Rebuilding Ukraine with Energy Efficiency

Empowering people and supporting recovery



International Energy Agency

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 32 Member countries, 14 Association countries and beyond.

IEA Member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Latvia
Lithuania
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Republic of Türkiye
United Kingdom
United States

The European Commission also participates in the work of the IEA

IEA Accession countries:

Brazil
Chile
Colombia
Costa Rica
Israel
Romania

IEA Association countries:

Argentina
China
Egypt
India
Indonesia
Kenya
Morocco
Nigeria
Senegal
Singapore
South Africa
Thailand
Ukraine
Viet Nam

This publication, as well as any data and map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA.
International Energy Agency
Website: www.iea.org

Abstract

Russia's full-scale invasion has damaged or destroyed an estimated 14% of Ukraine's housing stock, affecting around 3 million households, with housing reconstruction needs approaching USD 90 billion. Buildings account for roughly 40% of final energy consumption, so rebuilding offers a major opportunity to strengthen energy security, improve living conditions and support economic recovery.

This report develops a typology of 44 building archetypes and assesses upgrade packages for four representative buildings: a Stalinka and a Khruschevka-464A apartment building, a detached house and a Soviet-era school. Combining high-performance envelopes with heat pumps reduces delivered heating and cooling energy demand by 85-93%. Under current regulated tariffs, however, deep upgrades have long payback periods, and medium-depth packages offer a more scalable balance of savings and investment.

The report proposes a phased policy package of regulation, information and incentives over the near, medium and long term, supported by workforce training, better data, concessional finance and gradual tariff reform.

IEA. CC BY 4.0.

Acknowledgements, contributors and credits

This report was prepared by the Office of Energy Efficiency and Inclusive Transitions (EEIT) of the International Energy Agency. The lead authors were Ksenia Petrichenko and Ian Hamilton, with valuable input and analysis from Giulia D'Angiolini, Melanie Slade and Talya Vatman. Brian Motherway, Head of EEIT, provided strategic guidance to the report.

Several experts and organisations from outside of the IEA provided valuable insights, inputs and comments to ensure report accuracy and quality. They include: Borys Dodonov (Kyiv School of Economics), Artur Obidnyk (Ukrnafta), Dmitro Petrunin, (Ministry for Recovery, Infrastructure and Transport).

Clara Vallois, Astrid Dumond, Liv Gaunt and Poeli Bojorquez of the Communications and Digital Office (CDO) were key to the publication process.

Nicola Clark copyedited the report.

IEA. CC BY 4.0.

Table of contents

Aim of the report 6
Energy efficiency can anchor Ukraine's recovery 6
Integrated upgrades deliver substantial energy savings 6
A phased policy package can realize potential 7
Ukraine's buildings sector: challenges and opportunities 8
Characteristics of Ukraine's building stock 10
Policy and institutional framework 10
Challenges for scaling energy efficiency 12
Assessing energy efficiency in building reconstruction and renovation 17
Building typology 17
Assessment methodology 26
Results of energy-efficiency potential assessments 36
Stalinka 37
Khruschevka 43
Private house 49
School building 54
Policy recommendations for improving energy efficiency 59
Cross-cutting priorities 59
Regulation 60
Information 63
Incentives 64
Conclusion 67
Abbreviations and acronyms 69

IEA. CC BY 4.0.

Aim of the report

Energy efficiency can anchor Ukraine's recovery

Rebuilding Ukraine's homes and public buildings offers a major opportunity to strengthen energy security, improve living conditions and support economic recovery. The report estimates that 14% of the housing stock had been damaged or destroyed by December 2025, affecting around 3 million households. Housing reconstruction needs approach USD 90 billion. Integrating energy efficiency into these investments can deliver lasting reductions in energy demand, household expenditure and public-sector operating costs.

Buildings account for roughly 40% of Ukraine's final energy consumption. Much of the stock combines ageing envelopes, inefficient heating systems and limited controls. Recovery programmes can address war damage and accumulated renovation needs through high-performance reconstruction, deep renovation and energy-efficient new construction. More efficient envelopes will support thermal comfort during supply disruptions, and lower heating demand eases pressure on energy infrastructure.

Integrated upgrades deliver substantial energy savings

The report develops a typology of 44 building archetypes and assesses upgrade packages for four representative buildings: a Stalinka apartment building, a Khruschevka-464A apartment building, a detached house and a Soviet-era school. The assessment combines building-envelope improvements and heating-system modernisation, using standardised operating assumptions and Kyiv climate conditions. The results show that the combination of fabric and heating system energy efficiency can support substantial potential energy cost savings.

Packages combining high-performance envelopes with heat pumps reduce delivered heating and cooling energy demand by approximately 91% for the Stalinka building, 93% for the Khruschevka building, 91% for the detached house and 85% for the school. Heat pumps provide substantial reductions in delivered energy use across the assessed archetypes. Envelope improvements reduce underlying thermal demand and peak heating loads, improve comfort and support efficient system sizing. Detached houses particularly benefit from comprehensive fabric upgrades because of their large, exposed surface area.

IEA. CC BY 4.0.

Package selection can take into account energy savings, upfront investment, lifecycle costs, affordability and resilience. Medium-depth upgrades offer scalable options for apartment buildings and schools where financing is constrained. Deep renovation offers substantial potential in detached houses with low levels of performance and lack of access to district heating systems. Incentives such as grants, concessional lending and guarantees can enable investment across these segments where financing can be developed. Gradual movement towards cost-reflective tariffs, accompanied by targeted social protection and renovation support, can strengthen investment incentives and help households manage energy expenditure.

A phased policy package can realise potential

A phased package of regulation, information and incentives can support energy-efficient reconstruction and renovation across Ukraine. The following is a summary of policy options available to drive progress.

Near term: 0 to 3 years. Embed minimum energy-performance requirements in state- and donor-funded reconstruction. Deploy individual heating substations, balancing systems and weather-compensated controls. Provide practical guidance for nearly zero-energy buildings (nZEB), expand workforce training and strengthen municipal project preparation. Link building-energy data with damage registers and reconstruction platforms. Expand Energy Efficiency Fund support, prioritising vulnerable households, displaced people, heavily damaged municipalities and essential public services.

Medium term: 3 to 7 years. Scale standardised renovation packages for common building types, supported by demonstration projects and regional technical assistance. Tighten whole-building performance requirements and use lifecycle criteria in public procurement. Coordinate heating electrification with building upgrades and electricity-system capacity. Modernise viable district-heating networks through renewable and waste heat, large-scale heat pumps and lower-temperature operation. Broaden financing through soft loans, revolving funds and energy service models.

Long term: 7 years and beyond. Align building standards progressively with EU zero-emission objectives. Verify operational energy savings and link incentives to measured performance. Integrate building databases, smart metering and heat planning to support efficient, flexible districts. Renewables, storage and smart controls can complement efficient buildings and modern heating networks, strengthen resilience and support the integration of renewable electricity.

IEA. CC BY 4.0.

Ukraine's buildings sector: challenges and opportunities

The Russian Federation's (hereafter 'Russia') full-scale invasion of Ukraine has caused extensive damage to Ukraine's infrastructure, with the housing sector bearing the brunt. As of December 2025, an estimated 14% of the total housing stock had been damaged or destroyed, affecting around 3 million households. Housing-sector damage is estimated at USD 61 billion, nearly one-third of the country's total. Reconstruction needs are projected at nearly USD 90 billion, underscoring the scale of the damage and making housing one of the top long-term recovery priorities. In Kyiv alone, nearly 3 000 apartment buildings and hundreds of infrastructure sites had been damaged as of January 2026, including schools, hospitals, cultural venues and transport facilities

Critical energy infrastructure has also been targeted. Roughly half of pre-war power generation capacity has been occupied, destroyed or damaged, while dozens of large district-heating plants and hundreds of boiler houses have been ruined. The damage has led to frequent outages of natural gas, electricity and district-heating services.

This destruction creates an urgent challenge to provide shelter, thermal comfort and other energy services for displaced people and affected communities. At the same time, reconstruction offers an opportunity to "build back better" by restoring homes and public buildings to modern energy-efficiency and low-carbon standards, rather than locking in inefficiencies in long-lasting building envelopes.

Ukraine's government, the International Energy Agency (IEA) and other international partners recognise that post-war reconstruction must embed sustainability and resilience from the outset. A National Recovery Plan calls for recovery and rebuilding based on more advanced, sustainable technologies, a "green transition" and digital transformation, while aligning with the values of the European Union. In 2024, the European Union established the Ukraine Facility to support the country's recovery, reconstruction and modernisation efforts.

In the buildings sector, this means repairing and replacing war-damaged structures with high-performance designs that reduce energy waste and emissions while improving comfort and safety.

Residential, commercial and public buildings account for roughly 40% of Ukraine's final energy consumption and about one-third of national carbon dioxide (CO_2) emissions. Deep renovation – comprehensive upgrades to existing buildings – and

IEA. CC BY 4.0.

high-performance reconstruction could halve nationwide energy demand for heating. Typical buildings in Ukraine consume 160-200 kilowatt-hours per square metre (kWh/m²) annually, two to three times the EU average. Upgrading them could cut household energy bills by 50-70%, while also improving occupants' comfort and health.

Pre-war data from 2021 indicate that around 80% of Ukraine's housing stock, estimated at 1 billion square metres (m²), was already depreciated, reflecting widespread physical deterioration. The country had approximately 45 500 ageing buildings, of which 16 800 were classified as being in a critical state of disrepair. Most were three- to five-storey panel or brick buildings constructed in urban areas before the mid-1970s, many of which have since deteriorated significantly. Of Ukraine's roughly 200 000 apartment buildings, nearly 12% were built between 1919 and 1945, about 25% between 1946 and 1960, and a further 25% during the 1960s. More than 67 000 buildings date from 1960 to 1980.

The rate of thermal modernisation before Russia's full-scale invasion was – and remains – critically low, at approximately 0.1% a year, well below the average of around 1% across the EU, highlighting a substantial gap in renovation activity.

