITECTURE: three principles. (2011, December 16). https://lebbeuswoods.wordpress.com/2011/12/15/war-and-architecture-three-principles/
- Piątek, G. (2020). Warsaw: The Best City in the World. Rebuilding of Warsaw in 1944–1949. Warsaw: W.A.B. [In Polish]. [Piątek, G. (2020). Najlepsze miasto świata. Warszawa w odbudowie 1944–1949. Warszawa: Wydawnictwo W.A.B.]
- Serano, I. (2015)Forced Migration Review. Property rights and reconstruction in the Bosnian return process - Forced Migration Review. https://www.fmreview.org/dayton20/serrano/
- Piplas, H. (2019). Non-aligned City – Urban Laboratory of the New Sarajevo. ETH Zürich. DOI: https://doi.org/10.3929/ethz-b-000404735
- Aquilué, I., & Roca, E. (2016). Urban development after the Bosnian War: The division of Sarajevo's territory and the construction of East Sarajevo. Cities, 58, 152-163. DOI: https://doi.org/10.1016/j.cities.2016.05.008
- Dayton Agreement. (1995). General Framework Agreement for Peace in Bosnia and Herzegovina. https://www.osce.org/bih/126173
- Centre for Urban Research: Ukraine Preliminary Needs Assessment, September 2023
- United Nations Environment Programme, & Global Alliance for Buildings and Construction (2025). Not just another brick in the wall: The solutions exist - Scaling them will build on progress and cut emissions fast. Global Status Report for Buildings and Construction 2024/2025. https://wedocs.unep.org/20.500.11822/47214
- Ministry of Environmental Protection & Natural Resources of Ukraine. (2023). Management of waste containing asbestos – adopting the experience of Europe. https://mepr.gov.ua/en/upravlinnya-vidhodamy-shho-mistyat-azbest-perejmayemo-dosvid-yevropy/
- Miyamoto International. (2024). Asbestos detection in damaged buildings in Ukraine: analysis of materials from conflict-affected sites. (Miyamoto International report)
- Journal of Architectural Engineering. (2023). Reusing heavy-section steel in buildings: Carbon reduction potential and material availability.
- Stena Metall Group. (2024). Nearly zero climate impact with reuse. https://www.stenametall.com/news-insights/insights-inspiration/98-percent-lower-climate-impact-with-reuse/
- Ministry for Communities, Territories and Infrastructure Development of Ukraine. (2024). Ukraine to use construction waste from destroyed building for reconstruction. Ukrainska Pravda. https://www.pravda.com.ua/eng/news/2024/02/1/7439991/
- United Nations Development Programme. (2025, July 11). Creative recycling of rubble in Ukraine puts reconstruction in the spotlight. UNDP. https://www.undp.org/ukraine/press-releases/creative-recycling-rubble-ukraine-puts-reconstruction-spotlight-new-government-undp-campaign
- Babenko, A., & Kharitonova, Y. (2022). Post-Soviet urban regeneration and the challenges of sustainable development in Eastern Europe. Journal of Urban Studies, 58(4), 515–532.
- Dempsey, N., Brown, C., & Bramley, G. (2011). The key to sustainable urban development in Europe: Social sustainability in practice. Cities, 28(4), 150–157.
- European Commission. (2020). European Green Deal: Urban and territorial dimensions. Publications Office of the European Union.
- Gehl, J. (2010). Cities for people. Island Press.
- Lynch, K. (1960). The image of the city. MIT Press.
- Lydon, M., & Garcia, A. (2015). Tactical urbanism: Short-term action for long-term change. Island Press.
- Meuser, P., & Zadorin, D. (2015). Towards a typology of Soviet mass housing. DOM Publishers.
- Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A research framework. Journal of Cleaner Production, 143, 710–718.

- Talen, E. (2012). Design for diversity: Exploring socially mixed neighborhoods. Architectural Press.
- UN-Habitat. (2023). Rebuilding cities for resilience: Post-conflict and climate challenges. UN-Habitat Publications.
- UBE (2024, October 11). Material banks, explained: could they be the path to a circular future? University of the Built Environment. https://www.ube.ac.uk/whats-happening/articles/material-banks/
- European Commission: European Innovation Council and SMEs Executive Agency, EY, , Spatial Foresight, , & LSE, (2024). Scoping the socio-economic performance of the EU proximity economy : final report, Publications Office of the European Union. https://data.europa.eu/doi/10.2826/1010
- Kyiv School of Economic, Report on damages to infrastructure from the destruction caused by Russia's military aggression against Ukraine as of January 2024
- The Opportunities and Challenges of Modular Construction – National Institute of Building Sciences. (2024, July 30). https://nibs.org/the-opportunities-and-challenges-of-modular-construction/

ANNEX 1

Respondent 1
BLOCK 1: GENERAL INFORMATION
-26–35
- Male
- Odesa
- Odesa, flat
BLOCK 2: HOUSING
- Odesa, same place, closiness to the city's center
- Yes. I have too many relatives and friends here and i can't easily leave the country
- To the country area. It was a big house near the lake with a lot of free food
- No
- Door locks, another home neaby that probably will block a drone explosion.
BLOCK 3: COMMON SPACES
- Cafe, parks
- -
- first time more, since me and friends tried to spend more time together
- Cafe with undergroung floor
- Social contact, protection, interternet
- -
- Not much
- Safe, pieceful, cosy
BLOCK 4: VIEWS AND PARTICIPATION
- Home is people i value, and less of a space it was for me previously
- It's 2-3 room flat, bright, tidy, nothing special. The room to work in
- No
- Probably if i had time. If i was more-or-less sure the thing we disscuss will actually be implemented
- Sure
- I heard of some works in this direction about 2 years ago. No
- quite, with a lake nearby

Respondent 2
- 50-60
- Female
- Kherson
- Kherson, rented private house
BLOCK 2: HOUSING
- I used to live in a private house; comfort, my own fruit garden, dog kennel, community.
- Yes, I live in Ukraine.
- Currently, I am living in evacuation. The level of comfort is lower: stove heating, no air conditioning, no conditions for keeping animals comfortably.
- The house is completely destroyed. Emotionally — I lost the home where I lived my entire life; no memorable things remain (photos, furniture, appliances were destroyed; the garden and flower beds were burned). It feels as if my whole life has been destroyed, because for us, Ukrainians, our own home is a place of strength.
- Probably now there is no 100% feeling of safety. Support from neighbors and the community sometimes helps, but it also does not give a full guarantee of safety.
BLOCK 3: COMMON SPACES
- Cafes, parks, markets. Communication with people, with nature, and markets provided basic needs such as food and everyday items.
- Yes, now it is dangerous to visit places with large gatherings of people.
- Less, because it is dangerous.