Of the existing buildings that have sustained significant damage from Russian attacks, almost 90% are expected to remain in use in 2050. In addition to repairing war-damaged structures, Ukraine must therefore renovate and modernise its ageing housing stock.

Energy-efficient reconstruction requires action on three fronts: reconstructing buildings destroyed or severely damaged during the war; renovating those that sustained little or no damage; and ensuring that new buildings constructed during and after the war meet near-zero energy performance standards. In this report, the term "reconstruction and renovation of buildings" covers all of these activities.

Energy-efficient reconstruction and renovation in Ukraine are not just environmental imperatives: they are economic, social and national security necessities. Efficient buildings reduce dependence on imported natural gas, help maintain habitable indoor temperatures during power outages, ease the fiscal burden of energy subsidies and lower household energy bills, helping to alleviate energy poverty.

Rebuilding Ukraine with energy-efficient buildings addresses immediate humanitarian needs while advancing longer-term goals: strengthening energy security by reducing reliance on imported fossil fuels, supporting alignment with EU accession requirements, and meeting climate commitments under its Nationally Determined Contribution, which targets a 65% reduction in greenhouse gas emissions by 2030 compared to 1990 levels.

IEA. CC BY 4.0.

This report assesses the state of Ukraine's buildings sector and sets out a reconstruction strategy that capitalises on the opportunity to decarbonise and modernise its building stock in line with IEA's net-zero frameworks and EU standards.

Characteristics of Ukraine's building stock

Before the war, Ukraine's building stock comprised nearly 1 billion m² of floor area. Around 200 000 multi-family apartment buildings accounted for roughly 600 million m², or 60% of the total. Nearly two-thirds of these buildings were constructed between the 1960s and 1980s under Soviet-era norms that imposed no requirements for insulation or airtightness. As a result, heating energy consumption per square metre in most dwellings is roughly two to three times the EU average for comparable buildings.

District heating remains a major source of space heating, particularly in the residential sector. Nearly 60% of Ukraine's population relies on district heating to stay warm during the winter. Dependence is especially high large cities: in Kyiv, for example, close to 99% of residential buildings are connected to district-heating networks.

Over four consecutive winters, Russia has demonstrated that centralised district-heating systems are highly vulnerable and strategically valuable targets, repeatedly attacking them through both kinetic operations and cyber means. By the end of 2024, Russian attacks had damaged at least 18 combined heat and power (CHP) plants, more than 800 boiler houses and 354 kilometres (km) of heating pipelines across Ukraine.

Even when undamaged, these systems lose 20-30% of their heat during transmission, and fewer than 5% of connected buildings have modern automated controls to regulate heat supply. Much of the district-heating infrastructure is outdated and inefficient, while many buildings lack individual heat meters or thermostatic controls. The combination of poor building insulation, antiquated heating systems and limited regulation drive up energy costs and make indoor temperatures unpredictable, particularly during winter outages or supply disruptions.

Policy and institutional framework

Over the past decade, Ukraine has established a solid legislative foundation for energy-efficient buildings:

- **Law No. 2118-VIII, "On Energy Efficiency of Buildings" (2017).** Aligned with EU Directive 2010/31/EU, this law introduced building energy performance classifications (A to G), mandatory energy performance certificates for many

IEA. CC BY 4.0.

buildings, and minimum efficiency requirements. It established a framework for reducing energy consumption in buildings and a system for certifying their energy performance.

- **Law No. 1818-IX, "On Energy Efficiency" (2021).** Aligned with the EU Energy Efficiency Directive 2012/27/EU, this law set a broad framework for energy efficiency across all sectors. It mandates a National Energy Efficiency Action Plan and measures such as energy audits, energy management systems, public procurement of energy-efficient equipment, and penalties for non-compliance.
- **Building Code DBN B.2.6-31:2021 "Thermal Insulation and Energy Efficiency of Buildings" (2022).** Technical standards were updated to require new buildings and those undergoing major renovations to meet at least energy performance Class C, with minimum insulation levels and other efficiency requirements. This code also tightened thermal standards, including wall and roof U-values (thermal transmission) to reduce heating demand and move toward near-zero standards.
- **National Plan for Nearly Zero Energy Buildings (2020).** Ukraine's Nearly Zero-Energy Buildings (nZEB) roadmap (Cabinet of Ministers Order No. 88-p, Jan 29 2020) commits to phased adoption of nZEB standards: all new public buildings must be compliant by 2025 and all new buildings by 2027. In April 2025, requirements introduced under Order No. 168-p (6 February 2025) entered into force, establishing criteria for nZEB certification of new buildings. However, compliance with these criteria is voluntary. Under the new requirements, new buildings must achieve energy performance Class A, while renovated buildings must meet at least Class B. They also set strict limits on primary energy consumption from non-renewable sources and stipulate that renewable energy must meet at least 53% of heating and cooling demand in Climate Zone I (covering most of northern and central Ukraine) and 57% in Climate Zone II (primarily in the warmer southern and southwestern regions). Minimum thermal performance standards apply to the building envelope, including walls, roofs, floors and windows, with no scope to relax insulation requirements through adjustment coefficients. Additional provisions address airtightness and the efficiency of heating, cooling and ventilation systems. The framework also requires solar panels and external shading systems to support renewable energy generation and improve summer thermal comfort.
- **Long-Term Thermal Modernisation Strategy until 2050.** Ukraine's strategy for renovation targets a two-thirds reduction in energy consumption for building heating and cooling by 2050. Intermediate objectives by 2030 include renovating at least 10% of public buildings to nZEB standards, reducing final energy use in buildings by 15% and overcoming energy poverty. The strategy envisions accelerating building renovations after 2030, with the aim of achieving deep retrofits of most existing buildings by 2050.
- **Financing and Incentive Programmes.** Since 2019, the Energy Efficiency Fund (EEF) has provided grants to homeowner associations for thermal renovations under the "ENERGODIM" programme. In 2022 the EEF launched "VidnovyDIM," a grant programme (funded jointly by the European Union and Ukraine) to repair

IEA. CC BY 4.0.

war-damaged apartment buildings and improve their energy efficiency. In 2023, Ukraine established the State Decarbonisation and Energy Efficiency Transformation Fund – a budgetary fund and a new joint stock company (JSC) – which began operations in 2024 as the first state-run revolving financing mechanism for energy efficiency and decarbonisation projects. This fund, capitalised by a carbon tax, provides concessional loans and co-financing to businesses and municipalities for energy-saving projects.

- **Order No. 168 of the Ministry of Development (6 February 2025)** introduces new requirements for near-zero energy buildings.
- **Resolution No. 1210 (25 September 2025)** amended the procedures governing the use of the State Fund for Decarbonisation and Energy Efficiency to finance the installation of photovoltaic modules, hybrid inverters (capable of operating both in standalone and synchronous mode with the external grid) and energy storage systems at government-owned facilities in 2025-2026. The SvitloDIM programme (providing grants for backup power equipment) is in effect for the residential housing stock.

Despite this robust policy framework, energy efficiency measures remain poorly implemented. Local authorities often lack the capacity to enforce building regulations and initiate retrofits. As a result, the average building renovation rate remains very low – well below the 3% annual rate needed to meet EU-aligned climate targets. Many laws and plans have yet to translate into tangible improvements on the ground due to institutional and funding gaps, which are further exacerbated by ongoing military actions.

Challenges for scaling energy efficiency

Several persistent barriers hinder the widespread adoption of energy-efficiency measures in Ukraine's buildings sector and must be overcome to ensure effective, resilient reconstruction.

Policy, planning and data challenges

Until recently, Ukraine lacked clear, operational targets for large-scale thermal modernisation of buildings at both national and local levels. Adoption of the Long-Term Renovation Strategy to 2050, near-zero energy building requirements and related recovery plans marks genuine progress, but implementation capacity remains uneven. Historically, a lack of comprehensive data on the building stock and energy consumption has constrained planning and prioritisation. To address this gap, Ukraine in 2024 launched the National Database of Energy and Operational Characteristics of Buildings, together with a State Register of Damaged and Destroyed Property and digital reconstruction platforms like the Digital Restoration Ecosystem for Accountable Management (DREAM). Integrating these

IEA. CC BY 4.0.

systems effectively with energy performance and renovation data could significantly strengthen reconstruction planning, monitoring and investment prioritisation.

Institutional and public-sector capacity constraints

The war continues to place significant pressure on public finances and institutional capacity, limiting the ability of national and local authorities to prioritise investments in energy efficiency. Although improving the performance of public buildings remains an important objective, renovation rates remain low. Many municipalities still face limited technical and administrative capacity to prepare, procure and supervise complex renovation projects. Strengthening local project development capacity, technical assistance mechanisms and coordination between national and municipal authorities will therefore be essential to ensure that reconstruction funding translates into high-quality, energy-efficient outcomes across Ukraine.

Performance and quality risks

Without robust quality assurance, the performance gap between design and reality can be significant. Issues like incomplete air sealing, poorly fitted insulation and inadequate commissioning can reduce energy savings by 10-25% relative to estimated potential. On-site technical oversight and training of engineers, architects, builders and installers are needed to integrate energy efficiency into reconstruction and ensure that "build back better" delivers tangible results instead of remaining just a slogan. Rigorous construction standards, independent inspections and energy monitoring will be essential to achieving the expected efficiency gains.

Technical capacity and implementation challenges

Ukraine's construction sector continues to face shortages of qualified professionals capable of delivering high-quality, deep renovations and nZEB-compliant buildings at scale. This includes engineers, energy auditors, designers, installers, commissioning specialists and construction workers familiar with modern high-performance building techniques. The war has drawn a large share of Ukraine's male workforce into military service, leading to persistent shortages of technicians, construction workers and other skilled tradespeople. Since 2022, military mobilisation and displacement have reduced Ukraine's workforce by more than one-quarter. Millions of citizens (mostly women and children) remain abroad as refugees, and all men aged 25-60 are subject to conscription, depleting the available labour pool. In a 2024 survey, nearly 60% of businesses reported that finding skilled workers was their top challenge. In 2026, 78% of Ukrainian companies belonging to the European Business Association (EBA) reported a shortage of skilled workers.

IEA. CC BY 4.0.