- Yes.
- Probably all of the above.
- Yes.
- Yes, communication with neighbors and the community provides emotional support and useful information.
- Safe and comfortable.
BLOCK 4: VIEWS AND PARTICIPATION
- Home is not only about comfort; home is memories, traditions, and heritage. When you lose your home, it feels like you lose a part of yourself, your family, and your ancestral history.
- Probably safety and comfort first of all, preferably energy independence. Probably everything is important; nothing should be left unconsidered.
- No, I did not participate.
- Yes, I am ready. My main motivation is restoring my place and my house.
- Yes, architecture can influence these feelings.
- Yes, I know about the "e-restoration" program. No, I have not applied yet, but I plan to.
- No.

Respondent 3
BLOCK 1: GENERAL INFORMATION
- 18–25
- Female
- Mykolaiv region
- Zaporizhzhia, dormitory
BLOCK 2: HOUSING
- I lived in the village of Oleksandrivka, Mykolaiv region; the community around me, close relatives, friends, and fellow villagers were very important.
- I live in Ukraine — it is my homeland.
- Yes, I had to live in another city.There were no comfortable living conditions.
- My home was located in an occupied territory, with constant threats of shelling and danger for me and my children. This was emotionally and physically exhausting. We had to live in a basement, without electricity and without heating.
- It is hard to say, but most likely there is no 100% safety anywhere in Ukraine.
BLOCK 3: COMMON SPACES
- Libraries, cafés, recreational areas. They were important to me as places for communication, receiving information, and learning.
- Yes, this has changed. I do not feel safe in public spaces now.
- No, I did not have such experiences.
- The most important things are protection, warmth, and access to information (internet).
- Yes, they have been affected. What was helpful was increasing protection; what was unhelpful, in my opinion, was nothing.
- Yes, I had experience communicating with neighbors and the community — it unites people and provides moral support.
- After the war, I want to see common spaces primarily safe — probably everything: safety and also a place of remembrance.
BLOCK 4: VIEWS AND PARTICIPATION
- For me, home today is primarily protection.
- Yes, it has changed; the value of material things has changed. Home is about comfort and coziness, but the main value is life.
- My ideal home is, first of all, protection and convenience of use.
- Everything in the house is important, probably all the things listed.
- No, I did not participate.
- It is difficult to answer now, but probably more yes than no. The main motivation is protection and safety for me and my children.
- Yes.
- Yes, I know about it. No, I have not applied.
- No, I cannot recall; since the very beginning of the war I have been in constant stress.

Respondent 4

BLOCK 1: GENERAL INFORMATION

- 50–65
- Female
- Mykolaiv region
- Mykolaiv region, private house

BLOCK 2: HOUSING

- Mykolaiv region
- What I liked most was the planning and the location of the house.
- Yes, I still live in Ukraine; it is difficult to change my place of living, lifestyle, or country.
- No, I did not have to change my place of residence or evacuate.
- My housing has not undergone any changes.
- I cannot feel completely safe, although the house has strong walls and there is a shelter.

BLOCK 3: COMMON SPACES

- I prefer to stay alone, although sometimes I feel the need for common spaces. Probably parks are the best, they provide connection with nature and emotional rest.
- Probably no.
- Nothing has changed.
- Yes, they were.
- Probably all of the mentioned ones.
- Yes, they were affected. What was useful, I think, is that elevators were installed for people with limited mobility.
- Above all, comfort and safety.

BLOCK 4: VIEWS AND PARTICIPATION

- Home is a place of strength, safety, and warmth in the family circle. No, this has not changed, although my emotional attachment to my home has probably shifted — understanding that material things are not important because you can lose everything in a minute.
- I would like to keep my home; everything in it suits me — a home where there is warmth in the soul.
- Yes.
- I don’t know, maybe, but at the moment I have no motivation.
- Yes, architecture has a significant influence on these factors.
- Yes, I know about it; I haven’t needed to apply.
- Yes.

ANNEX 2

Thermal Insulation Measures — U-values

building variant: SI.N.AB.03.Gen.ReEx.001.001
description: Un-refurbished
construction year: 1971 ... 1980

		Roof 1	Roof 2	Wall 1	Wall 2	Wall 3	Floor 1	Floor 2	Window 1	Window 2	Door 1	
envelope area	$A_{env,i}$	504	0	2212	0	0	504	0	1840	0	2	m²

Construction Types

code		SI.Ceiling.ReEx.01.03		SI.Wall.ReEx.02.05			SI.Ceiling.ReEx.02.01		SI.Window.ReEx.02.01		SI.Door.ReEx.01.01	
U-value original state	$U_{original,i}$	1.80		2.80			1.00		2.80		2.20	W/(m²K)
included insulation thickness	$d_{ins,included,i}$	0		0			20					mm
border type		Unh		Ext			Cellar					
additional thermal resistance of unheated spaces	$R_{add,i}$	0.30		0.00			0.30					m²K/W
effective U-value original state	$U_{original,effective,i}$	1.17	0.00	2.80	0.00	0.00	0.77	0.00	2.80		2.20	W/(m²K)