To address these shortages, firms are recruiting more women, young people and even retirees for roles traditionally held by working-aged men.

Technical capacity varies widely across regions, with expertise concentrated in larger urban centres. Maintaining quality control during implementation is also challenging, particularly for complex building-envelope upgrades and advanced engineering systems. While building codes and nZEB requirements have advanced considerably in recent years, further efforts are needed to develop standardised technical solutions, demonstration projects, operational verification mechanisms and workforce training programmes to support widespread implementation.

A qualifications gap threatens to undermine building quality and energy performance. Vocational education curricula seldom include modern building physics, insulation techniques or nZEB concepts. Many builders and contractors lack the expertise to install high-performance materials and systems correctly. Poor installation practices – gaps in thermal insulation, inadequate air sealing and improper balancing of heating, ventilation and air conditioning (HVAC) – can reduce efficiency gains by 10-25% if left unaddressed. Strengthening training programmes and certification for energy professionals is therefore essential to ensure that design targets translate into real-world results.

Local governments, which oversee many public building retrofits, often lack the staff and technical expertise needed to design, finance and supervise projects. Even when funding is available, limited capacity at the city level remains a bottleneck to project implementation.

Some donor-funded programmes are supporting the development of energy-efficiency-related skills in Ukraine. For instance, under a project supported by Germany's Gesellschaft für Internationale Zusammenarbeit (GIZ), more than 600 Ukrainian professionals have been trained in energy auditing and modern retrofit methods since 2019, with women representing 36% of trainees. A second pilot project launched in 2025, Skills4Recovery, aims to train up to 500 workers through 12 training centres and 30 employers.

However, existing training initiatives remain small relative to the scale of Ukraine's reconstruction needs. In 2025, the construction sector was estimated to face a shortage of more than 500 000 skilled workers. Expanding education and vocational training programmes for energy auditors, building engineers, heat-pump installers, energy managers, construction workers and renovation specialists are therefore essential for implementing Ukraine's long-term building renovation strategy and recovery plans.

IEA. CC BY 4.0.

Financing and affordability constraints

Thermal modernisation and high-performance reconstruction remain highly capital-intensive, while financing mechanisms for deep renovation are still developing. Many households, homeowners' associations and municipalities continue to face barriers to affordable, long-term financing, while public support to cover upfront investment costs remains insufficient. Although programmes implemented through the Energy Efficiency Fund, including ENERGODIM, GreenDIM and VidnovyDIM, have expanded support for renovation and renewable energy integration, investment needs continue to far exceed available funding. Mobilising public and private finance – including international donor support, concessional loans, loan guarantees and green finance instruments – remains a critical priority.

Low energy prices weaken incentives for efficiency investments

Historically low, heavily regulated energy tariffs in Ukraine have made efficiency investments less economically attractive. Household heating and gas tariffs have largely remained frozen under martial law, weakening the price signals that would otherwise encourage efficiency improvements and electrification of heating. As of early 2025, household energy prices remain below cost-recovery levels.

- **Natural gas:** Regulated household gas tariffs are approximately UAH 7.96-8.00 per cubic metre (m^3) for the gas commodity alone, rising to as much as UAH 10 per m^3 when distribution costs are included (with VAT, roughly USD 0.22 per m^3). This equates to only around USD 0.02 per kWh of heat content, which is very low by international standards.

  Gas tariffs for households and the heat supplied to residential customers have remained frozen during the war under a moratorium on increases. As a result, most residents continue to pay pre-war prices despite cumulative inflation exceeding 60% since February 2022.
- **District heating:** Heating tariffs are determined at the regional level. According to figures published by the Ministry of Finance, tariffs vary across the country. In Kyiv, for example, the average tariff is UAH 1 652 per gigacalorie (Gcal), equivalent to approximately USD 0.03-0.04/kWh of thermal energy. These tariffs cover only 61% of heat supply costs, even when using heavily subsidised gas at UAH 7.4 (around 0.16 USD) per m^3 for residential heating.[1]
- **Electricity:** Until mid-2024, households paid UAH 2.64 (around USD 0.07) per kWh for electricity used for heating. In June 2024, the tariff was raised to a uniform UAH 4.32 (USD 0.11) per kWh to shore up the energy system. Even after this

[1] Ukraine's energy and utilities regulator estimated the average cost-reflective tariff at UAH 2 381/Gcal based on a natural gas price of UAH 7.4 per m^3 (around 0.16 USD).

IEA. CC BY 4.0.

increase, electricity prices remain well below European retail rates and continue to be subsidised by the state.

Under these low tariffs, the payback periods for deep retrofits or nZEB-compliant construction could stretch well beyond 20-25 years. A 2024 analysis by Civil Network OPORA, an independent organisation that monitors public institutions, found that building a new home to nZEB standards costs roughly 30% more than building to standard code. Although such homes would significantly reduce operating costs, the breakeven point is reached only if energy tariffs rise by more than 50% (or if significant grants are provided). A recent techno-economic study in Bucha, for example, found that if tariffs remain at current low levels, the average payback period for rebuilding to high efficiency is 27-33 years, compared to 15-19 years if energy prices properly reflected costs. In other words, so long as gas and heat are sold well below market cost, deep energy retrofits will struggle to pay for themselves through energy savings.

At the same time, energy poverty remains a major concern, with many households struggling to maintain adequate indoor thermal comfort even with subsidised tariffs. Balancing affordability, cost-reflective pricing and long-term energy security therefore remains a complex policy challenge. Gradual tariff reform, combined with targeted social support and large-scale thermal modernisation programmes, could improve both affordability and investment viability over time. Additional behavioural and governance challenges persist in multi-unit buildings, where collective decision making and co-financing arrangements can complicate renovation processes – particularly in buildings without active homeowners' associations.

IEA. CC BY 4.0.

Assessing energy efficiency in building reconstruction and renovation

Building typology

Ukraine's building stock is highly heterogeneous, reflecting successive construction waves shaped by pre-Soviet, Soviet, and post-independence periods. The typology developed for this analysis identifies 44 representative building archetypes across four major categories: apartment buildings, private houses, schools and hospitals. It provides a structured basis for assessing energy performance, renovation needs and reconstruction priorities.

Apartment buildings

Ukraine's stock of multi-unit residential buildings reflects more than a century of evolving construction practices, urbanisation patterns and housing policies. The identified archetypes range from pre-revolutionary masonry buildings to modern high-rise residential complexes, reflecting the shift from individually designed structures to highly standardised Soviet mass housing and, more recently, to more diverse, post-independence housing developments. The typology developed in this study groups apartment buildings into eight broad categories based on construction period, structural system, architectural characteristics and indicative energy performance.

IEA. CC BY 4.0.

Overview of archetypes for apartment buildings in Ukraine

Building archetype	Description	Estimated delivered energy demand
Pre-revolutionary (pre-1920)	Brick masonry buildings with thick walls, high ceilings, and outdated heating and insulation systems	~280 kWh/m² per year
Stalinka (1930s to1950s)	Solid brick apartment buildings with spacious layouts and high thermal mass, but inefficient systems and limited insulation	~320 kWh/m² per year
Khrushchevka (1950s to 1960s)	Standardised, large-scale prefabricated or brick housing with compact apartments and extremely poor thermal performance	~340 kWh/m² per year
Gostinka (1960s to 1980s)	Compact, high-density apartment buildings with small units and generally poor thermal performance	~280 kWh/m² per year
Czech project (1960s to 1970s)	Improved Soviet-era apartment buildings with larger layouts but continued reliance on inefficient panel systems	~280 kWh/m² per year
Late Soviet (1970s to 1990s)	Larger apartment buildings with improved layouts and amenities, but still significant heat losses	~250 kWh/m² per year
Early post-Soviet (1990s to 2000s)	Buildings with more flexible layouts and gradual improvements in insulation and glazing	~230 kWh/m²/year
Modern apartment complex (post-2000)	Contemporary buildings with improved envelopes, glazing systems, and lower energy demand	~140 kWh/m²/year

Note: Estimated delivered energy demand values are indicative and derived from representative examples identified within each archetype category. Actual performance varies depending on climatic conditions, occupancy patterns, user behaviour, renovation status and heating system configuration.

Pre-revolutionary buildings

Constructed before 1920, these are among the oldest surviving residential structures in Ukrainian cities. These buildings are typically low- to mid-rise masonry structures with thick, red-brick external walls, wooden or mixed floor systems, lofty ceilings (between three and four metres), and spacious apartments with large rooms and corridors. Architectural ornamentation, including mouldings, decorative façades and balconies, remains a defining feature.

Despite their robust construction and relatively good thermal inertia due to thick masonry walls, these buildings generally lack modern engineering systems and thermal insulation. Energy performance is typically poor, with estimated annual energy demand reaching around 277 kWh/m^2.

Stalinka buildings

Built primarily between the 1930s and early 1950s, these represent the first wave of standardised Soviet urban housing. Built mostly from brick with reinforced concrete or mixed floor systems, Stalinka buildings retained many qualities of pre-revolutionary architecture, including high ceilings (around 3.1 m), spacious living quarters and thick external walls. In central districts, façades were often decorated with stucco, bas-reliefs and monumental architectural elements.

IEA. CC BY 4.0.

Although structurally durable and offering relatively good sound insulation and thermal mass, Stalinka buildings are highly energy-intensive due to their outdated heating systems, limited insulation, and ageing infrastructure. Indicative annual energy demand reaches approximately 323 kWh/m².

Khrushchevka buildings

This typology emerged during the rapid post-World War II urbanisation of the mid-1950s to late 1960s. Khrushchevka buildings became the dominant form of Soviet mass housing across Ukraine and remain one of the most widespread residential archetypes today. Their design prioritised rapid construction, standardisation and low construction costs. These buildings are generally characterised by:

- five- to nine-storey construction
- small apartment sizes and compact (typically 5-7 m²) kitchens
- low ceiling heights (around 2.5-2.55 m)
- thin reinforced concrete panel or brick external walls
- limited thermal and acoustic insulation
- combined bathrooms and narrow hallways.

Several sub-series were identified, among them the 1-215, 1-464 and 1-464A-20 series. Early brick Khrushchevka buildings generally perform somewhat better thermally than panel-based variants, though all typologies remain highly inefficient by modern standards. Estimated annual energy demand ranges from 327-352 kWh/m², among the highest values in the typology.

A defining characteristic of Khrushchevka buildings is the prevalence of prefabricated reinforced concrete panels with poor thermal resistance. Typical wall U-values range from 1.9-2.7 watts per square metre per degree Kelvin (W/m²K), significantly above modern standards.

Gostinka buildings

These were developed primarily between the 1960s and 1980s as compact housing for small households, young families or temporary residents. Gostinka buildings are characterised by corridor-based layouts with high apartment density and a predominance of one-room (studio) apartments. Typical features include:

- nine-storey layouts with technical floors
- small apartment areas (25-35 m²)
- minimal kitchen and bathroom sizes
- corridor-type circulation systems
- limited elevators and shared infrastructure.

IEA. CC BY 4.0.

While some variants used brick construction, many later series relied on large-panel prefabrication systems with poor thermal performance. Indicative annual energy demand varies widely between 247-321 kWh/m² depending on construction series and wall systems.

Czech project buildings

This building type (1-KG-480 series), widely built from the mid-1960s to the late 1970s, represented an incremental improvement on Khrushchevka buildings. Czech project buildings introduced more spacious layouts, enlarged balconies, improved apartment orientation and better circulation systems. Most are nine-storey panel structures with:

- separate rooms in larger apartments
- expanded balconies and bay windows
- improved apartment layouts
- larger apartment sizes (up to 70-75 m² for three-room units).

Nevertheless, thermal performance remained weak due to continued reliance on thin concrete panel systems. Estimated annual energy demand remains high at 278-284 kWh/m².

Late Soviet buildings (1970s to 1990s)

The next generation of Soviet housing included several improved panel and brick typologies such as the 87, BPS, 134 and 96 series. These buildings, built mainly between the 1970s and 1990s, introduced:

- larger apartment areas
- improved room separation
- elevators and garbage chutes
- bigger kitchens
- more complex section configurations
- technical floors and enhanced layouts.

High-rise construction became increasingly common during this period, with many buildings reaching 12 to 18 storeys. Brick series such as the 87 series generally demonstrate somewhat better thermal characteristics than panel-based systems. However, panel buildings from this era continue to experience significant heat loss due to thermal bridges and poorly sealed joints between panels. Indicative annual energy demand for these buildings' ranges from 224-275 kWh/m².

IEA. CC BY 4.0.

Early post-Soviet and transition-period buildings (1990s to 2000s)

Buildings constructed after Ukrainian independence reflect a transition toward larger apartments, improved comfort standards and more diverse architectural solutions. Common typologies include KT, T-series, APPS, KP, KS, ES and KTU buildings. Key improvements included:

- larger kitchen sizes (often 8-15 m²)
- larger hallways and storage spaces
- improved glazing
- greater use of insulated panels
- more flexible apartment layouts
- widespread installation of freight elevators and technical floors.

Despite these improvements, buildings from this era still relied heavily on prefabricated concrete systems with insufficient thermal insulation by current standards. Indicative annual energy demand typically ranges between 208-248 kWh/m².

Modern buildings

Buildings constructed after 2000 represent a major shift toward contemporary residential design and higher energy performance standards. These include both serial and non-serial “special projects,” often using monolithic reinforced concrete frames, aerated concrete blocks, multi-layer façades and improved glazing systems. Modern buildings are characterised by:

- flexible layouts and open-plan kitchens
- larger apartment areas
- improved façade insulation
- lower wall U-values (as low as 0.21-0.23 W/m²K)
- improved glazing systems
- integrated balconies, terraces and loggias
- greater architectural diversity.

Indicative annual energy demand for recent buildings falls to 127-158 kWh/m², representing a substantial improvement over Soviet-era archetypes, although performance remains below European building standards.

Key observations across apartment building typologies

Ukraine’s apartment building stock consists largely of mass housing built during the Soviet era, from the 1950s to 1990s, primarily using prefabricated reinforced concrete panels designed to enable rapid, low-cost urbanisation. These buildings

IEA. CC BY 4.0.

– including Khrushchevka, Czech project, BPS, 96 and APPS series – typically have poor thermal performance due to thin external walls, significant thermal bridging, ageing heating systems and inadequate airtightness. As a result, many archetypes have very high estimated energy demand, often exceeding 250-350 kWh/m² per year, with the least efficient rated Class G.

At the same time, the standardisation of these building types creates opportunities for large-scale energy-efficient renovation. Repeated designs across entire districts enable standardised retrofit packages combining façade insulation, roof upgrades, window replacement, ventilation improvements and heating system modernisation. Buildings constructed after 2000 have progressively better thermal performance, with lower wall U-values, improved glazing and lower energy demand of around 127-158 kWh/m² per year. However, many still fall short of advanced near-zero building standards.

Private houses

Unlike apartment buildings, Ukraine's private housing stock is considerably more heterogeneous and less standardised, reflecting regional traditions, individual construction practices, varied income levels and evolving architectural preferences. The identified archetypes range from traditional rural clay houses and mid-century detached homes to modern energy-efficient villas and eco-houses. Differences in construction materials, envelope quality, heating systems, and overall energy performance result in wide variations in thermal performance and energy demand.

Overview of archetypes for private houses in Ukraine

Building archetype	Description	Estimated delivered energy demand
Individual houses up to 1960	Traditional rural houses built from clay, straw, wood and brick with limited insulation and basic heating	~400 kWh/m² per year
Individual houses 1960-1970	Detached homes built using more uniform brick or wood construction methods	~395 kWh/m² per year
Traditional rural houses (1970s to 1980s)	One-storey rural houses with improved construction quality but generally inefficient insulation and heating systems	~280 kWh/m² per year
Typical cottages (1980s to 1990s)	Larger brick or block houses with improved layouts and moderate improvements in thermal performance	~220 kWh/m² per year
Post-Soviet houses (1990s to 2000s)	Houses using more modern materials and layouts with gradual improvements in insulation and comfort	~210 kWh/m² per year
Modern private houses (2000s to 2020s)	Contemporary detached houses with improved insulation, glazing and construction materials	~190 kWh/m² per year
Eco-houses and energy-efficient buildings (2020-2024)	Low-energy houses using sustainable materials, efficient insulation and renewable energy systems	~180 kWh/m² per year

Note: Estimated delivered energy demand values are indicative and derived from representative examples identified within each archetype category. Actual performance varies depending on climatic conditions, occupancy patterns, user behaviour, renovation status and heating system configuration.

IEA. CC BY 4.0.

The oldest archetypes – including traditional village houses and detached houses constructed before the 1970s — were typically self-built using locally available materials such as clay, straw, wood and brick. These buildings generally feature compact layouts, pitched roofs, limited glazing areas, and simple heating systems based on wood-burning stoves. While thick clay or masonry walls can help regulate indoor temperatures by absorbing and releasing heat, these houses typically lack modern insulation, airtightness or efficient heating systems, resulting in estimated annual energy demand as high as 394-406 kWh/m² and an indicative energy efficiency rating of Class G.

From the 1970s onwards, private houses increasingly featured improved construction materials and more spacious interiors. Traditional rural houses and cottages built between the 1970s to 1990s increasingly used brick and block construction, larger windows and gas heating systems, bringing moderate improvements in thermal performance. Estimated energy demand for these archetypes declines to approximately 218-279 kWh/m² per year, although most remain highly energy intensive by modern standards.

A more significant shift occurred after the 1990s, with the emergence of modern private homes built using foam concrete, reinforced concrete, multilayer walls, improved glazing and more effective insulation. These buildings also introduced more open-plan layouts, larger floor areas, and higher comfort standards. Private homes built after 2000 increasingly feature energy-efficient materials, larger and better-performing windows and improved roof and floor insulation, reducing estimated energy demand to around 179-213 kWh/m² per year.

The newest archetypes – eco-houses and energy-efficient buildings developed after 2020 – place greater emphasis on low-energy design principles, renewable and natural materials, improved airtightness and integration of renewable energy technologies. These buildings often use wood, clay, straw, green roofs and high-performance glazing, achieving the lowest wall U-values in the typology (around 0.15 W/m²K) and the lowest estimated energy demand.

Overall, the private housing typology highlights the substantial efficiency gap between older, self-built homes and newer, energy-efficient housing. The diversity of private homes also means that renovations are likely to require more tailored approaches than in apartment buildings, with flexible policy instruments, targeted financial support and technical solutions adapted to different construction types and climatic conditions.

School buildings

Ukraine's school building stock reflects successive phases of educational infrastructure development, from masonry structures built before the Second World War to modern facilities. Many existing schools were built during the Soviet

IEA. CC BY 4.0.

period, particularly between the 1960s and 1980s, using standardised designs and prefabricated concrete panels. Designed primarily for rapid deployment and functionality rather than energy performance, these buildings typically have poor insulation, outdated engineering systems and high heating demand.

Overview of archetypes for school buildings in Ukraine

Building archetype	Description	Estimated delivered energy demand
Pre-1960	Traditional masonry or wood buildings with limited insulation and basic heating systems	~340 kWh/m² per year
1960-1970	Standardised brick buildings with functional layouts and basic central heating systems	~330 kWh/m² per year
1970-1980	Prefabricated concrete-panel buildings with expanded educational spaces and central heating	~240 kWh/m² per year
1980-1990	Improved brick and concrete buildings with better layouts and upgraded engineering systems	~180 kWh/m² per year
1990-2000	Mixed-design structures featuring gradual improvements in construction quality and amenities	~190 kWh/m² per year
2000-2020	Modern educational facilities with improved insulation, glazing and more energy-efficient systems	~150 kWh/m² per year
2020-2024	Recent, energy-efficient buildings incorporating sustainable materials and renewable energy systems.	~140 kWh/m² per year

Note: Estimated delivered energy demand values are indicative and derived from representative examples identified within each archetype category. Actual performance varies depending on climatic conditions, occupancy patterns, user behaviour, renovation status, and heating system configuration.