Refurbishment Measures

code												
thermal resistance of predefined measure	$R_{measure,predef,i}$	0.00		0.00			0.00					m²K/W
insulation thickness of predefined measure	$d_{insulation,predef,i}$	0		0			0					mm
actual insulation thickness	$d_{insulation,i}$	0		0			0					mm
thermal resistance of actual measure	$R_{measure,i}$	0.00		0.00			0.00		0.00		0.00	m²K/W
effective therrmal conductivity (indicative)	$\lambda_{insulation,effective,i}$	0.00		0.00			0.00					W/(m·K)

Resulting U-values

type of refurbishment												
thermal resistance before measure	$R_{before,i}$	0.86		0.36			1.30		0.36		0.45	m²K/W
after measure	$R_{measure,result,i}$	0.86		0.36			1.30		0.36		0.45	m²K/W
U-value of refurbished area fraction	$U_{measure,result,i}$	1.17		2.80			0.77		2.80		2.20	W/(m²K)
area fraction of measure	$f_{measure,i}$	100%		100%			100%		100%		100%	
resulting U-value of construction element	$U_{actual,i}$	1.17		2.80			0.77		2.80		2.20	W/(m²K)

Energy Balance Calculation — Building Performance

Standard Reference Calculation - based on: EN ISO 13790 / seasonal method

building: SI.N.AB.03.Gen.ReEx.001.001
climate: SI.N (SI)
reference area $A_{C,ref}$ (conditioned floor area): 6774 m²

construction element	original U-value $U_{original,i}$ W/(m²*K)	measure type	nominal insulation thickness $d_{insulation,i}$ mm	effective thermal conductivity $\lambda_{insulation,i}$ W/(m*K)	area fraction $f_{measure,i}$	actual U-value $U_{actual,i}$ W/(m²*K)		area (basis: external dimensions) $A_{env,i}$ m²		adjustment factor soil $b_{tr,i}$		$H_{tr,i}$ W/K	*annual heat flow related to $A_{C,Ref}$* kWh/(m²a)
roof 1	1.800			0.000	100%	1.169	x	504.0	x	1.00	=	589.1	6.2
roof 2							x		x		=		
wall 1	2.800			0.000	100%	2.80	x	2212.0	x	1.00	=	6193.6	65.3
wall 2							x		x		=		
wall 3							x		x		=		
floor 1	1.000			0.000	100%	0.77	x	504.0	x	0.50	=	193.8	2.0
floor 2							x		x		=		
window 1	2.800				100%	2.80	x	1840.0	x	1.00	=	5152.0	54.3
window 2							x		x		=		
door 1	2.200				100%	2.20	x	2.0	x	1.00	=	4.4	0.0
						ΔU_{tb}		$\sum A_{env,i}$				$H_{tr,tb}$	
thermal bridging: surcharge on the U-values						0.15	x	5062.0	x	1.00	=	759.3	8.0

related to: envelope area 2.55 / reference area 1.90 m²K

Heat transfer coefficient by transmission H_{tr} sum 12892 — 135.9

Heat transfer coefficient by ventilation H_{ve}

volume-specific heat capacity air $c_{p,air}$ Wh/(m³K)		air change rate by use $n_{air,use}$ 1/h	+	air change rate by infiltration $n_{air,infiltration}$ 1/h	) x	$A_{C,Ref}$ m²	x	room height (standard value) h_{room} m	=	W/K
0.34	x (	0.40	+	0.40	) x	6774.0	x	2.50	=	4606

48.6

Total heat transfer Q_{ht}

accumulated differences between internal and external temperature: internal temp. ϑ_i 20.0 °C − external temp. ϑ_e 4.3 °C) x heating days d_{hs} 206 d/a = 3234 Kd/a

H_{tr} W/K		H_{ve} W/K	) x	temperature reduction factor F_{red} (h_{tr}=W/(m²K))	x	x 0.024 kKh/a	=	kWh/a
12892	+	4606	) x	0.92	x	77.6	=	1249447

184.4

Solar heat load during heating season Q_{sol}

window orientation	reduction factors: external shading F_{sh}		frame area fraction F_F		non-perpendicular F_w	solar energy transmittance $g_{gl,n}$	window area $A_{window,i}$ m²	solar global radiation $I_{sol,i}$ kWh/(m²a)		kWh/a
1. horizontal	0.80	x (1 -	0.30	) x	0.90	x 0.60 x		x 375	=	
2. east	0.60	x (1 -	0.30	) x	0.90	x 0.60 x	844.0	x 241	=	46132
3. south	0.60	x (1 -	0.30	) x	0.90	x 0.60 x	76.0	x 292	=	5033
4. west	0.60	x (1 -	0.30	) x	0.90	x 0.60 x	844.0	x 218	=	41729
5. north	0.60	x (1 -	0.30	) x	0.90	x 0.60 x	76.0	x 98	=	1689

sum 94584 — 14.0

Internal heat sources Q_{int}

internal heat sources φ_i 0.024 kh/d x 3.00 W/m² x heating days d_{hs} 206 d/a x $A_{C,ref}$ 6774.0 m² = 100472 kWh/a — 14.8

internal heat capacity per m² $A_{C,ref}$: c_m 45 Wh/(m²K)

time constant of the building: $\tau = \frac{c_m \times A_{C,ref}}{H_{tr} + H_{ve}}$ = 17

parameter: $a_H = a_{H,0} + \frac{\tau}{\tau_{H,0}}$ = 1.38

heat balance ratio for the heating mode: $\gamma_{h,gn} = \frac{Q_{sol} + Q_{int}}{Q_{ht}}$ = 0.156

gain utilisation factor for heating: $\eta_{h,gn} = \frac{1 - \gamma^{aH}}{1 - \gamma^{aH+1}}$ = 0.93

Energy need for heating $Q_{H,nd}$

$Q_{ht} - \eta_{h,gn} \times (Q_{sol} + Q_{int})$ = 1067218 kWh/a — 157.5

Energy Balance Calculation — System performance

Standard Reference Calculation - based on: EN ISO 15316 / level B (tabled values)

building: SI.N.AB.03.Gen.ReEx.001.001
conditioned floor area $A_{C,ref}$: 6774 m²
system: SI.<Oil.B_NC.SUH.01>.<EI.E.MUH.13>.<-.Gen.01>.<->