Older school archetypes typically feature brick, wood or concrete-panel construction with limited insulation, poor glazing performance, and outdated heating systems. Indicative wall U-values range from approximately 1.2-1.4 W/m²K in schools built before 1980, while estimated delivered energy demand reaches around 237-343 kWh/m² per year. Schools built after 2000 increasingly feature better insulation, better-performing windows, modern ventilation and cooling systems, and more energy-efficient designs, reducing estimated energy demand to around 139-146 kWh/m² per year.

Overall, the typology highlights the significant energy savings possible through deep renovation of existing educational facilities, particularly those built during the Soviet era. Key measures include façades and roof insulation, replacing windows, modernising heating systems, improving ventilation and integrating renewable energy to reduce energy use and improve indoor learning conditions.

Hospital buildings

Ukraine's hospital buildings have complex technical requirements, operate around the clock and consume more energy than most other public buildings. Many were designed to expand healthcare capacity quickly, with little consideration of energy performance, leaving them poorly insulated and saddled with ageing, energy-hungry engineering systems. Soviet-era hospitals constructed between the 1960s and 1980s

IEA. CC BY 4.0.

still account for a large share of the stock, typically feature prefabricated concrete structures, and suffer from poor thermal performance and substantial heat loss.

The typology shows a gradual shift from low-rise masonry facilities toward larger and more technically sophisticated hospital complexes incorporating central heating, ventilation, cooling (HVAC) systems and specialised medical equipment. Indicative wall U-values decline significantly across the archetypes – from approximately 1.2-1.6 W/m²K in older hospitals to around 0.2-0.3 W/m²K in more modern facilities – reflecting improvements in insulation materials and envelope design. Estimated delivered energy demand correspondingly declines from more than 320 kWh/m² per year in older archetypes to around 130-160 kWh/m² per year in modern hospitals. Hospitals nevertheless remain among the most energy-intensive building types because they operate continuously, require extensive ventilation and use energy-intensive medical equipment.

The typology highlights significant opportunities to improve energy efficiency and resilience across the healthcare sector, particularly through comprehensive renovations of building insulation, HVAC systems and on-site energy infrastructure.

Overview of archetypes for hospital buildings in Ukraine

Building archetype	Description	Estimated delivered energy demand
Pre-1960	Traditional masonry or wood structures with basic heating systems and limited insulation	~320 kWh/m² per year
1960-1970	Standardised brick buildings with central heating and functional layouts	~325 kWh/m² per year
1970-1980	Prefabricated concrete-panel buildings designed for expanded healthcare capacity and specialised medical functions	~290 kWh/m² per year
1980-1990	Improved brick and concrete structures with upgraded engineering systems and expanded facilities	~200 kWh/m² per year
1990- 2000	Mixed-design facilities with gradual improvements in materials, layouts, and building systems	~215 kWh/m² per year
2000-2020	Modern healthcare facilities with improved insulation, glazing and more energy-efficient engineering systems	~160 kWh/m² per year
2020-2024	Recent, energy-efficient buildings incorporating sustainable materials and advanced energy systems	~130 kWh/m² per year

Note: Estimated delivered energy demand values are indicative and derived from representative examples identified within each archetype category. Actual performance varies depending on climatic conditions, occupancy patterns, user behaviour, renovation status and heating system configuration.

Conclusions on building typology

The building typology developed for this analysis provides a structured representation of Ukraine's diverse building stock across the residential and public sectors. It captures the evolution of construction practices, materials, engineering systems and energy performance from masonry buildings constructed before the Second World War to modern low-energy developments. The analysis shows that many of Ukraine's buildings – particularly Soviet-era apartment blocks, schools

IEA. CC BY 4.0.

and hospitals – have poor insulation, inefficient heating systems and high energy demand. More recent archetypes generally demonstrate better energy performance. The standardised designs of Soviet-era building types also create significant opportunities to apply energy-efficiency upgrades at scale and replicate them across similar buildings.

To assess the technical and economic potential for energy efficiency improvements in greater detail, this report's quantitative analysis focuses on four common building archetypes:

- Stalinka multi-apartment building
- Khrushchevka-464A multi-apartment building
- detached single-family house
- typical Soviet-era school building.

These archetypes were selected to represent different construction periods, building uses, construction methods and energy performance characteristics across Ukraine's building stock. The following section outlines the methodology used to assess their energy efficiency potential, identify upgrade pathways and estimate energy cost savings, before presenting the detailed results of each archetype.

Assessment methodology

This section presents the methodology used to assess the energy performance, energy savings potential, upgrade costs and long-term economic implications of different reconstruction and renovation pathways for selected building archetypes in Ukraine. The approach combines archetype-based assessments of energy savings and economic benefits to evaluate how different levels of building envelope upgrades and heating system modernisation (hereafter, "upgrade packages") affect delivered energy demand, energy costs, investment needs and the cost-effectiveness of energy efficiency measures.

The methodology is designed to support both near-term reconstruction planning and longer-term policy development by providing a transparent and scalable analytical framework applicable across different building typologies. It enables comparison of alternative upgrade packages under different energy tariff assumptions and performance levels. The following subsections describe the assessment framework, assumptions, cost assessment approach and economic indicators used throughout the analysis.

IEA. CC BY 4.0.

Energy savings

This part of the analysis uses a structured approach to assess the energy performance of selected building archetypes in Ukraine and estimate the implications of alternative reconstruction and renovation pathways. The methodology is designed to support both near-term recovery planning and longer-term policy development by linking building-level energy performance to broader needs for construction materials, technologies, investment, infrastructure and workforce capacity. In line with the approach used in recent IEA work focused on the People's Republic of China, the methodology combines a transparent analytical framework to evaluate how different upgrade packages for improving building energy performance affect energy demand and related outcomes across the building stock.

The analysis is based on representative building archetypes. Archetypes are used to reflect the principal characteristics of common building typologies in Ukraine, including differences in use, scale, form, construction and thermal performance. They are not intended to reproduce the full diversity of the national building stock. Rather, they provide a standardised basis for modelling a variety of building types in a way that enables comparison across those typologies, climate conditions and energy performance selections. This archetype-based structure allows the assessment to move from individual building-level calculations to typology-level estimates of energy demand, emissions and reconstruction needs.

The methodology applies the IEA's Building Energy Efficiency Performance Tool as a simplified building energy calculation that tests different building energy performance parameters. The tool estimates annual building energy demand for heating and cooling, as well as the associated delivered energy demand, accounting for heating system efficiency, key physical characteristics of the building, typical usage patterns and local climate conditions. It does not seek to replicate the full complexity of a dynamic simulation model. Instead, it focuses on the main determinants of heating and cooling demand and provides a clear framework for testing the implications of policy and regulatory assumptions, including requirements related to building codes, component standards and performance thresholds.

For the selected Ukrainian building typologies, the analysis estimates heating, and, to a lesser extent, cooling demand under standardised operating and climate conditions. These estimates are based on the typology review, including U-values, climate data, standardised indoor temperatures and ventilation requirements. Together, these inputs determine the expected demand for heating and cooling services (i.e. energy service demand). The estimates also account for heating and cooling system efficiency (not included in the Ukrainian typologies) to determine the amount of delivered energy (natural gas, electricity or district heat) required to

IEA. CC BY 4.0.

meet the energy service demand. These two estimates show how different combinations of building materials and heating system improvements can affect energy use across selected Ukrainian building typologies.

Estimated service energy demand (heating and cooling) and associated delivered energy by building archetype

Typology	Service (heating/cooling) demand (kWh/m^2/year)	Delivered heating/cooling energy (kWh/m^2/year)
Stalinka 1945-60 (apartment building)	146	286
Khruschevka 464A 1960-70 (apartment building)	187	367
96 1970-96 (apartment building)	122	135
KT 1976 (apartment building)	101	112
Gostinka 1y-438-20 (apartment building)	113	125
APPS (K-134) (apartment building)	82	91
House pre-1960	331	487
House 1960-1970	422	621
House 1970-1980	467	519
House 1980-1990	222	246
School 1960-1970	202	297
School 1980-1990	134	144
Hospital 1960-1970	186	200
Hospital 1980-1990	117	126

Note: Estimated service and delivered energy demand values are indicative and derived from representative examples identified within each archetype category. Actual performance varies depending on climatic conditions, occupancy patterns, user behaviour, renovation status and heating system configuration.

The analysis considers multiple upgrade packages with different levels of achieved building energy performance and different depths of energy efficiency improvement. These packages may include reconstruction to baseline conditions; reconstruction or renovation to meet higher-performance envelope standards; or deeper renovation and reconstruction that combine improvements to the building fabric (i.e. physical structure) with more efficient heating and cooling systems. This package-based approach is preferred because reconstruction or renovation choices can lock in building performance outcomes for decades, affecting future energy demand, operating costs and emissions. It also allows the analysis to compare the scale of additional materials, technologies and investments needed to move from basic restoration to higher-performance and lower-carbon outcomes.

For each selected archetype, the assessment requires a defined set of inputs covering building information, geometry, thermal characteristics, energy service demand, climate conditions and material composition. Building information includes location, building type and key design features such as the window-to-

IEA. CC BY 4.0.

wall ratio, frame-to-window ratio, ceiling height, number of external doors and airtightness, expressed as an air change rate. These parameters are used to estimate heat losses and gains through the building envelope and air exchange. As the method covers a range of building typologies, the values are defined separately for each archetype to reflect differences between, for example, single-family homes, multi-storey residential buildings and non-residential buildings.

The geometry and envelope module defines the physical dimensions and thermal characteristics of the main building elements. For each archetype, the model includes the dimensions and orientation of walls, windows, doors, roofs and floors, along with their corresponding U-values. These U-values may be entered directly where reliable data are available or derived from the material composition of the building element. The inclusion of orientation makes it possible to estimate directional solar gains through opaque and glazed surfaces, while the envelope characteristics determine the scale of transmission losses and gains over the year.

A separate module captures annual energy service demand for end uses such as lighting, hot water, fans, information and communication technology and other plug loads. These values are expressed per unit of floor area and are used both as energy-demand inputs and as a proxy for internal heat gains. This is a simplified representation of operational loads, but it provides a practical basis for comparing different building typologies where detailed end-use metering data are not consistently available. The approach is particularly useful in the Ukrainian context, where the need for timely stock-level assessment may require the use of benchmark and archetype-based assumptions.

Climate data are used to estimate both solar gains and heat losses through the building envelope. The model requires average monthly temperatures and solar radiation values by orientation, expressed as representative values for the relevant city or climate zone for the selected archetype buildings. For the propose of the analysis, these archetypes are analysed using the Kyiv climate. This allows the methodology to capture regional differences in heating and cooling demand while maintaining consistency across a large and diverse set of building typologies.

The building physics component combines geometry, thermal performance, internal gains, airtightness and climate data to calculate monthly and annual energy balances. It estimates solar transmission gains, fabric heat losses or gains, and air-exchange losses, and uses these to derive annual service energy demand for space heating and cooling. Because the same analytical structure is applied to each archetype, the results can be compared systematically across typologies and upgrade packages. This makes it possible to identify which building types have the highest demand, the greatest potential for improvement, or the strongest sensitivity to changes in envelope standards, airtightness or system performance.

IEA. CC BY 4.0.

The methodology also incorporates the performance of heating and cooling systems. Delivered energy demand is calculated by adjusting service demand according to the efficiency of the relevant system, expressed through a coefficient of performance or an equivalent efficiency indicator. The model also estimates heating and cooling system sizing based on design temperature conditions, which for the Ukrainian stock is to achieve a setpoint of 21ºC. In addition, a primary energy perspective can be applied through the use of primary energy ratios or factors, which account for upstream losses in the generation and delivery of the relevant energy carrier. This enables comparison not only of building demand, but also of the wider system implications of different technology choices across building typologies.

Material composition is included through a dedicated module that calculates the thermal transmittance of walls, roofs and floors based on the thickness and conductivity of each material layer. This enables the derivation of U-values where direct inputs are not available, and supports transparent comparison of different construction assemblies and retrofit measures. In the context of reconstruction planning, this is especially important because it links energy performance improvements to the additional materials required to deliver them. The assessment can therefore be used not only to estimate operational energy demand, but also to quantify the amount and type of materials and technologies needed under different reconstruction and upgrade packages, as well as associated embodied emissions where relevant.

For each building typology and upgrade package, the methodology generates a consistent set of outputs. These include service energy demand for heating and cooling, delivered energy demand accounting for system efficiency, primary energy demand and greenhouse gas emissions, as well as estimates of the materials and technologies required to improve building performance. At a broader level, the results can be aggregated to estimate investment needs, infrastructure implications and workforce requirements associated with the reconstruction and renovation of different parts of the Ukrainian building stock. This provides a basis for identifying priority building categories, comparing reconstruction pathways and assessing the trade-offs between short-term restoration and longer-term performance improvements.

The methodology provides a practical, scalable approach to assessing the energy performance of different building typologies across Ukraine. By combining archetype-based modelling, analysis of retrofit packages and clearly defined physical assumptions, it enables reconstruction options to be evaluated not only in terms of restoring buildings, but also of improving energy performance and supporting broader climate, resilience and energy security objectives.

IEA. CC BY 4.0.

Energy cost savings and costs of upgrades

A separate cost assessment was used to estimate both the cost of energy use and the cost of retrofit interventions for the building typologies included in the analysis. This economic component is designed to complement the building energy modelling by translating the physical outputs of the model into financial indicators that can be compared across building types and intervention cases. The cost assessment uses available tariff data to estimate energy costs and savings based on modelled energy demand, and applies technology and materials cost data to estimate the costs of retrofit packages for each building typology.

The first component of the cost assessment estimates energy costs and savings by applying the relevant tariffs for electricity, gas or district heating to the modelled energy demand of each building case. Energy savings are then calculated by comparing the demand of each improved case with that of the corresponding baseline case for the same typology. The results are expressed both in physical terms (energy saved per square metre) and in monetary terms, based on the applicable tariffs.

The second component estimates retrofit costs by applying unit cost data to the materials and technologies included in each intervention package. The cost inputs are based on a combination of published research and a desk-based review of local market data in Ukraine. For apartment typologies, the analysis draws primarily on published research into building envelope and heating system improvements. For typical houses, it relies more heavily on prices observed from product retailers and service providers. Where possible, installed costs, including labour, are used to better reflect implementation conditions.

Estimated costs of typical retrofit for building energy upgrades in Ukraine (2025 UAH)[2]

Element	Minimum price	Maximum price	Unit
Apartment			
Wall insulation	1 370	1 915	UAH/m^2
Roof insulation	2 200	3 080	UAH/m^2
Floor insulation	1 020	1 420	UAH/m^2
Glazing upgrade	4 000	5 600	UAH/m^2
Heat exchanger upgrade	4 300	6 010	UAH/kW
Heat pump upgrade	26 000	36 460	UAH/kW
Scaffolding	54	76	UAH/m^2
House			
Wall insulation	1 370	1 915	UAH/m^2
Roof insulation	125	175	UAH/m^2
Floor insulation	650	910	UAH/m^2
Glazing upgrade	5 500	7 700	UAH/m^2
Boiler upgrade	7 800	10 920	UAH/kW
Heat pump upgrade	26 000	36 460	UAH/kW

[2] Exchange rate: 1 UAH = 0.02200 USD (as of November 2026).

IEA. CC BY 4.0.

For fabric measures, retrofit costs are calculated by applying unit costs to the relevant areas of the building envelope. This includes measures such as wall insulation, roof insulation, floor insulation and glazing upgrades, which are costed per square metre of the associated building element. Because the building geometry varies by typology, the same measure can result in different total costs across detached houses, apartment buildings and other archetypes. This ensures that retrofit costs remain directly linked to the physical characteristics of each building typology.

For technology measures, retrofit costs are calculated using unit costs that scale with system capacity. Heating system upgrades, for example, are costed per kilowatt (kW) of installed capacity so that the cost of the measure reflects the size of the system required for a given building typology and energy demand profile. This approach aligns the cost calculation with the service demand and system sizing outputs of the energy model. It therefore allows consistent comparison of alternative system upgrades across different building types.

To reflect uncertainty in market conditions and implementation complexity, the methodology uses lower- and upper-bound cost estimates for key measures. In cases where desk research is used, the lower value reflects the observed or published price, while the upper value is derived by applying an overall 40% adjustment to reflect more complex installation conditions or higher-cost products. This range-based approach provides a more robust basis for assessing costs in a context where prices may vary significantly across suppliers, products and locations.

The cost assessment also includes a longer-term indicator of economic performance. Future energy cost savings are discounted over a 20-year period using a 5% annual discount rate to calculate their present value in dollars (USD). These discounted savings are then compared with retrofit costs to calculate the levelised cost of saved energy. This provides a common basis for assessing the cost effectiveness of retrofit packages across different building typologies and levels of intervention.

Taken together, the energy performance estimation and cost assessment provide an integrated framework for analysing building reconstruction and renovation pathways in Ukraine. The first estimates how different intervention packages affect building energy performance, while the second estimates how those changes translate into energy costs, retrofit costs and longer-term economic value. This combined approach makes it possible to compare technical and financial outcomes across a range of building typologies and to support more informed decisions on reconstruction priorities, investment needs and policy design.

IEA. CC BY 4.0.

Levelised cost of saved energy and net cost savings

To assess the economic performance of different building renovation pathways, this analysis applies two complementary indicators: the levelised cost of saved energy (LCSE) and cumulative net cost savings over a 20-year period. The methodology was applied to the four selected building types across multiple renovation and reconstruction scenarios, combining different levels of building envelope modernisation and heating system upgrades.

The LCSE indicator measures the discounted cost of achieving one unit of energy savings over the lifetime of an energy-efficiency measure. It is calculated as:

LCSE = upfront costs of energy-efficiency measure / discounted lifetime energy savings

where upfront costs of an energy efficiency measure include the initial investments in building envelope and heating system upgrades, while discounted lifetime energy savings are expressed in kilowatt hours per square metre (kWh/m²) over the 20-year assessment period. A discount rate of 5% is assumed in all calculations in this report.

The LCSE metric provides a consistent basis for comparing retrofit cases with different investment costs and energy performance levels. This method factors in the time value of money through discount rates, making it possible to compare results across projects and technologies. Lower LCSE values indicate lower costs of achieving energy savings and therefore greater cost-effectiveness of retrofit measures.

To assess the economic attractiveness of energy efficiency measures under different energy price conditions, the analysis compares LCSE values against residential energy tariffs. Net savings per unit of energy saved are calculated as:

net savings (USD/kWh) = energy tariff − LCSE

Positive values indicate that the monetary value of avoided energy consumption exceeds the discounted cost of achieving those savings, while negative values indicate that retrofit measures are not fully recovered through energy cost savings alone under the assumed tariff conditions.

The charts additionally present cumulative net savings over 20 years, expressed in USD/m², calculated by applying net savings per kWh across the total discounted lifetime energy savings achieved by each retrofit case. This provides an estimate of the aggregate long-term economic benefit of renovation measures at the building level.

The analysis considers two tariff scenarios:

IEA. CC BY 4.0.

- current regulated residential energy tariffs in Ukraine
- higher adjusted tariffs intended to reflect potential future market-oriented energy pricing.

Assumptions for energy tariffs used in the analysis

The analysis applies current regulated residential energy tariffs in Ukraine as a baseline, combined with an adjusted electricity tariff case to reflect a likely evolution toward more cost-reflective energy pricing during reconstruction and market reform. Residential electricity tariffs are based on the tariff established by Resolution No. 632 of the Cabinet of Ministers of Ukraine, which set household electricity prices for electricity based heating at UAH 2.64/kWh (for monthly consumption up to 2 000 kWh – approximately USD 0.06/kWh at prevailing exchange rates) and it will remain unchanged until at least October 2026. Residential natural gas tariffs are assumed at approximately UAH 0.9/kWh (around USD 0.02/kWh), while district heating tariffs are represented by an average heat cost equivalent of approximately UAH 2.24/kWh (around USD 0.03-0.034/kWh).