Domestic Hot Water System

system: SI.EI.E.MUH.13

energy need hot water		$q_{nd,w}$	15.0
+ losses distribution	SI.C_NoCirc_Int.Gen.01	$q_{d,w}$	0.6
+ losses storage	SI.S_Gas.Gen.01	$q_{s,w}$	0.0
		$q_{g,w,out} = q_{nd,w} + q_{d,w} + q_{s,w}$	15.6 kWh/(m²a)

thereof recoverable for space heating: $q_{d,w,h}$ 0.5; $q_{s,w,h}$ 0.0; $q_{w,h} = q_{d,w,h} + q_{s,w,}$ 0.5 kWh/(m²a)

	energyware for domestic hot water	heat generator	$\alpha_{nd,w,i}$	heat generator output $e_{g,w,out}$	expenditure factor $e_{g,w,i}$	delivered energy $q_{del,w,i}$	combined heat and power: expenditure factor electricity generation $e_{g,el,w,i}$	electricity production $q_{prod,el,w,i}$
1	El	SI.E.Gen.01	100%	15.6 kWh/(m²a)	1.00	15.6	0.00	0.0
2			0%		0.00	0.0	0.00	0.0
3			0%		0.00	0.0	0.00	0.0

related to gross calorific value; kWh/(m²a)

auxiliary energy

			$q_{del,w,aux}$
aux	El	SI.C_NoCirc.SUH.01	0.0 kWh/(m²a)

Heating System

system: SI.Oil.B_NC.SUH.01

gain utilisation factor (heating contributions from DHW and vent. system): $\eta_{h,gn} = \frac{1 - \gamma^{aH}}{1 - \gamma^{aH+1}}$ = 1.00

building parameter a_H 1.38

gain/loss ratio $\gamma_{h,gn} = \frac{q_{w,h} + q_{ve,h,rec}}{q_{nd,h}}$ = 0.00

energy need space heating		$q_{nd,h}$	157.5 kWh/(m²a)
- usable contribution of hot water system		$\eta_{h,gn} \cdot q_{w,h}$	0.5 kWh/(m²a)
- usable contrib. of vent. heat recovery		$\eta_{h,gn} \cdot q_{ve,h,rec}$	0.0 kWh/(m²a)
+ losses distribution and heat emission	SI.C.Gen.01	$q_{d,h}$	4.0 kWh/(m²a)
+ losses storage	SI.BS.Gen.01	$q_{s,h}$	2.0 kWh/(m²a)
		$q_{g,h,out} = q_{nd,h} - q_{w,h} - q_{ve,h,rec} + q_{d,h} + q_{s,h}$	163.1 kWh/(m²a)

ventilation heat recovery: $\eta_{ve,rec}$ 0% x $q_{ve,h,rec}$ → $q_{ht,ve}$ 48.6 kWh/(m²a)

for information: net energy need for heating $q_{nd,h,net} = q_{nd,h} - \eta_{h,gn} \cdot q_{ve,h,rec}$ 157.5 kWh/(m²a)

	energyware for space heating	heat generator	$\alpha_{nd,h,i}$	heat generator output $q_{g,h,out}$	expenditure factor $e_{g,h,i}$	delivered energy $q_{del,h,i}$	combined heat and power: expenditure factor electricity generation $e_{g,el,h,i}$	electricity production $q_{prod,el,h,i}$
1	Oil	SI.B_NC.Gen.01	100%	163.1 kWh/(m²a)	1.35	220.4	0.00	0.0
2			0%		0.00	0.0	0.00	0.0
3			0%		0.00	0.0	0.00	0.0

related to gross calorific value; kWh/(m²a)

auxiliary energy

			$q_{del,h,aux}$
aux	heating system: El	SI.C.Gen.01	2.7
aux	ventilation system: El	SI.-.Gen.01	$q_{del,ve,aux}$ 0.0 kWh/(m²a)

Electricity Production

Photovoltaic unit — calculation according to EN 15316-4-6 "Photovoltaic Systems"

	PV module area (without frame) $A_{pv,system}$		peak power coefficient $K_{pv,p}$		rated PV capacity ("peak power") $P_{pv,p}$	ratio of annual electricity output to rated PV capacity $q_{prod,el,pv,kWp}$	rated PV capacity ("peak power") $P_{pv,p}$	annual electricity produced by PV panels $Q_{el,pv}$	electricity prod. PV system per m² ref. area $q_{el,pv}$
	0.0	x	0.00	=	0.0	0	0.0	0	0.0
	0.0	x	0.00	=	0.0	0	0.0	0	0.0
Sum	0.0							0	0.0
	m²		kW/m²		kW	kWh/a/kW$_p$	kW	kWh/a	kWh/(m²a)

Total electricity production: $q_{prod,el} = \sum q_{prod,el,w,i} + \sum_i q_{prod,el,h,i} + q_{prod,el,pv}$ = 0.0 kWh/(m²a)

Energy Balance Calculation — Energy Carriers

Standard Reference Calculation - based on: EN ISO 15316 / level B (tabled values)

building: SI.N.AB.03.Gen.ReEx.001.001 — conditioned floor area $A_{C,ref}$: 6774.0 m²

system: SI.<Oil.B_NC.SUH.01>.<El.E.MUH.13>.<-.Gen.01>.<->

Assessment of Energywares

version of energy carrier specification: EU.001

Assessment by Energy Carrier (Standard Calculation)