Current residential electricity tariffs in Ukraine remain substantially below full cost-recovery levels and below European market averages. Therefore, an adjusted electricity tariff of USD 0.19/kWh was additionally applied in parts of the economic assessment to reflect possible medium- to long-term tariff convergence under electricity market reform, infrastructure recovery needs and increasing system costs. This assumption is informed by statements from the Ministry of Energy of Ukraine indicating that the estimated market price of electricity in Ukraine was already close to UAH 7.5/kWh (approximately USD 0.18/kWh). The adjusted tariff case therefore reflects the more cost-reflective electricity price environment that is likely to emerge as Ukraine reconstructs and modernises its energy system.

Considering both current and adjusted tariff scenarios allows the cost effectiveness of energy efficiency measures to be assessed under present-day conditions as well as potential future market-based pricing as Ukraine rebuilds and integrates with European energy markets.

Comparing the two energy tariff scenarios is particularly important in Ukraine, where regulated residential energy tariffs continue to shape the economic case for energy efficiency investments. Artificially low end-user tariffs reduce the financial benefits of saving energy and can weaken incentives for deep renovation and electrification, even where the technical potential for energy savings is substantial.

The selected methodology is particularly suitable for assessing building retrofits and building reconstruction in Ukraine for several reasons.

IEA. CC BY 4.0.

First, Ukraine faces substantial reconstruction needs and limited public and private financial resources. LCSE allows upgrade packages to be compared based on the cost of delivered energy saved, rather than upfront investment alone.

Second, the methodology enables comparison of shallow, medium-depth and deep upgrade packages, combining different levels of:

- building envelope improvements (to achieve moderate or high energy performance)
- district heating modernisation
- heat pump deployment.

Third, the framework accounts for how future energy prices may affect the economic viability of reconstruction and renovation pathways. This is especially relevant in Ukraine, given anticipated tariff reforms, changes to energy markets and the need to reduce dependence on imported fossil fuels.

Finally, the methodology supports the assessment of reconstruction and renovation pathways against Ukraine's long-term policy objectives, including:

- implementing near-zero energy building standards (nZEB)
- electrifying heating
- integrating renewable energy
- strengthening energy security and resilience by reducing building energy demand.

By combining technical energy performance with lifecycle economic assessment, the methodology provides a practical framework for identifying reconstruction and renovation pathways capable of delivering cost-effective and scalable energy-efficiency outcomes for Ukraine's building sector.

IEA. CC BY 4.0.

Results of energy-efficiency potential assessments

To assess the potential for energy efficiency improvements and decarbonisation across Ukraine's building stock, four representative building archetypes were selected from the broader national typology developed for this study. These archetypes cover some of the country's most common and energy-intensive building categories, reflecting differences in construction periods, structural systems, ownership patterns and heating characteristics. Together, they account for a substantial share of national heating demand and illustrate the range of retrofit and reconstruction challenges across the residential and public building sectors. The selected archetypes include:

- "Stalinka" multi-apartment building
- "Khruschevka-464A" multi-apartment building
- detached single-family home
- typical Soviet-era school building.

These archetypes were selected because they are widely distributed building forms across Ukrainian cities and regions, represent major historical construction periods of the Soviet era and typically exhibit high levels of heat loss and low thermal performance. They also account for a significant share of current building energy consumption and include building types frequently damaged during the war and that are likely to undergo reconstruction or deep renovation.

The analysis presented for these four building types can be replicated for any of the other 44 archetypes included in the broader Ukrainian building typology described earlier in this report.

For each selected archetype, the analysis assesses potential energy savings from building envelope improvements and heating system upgrades, alongside the associated retrofit investment costs and operational energy cost savings. It also evaluates lifecycle cost-effectiveness over a 20-year period and examines how current and adjusted energy tariff scenarios affect net economic savings.

The assessment compares upgrade packages ranging from moderate improvements to deep renovation, including high-performance building envelope upgrades and heat pump integration. This approach helps identify technically and economically optimal pathways for scaling up renovation and reconstruction across Ukraine's diverse building stock.

IEA. CC BY 4.0.

Stalinka

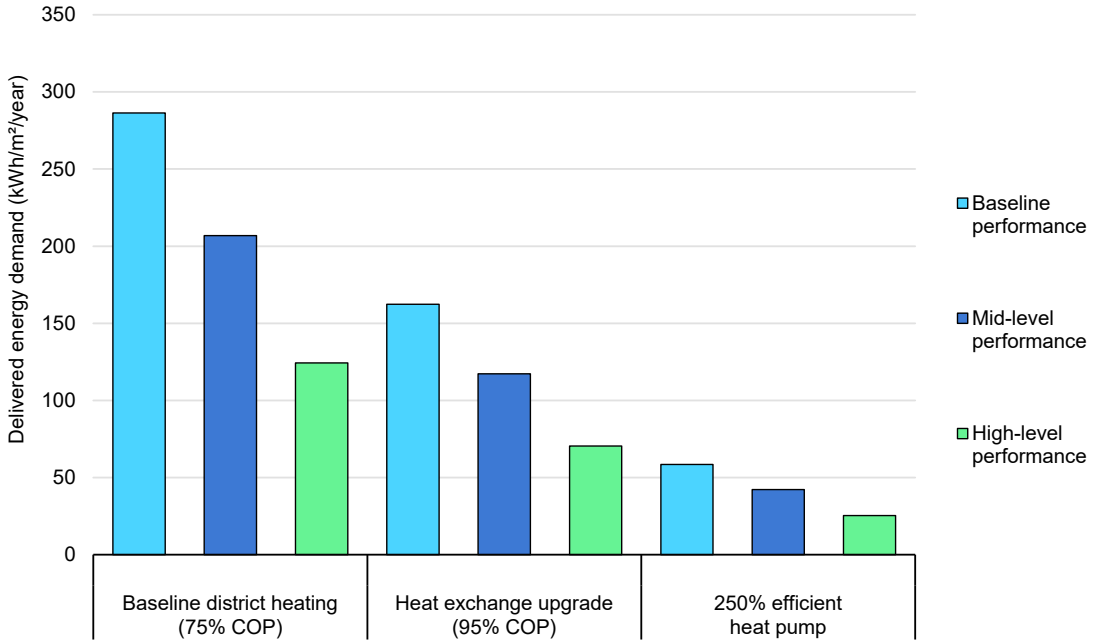
This archetype comprises masonry apartment buildings constructed mainly between 1945 and 1960. Typically, four to six storeys high, these buildings were designed with relatively generous ceiling heights, thick brick walls and large windows. Their structure generally consists of load-bearing brick walls and reinforced concrete floor slabs.

Despite comparatively robust construction quality relative to later Soviet-era housing, these buildings generally have poor thermal performance due to:

- uninsulated solid brick walls
- thermal bridges at floor slabs and balconies
- outdated wooden window frames with significant air leakage
- poorly insulated roofs and basements
- ageing centralised heating systems with limited control capabilities.

The analysed archetype is estimated to have a space heating and cooling of approximately 146 kWh/m² per year and a delivered energy demand of around 286 kWh/m² per year, reflecting the low efficiency of the heating system.

Delivered energy demand by upgrade package for a typical Stalinka-type building



IEA. CC BY 4.0

Notes: COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

IEA. CC BY 4.0.

Delivered energy demand and savings by upgrade package for a Stalinka-type building

Envelope performance	Heating system option							
	Baseline district heating (75% COP)		Heat-exchanger upgrade (95% COP)			250% efficient heat pump		
Baseline	286		162			58		
Mid-level	207		117			42		
High-level	124		70			25		
Energy savings (kWh/m² per year)	80	162	124	169	216	228	244	261
Energy savings (%)	28%	57%	43%	59%	75%	80%	85%	91%

Notes: Energy savings are measured against the baseline. COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

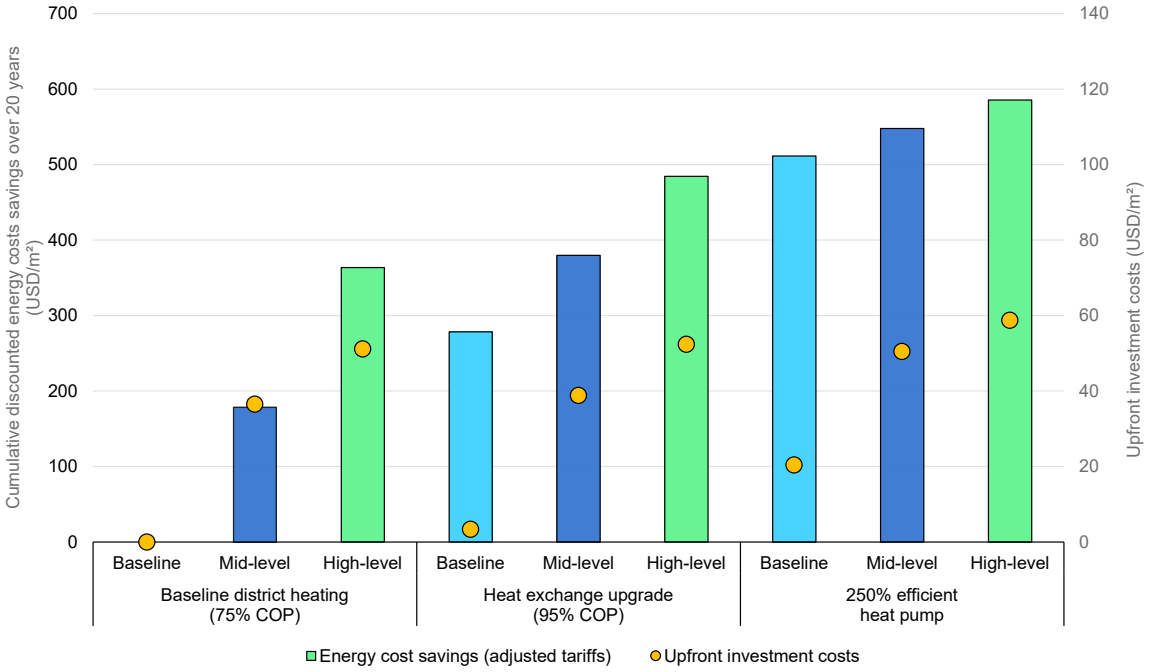
The results show that switching from conventional district heating to high-efficiency heat pumps delivers the largest reduction in delivered energy demand across all upgrade packages. In the analysed Stalinka building, replacing the baseline district heating system with a heat pump reduces delivered energy demand from approximately 286 kWh/m² per year to 58 kWh/m² even without substantial envelope upgrades, corresponding to energy savings of approximately 80%. This reflects the higher efficiency of heat pumps, which draw on ambient renewable heat and therefore require substantially less delivered energy than conventional heating systems to provide the same amount of heat.