		delivered energy $q_{del,i}$	total primary energy $f_{p,total,i}$	total primary energy $q_{p,total,i} = q_{del,i} \cdot f_{p,total,i}$	non-renewable primary energy $f_{p,nonren,i}$	non-renewable primary energy $q_{p,nonren,i} = q_{del,i} \cdot f_{p,nonren,i}$	carbon dioxide emissions $f_{CO2,i}$	carbon dioxide emissions $m_{CO2,i} = q_{del,i} \cdot f_{CO2,i}$	energy costs p_i (energyware price)	energy costs $c_i = q_{del,i} \cdot p_i$
Heating (+ Ventilation) System										
Oil		220.4	1.05	231.4	1.05	231.4	330	72.7	8.0	17.63
		0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
		0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
auxiliary electricity	El	2.7	2.50	6.8	2.30	6.2	617	1.7	24.0	0.65
CHP electr. production**		0.0	*0.00*	0.0	*0.00*	0.0	*0*	0.0	*0.0*	0.00
Domestic Hot Water System										
El		15.6	2.50	39.0	2.30	35.9	617	9.6	24.0	3.74
		0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
		0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
auxiliary electricity	El	0.0	2.50	0.00	2.30	0.0	617	0.0	24.0	0.00
CHP electr. production**		0.0	*0.00*	0.0	*0.00*	0.0	*0*	0.0	*0.0*	0.00
Photovoltaic System										
PV electr. production**	(eff. values*)	0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
*) effective assessment factors,see below		kWh/(m²a)		kWh/(m²a)		kWh/(m²a)	g/kWh	kg/(m²a)	Cent/kWh	Euro/(m²a)

**)electricity production = negative values

Electricity Generation - Direct Coverage of Electricity Demand

version of coverage, depending on supply / load ratio:

systems considered:
- [ ] PV
- [ ] CHP

supply/load ratio: 0.00 = $q_{prod,el}$ 0.0 kWh/(m²a) / ($\sum_i q_{del,el,i}$ + $\sum_i q_{del,aux,i}$ 18.3 kWh/(m²a))

max.coverage (according to pre-determined coverage table) $q_{el,prod,coverage,max}$: 0% x 18.3 kWh/(m²a) = 0.0 kWh/(m²a) (max. covered on-site demand)

		delivered energy	total primary energy	total primary energy	non-renewable primary energy	non-renewable primary energy	carbon dioxide emissions	carbon dioxide emissions	energy costs	energy costs
coverage of on-site demand of electricity**		0.0	0.00	0.0	0.0	0.0	0	0.0	0.0	0.00
el. exported to the grid**		-0.0	0.00	-0.0	0.0	-0	0	-0.0	0.0	-0.00
total / resulting assessment factors**		0.0	*0.00*	0.0	*0.00*	0.0	*0*	0.0		0.00

**) electricity production = negative values

Summary and Expenditure Factors

	$q_{n,d}$ heat need	$\sum q_{del}$	$e_{p,total} = q_{p,total}/q_{nd}$	$q_{p,total} = \sum q_{p,total}$	$e_{p,nonren} = q_{p,nonren}/q_{nd}$	$q_{p,nonren} = \sum q_{p,nonren,i}$	$f_{CO2,heat} = m_{CO2}/q_{nd}$	$m_{CO2,i} = \sum m_{CO2,i}$	$p_{heat} = c/q_{nd}$	$c = \sum c_i$
heating (+ ventilation) system	157.5	223.1	1.51	238.1	1.51	237.6	472	74.4	11.6	18.28
domestic hot water system	15.0	15.6	2.60	39.0	2.39	35.9	642	9.6	25.0	3.74
total	172.5	238.7	1.61	**277.1**	1.58	**273.5**	487	**84.0**	12.8	**22.02**
PV electricity bonus		0.0		0.0		0.0		0.0		0.00
total, considering PV bonus		238.7		**277.1**		**273.5**		**84.0**		**22.02**
	kWh/(m²a)	kWh/(m²a)		kWh/(m²a)		kWh/(m²a)	g/kWh	kg/(m²a)	Cent/kWh	Euro/(m²a)

Typical Values of the Measured Consumption - Empirical Calibration

code	EU.M.01
application field	average adaptation
determination method	average values from countries where information is available
accuray level	C = estimated (e.g. on the basis of few example buildings)

	empirical relation						current value
	0	100	200	300	400	500	236.0
adaptation factor	1.10	0.95	0.80	0.65	0.55	0.47	3 0.74

Summary (including subcategories)			Standard Calculation heating	Standard Calculation dhw	Standard Calculation **sum**	Typical Measured Consumption heating	Typical Measured Consumption dhw	Typical Measured Consumption **sum**
Gas	related to	$q_{del,\sum gas}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Oil	gross	$q_{del,\sum oil}$	220.4	0.0	**220.4**	163.7	0.0	**163.7**
Coal	calorific	$q_{del,\sum coal}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Bio	value	$q_{del,\sum bio}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
El		$q_{del,\sum el}$	0.0	15.6	**15.6**	0.0	11.6	**11.6**
DH		$q_{del,\sum dh}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Other		$q_{des,\sum other}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Auxiliary Electricity		$q_{des,\sum aux}$	2.7	0.0	**2.7**	2.0	0.0	**2.0**
CHP net electricity production		$q_{exp,\sum chp}$	0.0	-0.0	**0.0**	0.0	-0.0	**0.0**
PV net electricity production		$q_{exp,\sum el,pv}$			**0.0**			**0.0**

Thermal Insulation Measures — U-values

building variant: SI.N.AB.03.Gen.ReEx.001.002 — construction year: 1971 ... 1980

description: Standard refurbishment

		Roof 1	Roof 2	Wall 1	Wall 2	Wall 3	Floor 1	Floor 2	Window 1	Window 2	Door 1	
envelope area	$A_{env,i}$	504	0	2212	0	0	504	0	1840	0	2	m²

Construction Types

code		SI.Ceiling.ReEx.01.03		SI.Wall.ReEx.02.05			SI.Ceiling.ReEx.02.01		SI.Window.ReEx.02.01		SI.Door.ReEx.01.01	
U-value original state	$U_{original,i}$	1.80		2.80			1.00		2.80		2.20	W/(m²K)
included insulation thickness	$d_{ins,included,i}$	0		0			20					mm
border type		Unh		Ext			Cellar					
additional thermal resistance of unheated spaces	$R_{add,i}$	0.30		0.00			0.30					m²K/W
effective U-value original state	$U_{original,effective,i}$	1.17	0.00	2.80	0.00	0.00	0.77	0.00	2.80		2.20	W/(m²K)

Refurbishment Measures

code		SI.Ceiling.Insulation15cm.01		SI.Wall.Insulation15cm.01			SI.Ceiling.Insulation08cm.01		SI.Window.2p-LowE-arg.01			
thermal resistance of predefined measure	$R_{measure,predef,i}$	4.29		3.75			2.29					m²K/W
insulation thickness of predefined measure	$d_{insulation,predef,i}$	150		150			80					mm
actual insulation thickness	$d_{insulation,i}$	150		150			80					mm
thermal resistance of actual measure	$R_{measure,i}$	4.29		3.75			2.29		0.91		0.00	m²K/W
effective therrmal conductivity (indicative)	$\lambda_{insulation,effective,i}$	0.03		0.04			0.03					W/(m·K)

Resulting U-values

type of refurbishment		Add		Add			Add		Replace			
thermal resistance before measure	$R_{before,i}$	0.86		0.36			1.30		0.36		0.45	m²K/W
after measure	$R_{measure,result,i}$	5.14		4.11			3.59		0.91		0.45	m²K/W
U-value of refurbished area fraction	$U_{measure,result,i}$	0.19		0.24			0.28		1.10		2.20	W/(m²K)
area fraction of measure	$f_{measure,i}$	100%		100%			100%		100%		100%	
resulting U-value of construction element	$U_{actual,i}$	0.19		0.24			0.28		1.10		2.20	W/(m²K)

Energy Balance Calculation — Building Performance

Standard Reference Calculation - based on: EN ISO 13790 / seasonal method

building	SI.N.AB.03.Gen.ReEx.001.003	reference area $A_{C,ref}$ (conditioned floor area)	6774 m²
climate	SI.N (SI)		

construction element	original U-value $U_{original,i}$ W/(m²*K)	measure type	nominal insulation thickness $d_{insulation,i}$ mm	effective thermal conductivity $\lambda_{insulation,i}$ W/(m*K)	area fraction $f_{measure,i}$	actual U-value $U_{actual,i}$ W/(m²*K)		area (basis: external dimensions) $A_{env,i}$ m²		adjustment factor soil $b_{tr,i}$		$H_{tr,i}$ W/K	*annual heat flow related to $A_{C,Ref}$ kWh/(m²a)*
roof 1	1.800	Add	200	0.035	100%	0.152	x	504.0	x	1.00	=	76.7	0.9
roof 2							x		x		=		
wall 1	2.800	Add	200	0.040	100%	0.19	x	2212.0	x	1.00	=	412.9	4.8
wall 2							x		x		=		
wall 3							x		x		=		
floor 1	1.000	Add	200	0.035	100%	0.14	x	504.0	x	0.50	=	35.9	0.4
floor 2							x		x		=		
window 1	2.800	Replace			100%	0.75	x	1840.0	x	1.00	=	1380.0	16.1
window 2							x		x		=		
door 1	2.200				100%	2.20	x	2.0	x	1.00	=	4.4	0.1
						ΔU_{tb}		$\sum A_{env,i}$				$H_{tr,tb}$	
thermal bridging: surcharge on the U-values						0.05	x	5062.0	x	1.00	=	253.3	3.0

related to: envelope area 0.43 — reference area 0.32 — W/m²K — sum **2163** — 25.2

Heat transfer coefficient by transmission H_{tr}

Heat transfer coefficient by ventilation H_{ve}

volume-specific heat capacity air $c_{p,air}$ Wh/(m³K)	air change rate by use $n_{air,use}$ 1/h	+ by infiltration $n_{air,infiltration}$ 1/h	) x $A_{C,Ref}$ m²	x room height (standard value) h_{room} m	= W/K	
0.34	x (0.40	+ 0.10	) x 6774.0	x 2.50	= **2879**	33.6

Total heat transfer Q_{ht}

accumulated differences between internal and external temperature

internal temp. ϑ_i °C	- external temp. ϑ_e °C	) x heating days d_{hs} d/a	= Kd/a
(20.0	- 4.3	) x 206	= 3234

H_{tr} W/K	+ H_{ve} W/K	) x temperature reduction factor F_{red} (h_{tr}=W/(m²K))	x 0.024 kKh/a	= kWh/a	
(2163	+ 2879	) x 1.02	x 77.6	= **398450**	58.8

Solar heat load during heating season Q_{sol}

window orientation	reduction factors: external shading F_{sh}	frame area fraction F_F	non-perpendicular F_w	solar energy transmittance $g_{gl,n}$	window area $A_{window,i}$ m²	solar global radiation $I_{sol,i}$ kWh/(m²a)	kWh/a	
1. horizontal	0.80	x (1 - 0.30	) x 0.90	x 0.50	x	x 375	=	0.0
2. east	0.60	x (1 - 0.30	) x 0.90	x 0.50	x 844.0	x 241	= 38443	5.7
3. south	0.60	x (1 - 0.30	) x 0.90	x 0.50	x 76.0	x 292	= 4194	0.6
4. west	0.60	x (1 - 0.30	) x 0.90	x 0.50	x 844.0	x 218	= 34774	5.1
5. north	0.60	x (1 - 0.30	) x 0.90	x 0.50	x 76.0	x 98	= 1408	0.2
							sum **78820**	11.6

Internal heat sources Q_{int}

internal heat sources kh/d	φ_i W/m²	heating days d_{hs} d/a	$A_{C,ref}$ m²	kWh/a	
0.024	x 3.00	x 206	x 6774.0	= **100472**	14.8

internal heat capacity per m² $A_{C,ref}$ c_m = 45 Wh/(m²K)

time constant of the building $\tau = \frac{c_m \times A_{C,ref}}{H_{tr} + H_{ve}}$ = 60

parameter $a_H = a_{H,0} + \frac{\tau}{\tau_{H,0}}$ = 2.82

heat balance ratio for the heating mode $\gamma_{h,gn} = \frac{Q_{sol} + Q_{int}}{Q_{ht}}$ = 0.450

gain utilisation factor for heating $\eta_{h,gn} = \frac{1 - \gamma^{aH}}{1 - \gamma^{aH+1}}$ = 0.94

Energy need for heating $Q_{H,nd}$

$Q_{ht} - \eta_{h,gn} \times (Q_{sol} + Q_{int})$ = **230091** kWh/a — 34.0 kWh/(m²a)

Energy Balance Calculation — System performance

Standard Reference Calculation - based on: EN ISO 15316 / level B (tabled values)

building	SI.N.AB.03.Gen.ReEx.001.003	conditioned floor area $A_{C,ref}$	6774 m²
system	SI.<Oil.B_NC_LT.SUH.03>.<Oil.B_NC_LT+Solar.SUH.10>.<-.Gen.01>.<->		

Domestic Hot Water System

system: SI.Oil.B_NC_LT+Solar.SUH.10

energy need hot water		$q_{nd,w}$	15.0
+ losses distribution	SI.C_Circ_Int.Gen.01	$q_{d,w}$	1.0
+ losses storage	SI.S_C_Int.Gen.01	$q_{s,w}$	0.5
		$q_{g,w,out} = q_{nd,w} + q_{d,w} + q_{s,w}$	16.5 kWh/(m²a)

thereof recoverable for space heating: $q_{d,w,h}$ 0.8; $q_{s,w,h}$ 0.0; $q_{w,h} = q_{d,w,h} + q_{s,w,}$ 0.8 kWh/(m²a)

energyware for domestic hot water	heat generator	$\alpha_{nd,w,i}$	heat generator output $e_{g,w,out}$	expenditure factor $e_{g,w,i}$	delivered energy $q_{del,w,i}$	combined heat and power: expenditure factor electricity generation $e_{g,el,w,i}$	electricity production $q_{prod,el,w,i}$
1 Oil	SI.B_NC_LT.Gen.01	20%	x 16.5 kWh/(m²a)	x 1.10	= 3.6	: 0.00	= 0.0
2	SI.Solar.Gen.01	80%		x 0.00	= 0.0	: 0.00	= 0.0
3		0%		x 0.00	= 0.0	: 0.00	= 0.0
				related to gross calorific value	kWh/(m²a)		

auxiliary energy

aux El	SI.C_Circ.Gen.01	$q_{del,w,aux}$	1.7 kWh/(m²a)

Heating System

system: SI.Oil.B_NC_LT.SUH.03

gain utilisation factor (heating contributions from DHW and vent. system) $\eta_{h,gn} = \frac{1 - \gamma^{aH}}{1 - \gamma^{aH+1}}$ = 1.00

building parameter a_H = 2.82

gain/loss ratio $\gamma_{h,gn} = \frac{q_{w,h} + q_{ve,h,rec}}{q_{nd,h}}$ = 0.02

ventilation heat recovery: $\eta_{ve,rec}$ 0% × $q_{ve,h,rec}$ → $q_{ht,ve}$ 33.6 kWh/(m²a)

energy need space heating		$q_{nd,h}$	34.0 kWh/(m²a)
- usable contribution of hot water system		$\eta_{h,gn} \cdot q_{w,h}$	0.8 kWh/(m²a)
- usable contrib. of vent. heat recovery		$\eta_{h,gn} \cdot q_{ve,h,rec}$	0.0 kWh/(m²a)
+ losses distribution and heat emission	SI.C.Gen.01	$q_{d,h}$	4.0 kWh/(m²a)
+ losses storage	SI.BS.Gen.02	$q_{s,h}$	8.5 kWh/(m²a)
		$q_{g,h,out} = q_{nd,h} - q_{w,h} - q_{ve,h,rec} + q_{d,h} + q_{s,h}$	45.7 kWh/(m²a)

for information: net energy need for heating $q_{nd,h,net} = q_{nd,h} - \eta_{h,gn} \cdot q_{ve,h,rec}$ 34.0 kWh/(m²a)

energyware for space heating	heat generator	$\alpha_{nd,h,i}$	heat generator output $q_{g,h,out}$	expenditure factor $e_{g,h,i}$	delivered energy $q_{del,h,i}$	combined heat and power: expenditure factor electricity generation $e_{g,el,h,i}$	electricity production $q_{prod,el,h,i}$
1 Oil	SI.B_NC_LT.Gen.01	100%	x 45.7 kWh/(m²a)	x 1.10	= 50.2	: 0.00	= 0.0
2		0%		x 0.00	= 0.0	: 0.00	= 0.0
3		0%		x 0.00	= 0.0	: 0.00	= 0.0
				related to gross calorific value	kWh/(m²a)		kWh/(m²a)

auxiliary energy

heating system: aux El — SI.C.Gen.01 — $q_{del,h,aux}$ 2.7 kWh/(m²a)

ventilation system: aux El — SI.-.Gen.01 — $q_{del,ve,aux}$ 0.0 kWh/(m²a)

Electricity Production

Photovoltaic unit — calculation according to EN 15316-4-6 "Photovoltaic Systems"

	PV module area (without frame) $A_{pv,system}$		peak power coefficient $K_{pv,p}$		rated PV capacity ("peak power") $P_{pv,p}$	ratio of annual electricity output to rated PV capacity $q_{prod,el,pv,kWp}$	rated PV capacity ("peak power") $P_{pv,p}$	annual electricity produced by PV panels $Q_{el,pv}$	electricity prod. PV system per m² ref. area $q_{el,pv}$
	0.0	x	0.00	=	0.0	0	x 0.0	= 0	0.0
	0.0	x	0.00	=	0.0	0	x 0.0	= 0	0.0
Sum	0.0							0	0.0
	m²		kW/m²		kW	kWh/a/kW$_p$	kW	kWh/a	kWh/(m²a)

Total electricity production

$q_{prod,el} = \sum q_{prod,el,w,i} + \sum_i q_{prod,el,h,i} + q_{prod,el,pv}$ 0.0 kWh/(m²a)

Resilient recovery in Ukraine: housing and common spaces renovation during and after war

Energy Balance Calculation — Energy Carriers

Standard Reference Calculation - based on: EN ISO 15316 / level B (tabled values)

building: SI.N.AB.03.Gen.ReEx.001.003 — conditioned floor area $A_{C,ref}$: 6774.0 m²

system: SI.<Oil.B_NC_LT.SUH.03>.<Oil.B_NC_LT+Solar.SUH.10>.<-.Gen.01>.<->

Assessment of Energywares

version of energy carrier specification: EU.001

Assessment by Energy Carrier (Standard Calculation)

		delivered energy $q_{del,i}$	total primary energy $f_{p,total,i}$	total primary energy $q_{p,total,i} = q_{del,i} \cdot f_{p,total,i}$	non-renewable primary energy $f_{p,nonren,i}$	non-renewable primary energy $q_{p,nonren,i} = q_{del,i} \cdot f_{p,nonren,i}$	carbon dioxide emissions $f_{CO2,i}$	carbon dioxide emissions $m_{CO2,i} = q_{del,i} \cdot f_{CO2,i}$	energy costs p_i (energyware price)	energy costs $c_i = q_{del,i} \cdot p_i$
Heating (+ Ventilation) System										
Oil		50.2	1.05	52.7	1.05	52.7	330	16.6	8.0	4.02
		0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
		0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
auxiliary electricity	El	2.7	2.50	6.8	2.30	6.2	617	1.7	24.0	0.65
CHP electr. production**		0.0	*0.00*	0.0	*0.00*	0.0	*0*	0.0	*0.0*	0.00
Domestic Hot Water System										
Oil		3.6	1.05	3.8	1.05	3.8	330	1.2	8.0	0.29
		0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
		0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
auxiliary electricity	El	1.7	2.50	0.00	2.30	3.9	617	1.0	24.0	0.41
CHP electr. production**		0.0	*0.00*	0.0	*0.00*	0.0	*0*	0.0	*0.0*	0.00
Photovoltaic System										
PV electr. production**	(eff. values*)	0.0	0.00	0.0	0.00	0.0	0	0.0	0.0	0.00
**) effective assessment factors,see below*		kWh/(m²a)		kWh/(m²a)		kWh/(m²a)	g/kWh	kg/(m²a)	Cent/kWh	Euro/(m²a)
***)electricity production = negative values*										

Electricity Generation - Direct Coverage of Electricity Demand

version of coverage, depending on supply / load ratio

systems considered:

[ ] PV

[ ] CHP

supply/load ratio: $\frac{q_{prod,el}}{\sum_i q_{del,el,i} + \sum_i q_{del,aux,i}}$ = 0.00 = 0.0 kWh/(m²a) / 4.4 kWh/(m²a)

pre-determined coverage table: $q_{el,prod,coverage,max}$ = 0% x 4.4 kWh/(m²a) = 0.0 kWh/(m²a)

max.coverage (according to pre-determined coverage table) | max. covered on-site demand

coverage of on-site demand of electricity**		0.0	0.00	0.0	0.0	0.0	0	0.0	0.0	0.00
el. exported to the grid**		-0.0	0.00	-0.0	0.0	-0	0	-0.0	0.0	-0.00
total / resulting assessment factors**		0.0	*0.00*	0.0	*0.00*	0.0	*0*	0.0		0.00

***) electricity production = negative values*

Summary and Expenditure Factors

	$q_{n,d}$ heat need	$\sum q_{del}$	$e_{p,total} = \frac{q_{p,total}}{q_{hd}}$	$q_{p,total} = \sum q_{p,total}$	$e_{p,nonren} = \frac{q_{p,nonren}}{q_{hd}}$	$q_{p,nonren} = \sum q_{p,nonren,i}$	$f_{CO2,heat} = \frac{m_{CO2}}{q_{hd}}$	$m_{CO2,i} = \sum m_{CO2,i}$	$p_{heat} = \frac{c}{q_{hd}}$	$c = \sum c_i$
heating (+ ventilation) system	34.0	52.9	1.75	59.5	1.74	59.0	537	18.2	13.7	4.67
domestic hot water system	15.0	5.3	0.54	8.1	0.51	7.7	150	2.2	4.7	0.70
total	49.0	58.3	1.38	**67.6**	1.36	**66.7**	418	**20.5**	11.0	**5.37**
PV electricity bonus		0.0		0.0		0.0		0.0		0.00
total, considering PV bonus		58.3		**67.6**		**66.7**		**20.5**		**5.37**
	kWh/(m²a)	kWh/(m²a)		kWh/(m²a)		kWh/(m²a)	g/kWh	kg/(m²a)	Cent/kWh	Euro/(m²a)

Typical Values of the Measured Consumption - Empirical Calibration

code	EU.M.01
application field	average adaptation
determination method	average values from countries where information is available
accuray level	C = estimated (e.g. on the basis of few example buildings)

	empirical relation						current value
	0	100	200	300	400	500	53.9
adaptation factor	1.10	0.95	0.80	0.65	0.55	0.47	1 → 1.02

Summary (including subcategories)			Standard Calculation heating	Standard Calculation dhw	Standard Calculation **sum**	Typical Measured Consumption heating	Typical Measured Consumption dhw	Typical Measured Consumption **sum**
Gas	related to	$q_{del,\sum gas}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Oil	gross	$q_{del,\sum oil}$	50.2	3.6	**53.9**	51.2	3.7	**54.9**
Coal	calorific	$q_{del,\sum coal}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Bio	value	$q_{del,\sum bio}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
El		$q_{del,\sum el}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
DH		$q_{del,\sum dh}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Other		$q_{des,\sum other}$	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Auxiliary Electricity		$q_{des,\sum aux}$	2.7	1.7	**4.4**	2.8	1.7	**4.5**
CHP net electricity production		$q_{exp,\sum chp}$	0.0	-0.0	**0.0**	0.0	-0.0	**0.0**
PV net electricity production		$q_{exp,\sum el,pv}$			**0.0**			**0.0**