Building envelope upgrades remain essential because they reduce a building's underlying thermal demand and improve overall system performance. Under baseline district heating conditions, advanced envelope retrofits reduce delivered energy demand to 124 kWh/m² per year from approximately 286 kWh/m², a savings of around 57%. When combined with efficient heat pumps, these upgrades reduce delivered energy demand further, to approximately 25 kWh/m² per year, representing an overall savings of around 91% relative to the baseline building.

The analysis highlights strong synergies between heating electrification and building envelope modernisation. Heat pumps deliver the largest direct reductions in delivered energy demand, while envelope upgrades further improve energy performance, reduce peak heating loads, enhance thermal comfort and increase long-term system efficiency. These synergies are particularly important in the Ukrainian context, where large-scale heating electrification of heating must be balanced against constraints on electricity infrastructure and winter peak demand.

IEA. CC BY 4.0.

Cumulative discounted energy cost savings and upfront retrofit costs by building-envelope and heating-system upgrade package for a typical Stalinka-type building



IEA. CC BY 4.0

Notes: COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

The analysis shows that upgrade packages combining improvements to heating systems and building envelopes can deliver substantial long-term reductions in energy costs, although with important trade-offs in upfront investment requirements.

Under baseline district heating conditions, upgrade packages focused primarily on envelope improvements delivered only modest energy cost savings over the assessment period. Moderate envelope upgrades deliver savings of approximately USD 35/m² over 20 years, while advanced envelope upgrades can double these savings. Although these measures significantly reduce thermal demand, the resulting financial savings remain limited under current regulated residential energy tariffs in Ukraine.

Improving heating system efficiency substantially increases cumulative energy cost savings across all upgrade packages. Packages that include heat exchanger improvements deliver cumulative savings of approximately USD 50-90/m², depending on envelope performance, while those incorporating high-efficiency heat pumps deliver the largest lifecycle energy cost reductions. Replacing conventional district heating with heat pumps delivers cumulative discounted savings of nearly USD 180/m² over 20 years, even without major envelope

IEA. CC BY 4.0.

improvements. Combining heat pumps with moderate or advanced envelope upgrades increases savings further, to approximately USD 190-205/m².

The results show that electrifying heating with high-efficiency heat pumps is the main driver of reductions in delivered energy consumption across the upgrade packages analysed. This reflects the substantial reduction in delivered energy demand compared to conventional district heating systems. Deep envelope retrofits remain an important complementary component, reducing thermal demand and peak heating loads while improving overall system performance, particularly when combined with heat pumps.

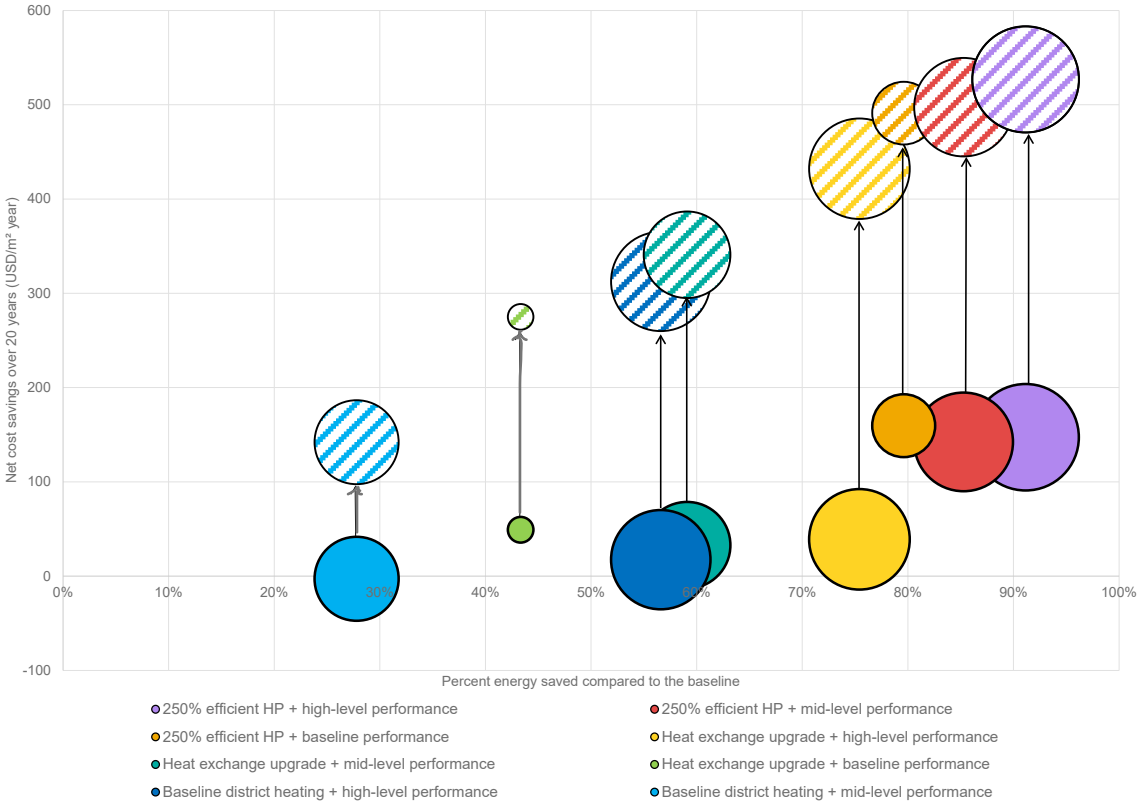
The analysis also highlights important trade-offs between lifecycle savings and upfront investment costs. Deep renovation packages combining advanced envelope retrofits with heat pumps deliver the greatest cumulative savings but require the largest capital investments — exceeding USD 200/m² in some cases. Medium-depth packages offer a more balanced trade-off between investment costs and lifecycle savings, potentially making them easier to scale up when reconstruction financing is limited.

This analysis is based on current regulated residential energy tariffs in Ukraine. Because energy prices remain relatively low, cumulative discounted savings are lower than would be expected under more cost-reflective pricing. Higher energy tariffs would significantly improve the financial attractiveness of deep renovation and heating electrification packages.

Overall, the results indicate that combining electrification with targeted envelope improvements can substantially reduce long-term building energy costs while supporting Ukraine’s reconstruction, energy security and decarbonisation objectives. However, scaling up these solutions will likely require concessional financing and targeted public support to overcome high upfront investment costs.

IEA. CC BY 4.0.

Energy savings and net cost savings over 20 years under current and increased energy tariffs for a typical Stalinka-type building



IEA. CC BY 4.0

Notes: HP=heat pump. The size of each bubble indicates the amount of upfront investment required for any given upgrade. Bubbles with a patterned fill show the results with increased energy tariffs, while solid bubbles reflect current energy tariffs.

Building on the previous analysis, it is important to consider how different upgrade packages perform when both energy savings and net lifecycle financial savings are assessed under current and increased tariff scenarios.

The results show that heating electrification through high-efficiency heat pumps is the primary driver of reductions in final delivered energy consumption across the upgrade packages analysed. Even without deep envelope improvements, upgrade packages centred on heat pump deployment achieve energy savings approaching 80% relative to the baseline, reflecting the substantial gains in heating system efficiency. Combining heat pumps with advanced envelope upgrades increases savings further, to approximately 90-95%, delivering the greatest reductions among the packages analysed.

Envelope improvements remain an important complement to heating system upgrades. Although their impact on delivered energy consumption is smaller once high-efficiency heat pumps are installed, deep envelope retrofits continue to reduce thermal demand, improve thermal comfort, lower peak heating loads and enhance overall system performance. These benefits are particularly important in

IEA. CC BY 4.0.

the Ukrainian context, where reducing peak demand and improving resilience during outages are strategically valuable.

The analysis shows that the greatest energy savings do not necessarily translate into the highest financial returns under current tariff conditions. Although deep upgrade packages deliver the largest reductions in energy demand, their high upfront investment costs limit net lifecycle savings when residential energy prices remain regulated and relatively low. As a result, several medium-depth upgrade packages offer a more attractive balance between energy savings, net cost savings and investment requirements.

The comparison between current and increased tariff scenarios highlights the strong influence of energy prices on retrofit economics. Under current tariffs, many ambitious upgrade packages deliver relatively modest net financial benefit despite substantial reductions in energy consumption. Under higher tariffs, the economic case for deep renovation strengthens considerably, particularly for packages combining high-performance envelopes with heat pumps. In several cases, cumulative net savings over 20 years more than double compared with the current tariff scenario.

The analysis therefore suggests that gradual tariff reform could strengthen incentives for thermal modernisation and heating electrification in Ukraine. However, higher tariffs would need to be accompanied by targeted financial support, and social protection measures to ensure that energy remains affordable for vulnerable households.

The results also highlight diminishing marginal returns at the highest levels of energy performance. Achieving additional energy savings beyond approximately 80% requires disproportionately greater investment. Although these ultra-deep upgrade packages are aligned with long-term nZEB and decarbonisation objectives, they are likely to require concessional financing and prioritisation for strategic building categories.

Beyond direct financial benefits, deep renovation and heating electrification also offer important resilience advantages for Ukraine. Buildings with efficient envelopes, heat pumps, rooftop solar and energy storage systems are better positioned to maintain thermal comfort during outages, reduce dependence on disrupted fuel supply chains and integrate with decentralised and renewable-based energy systems.

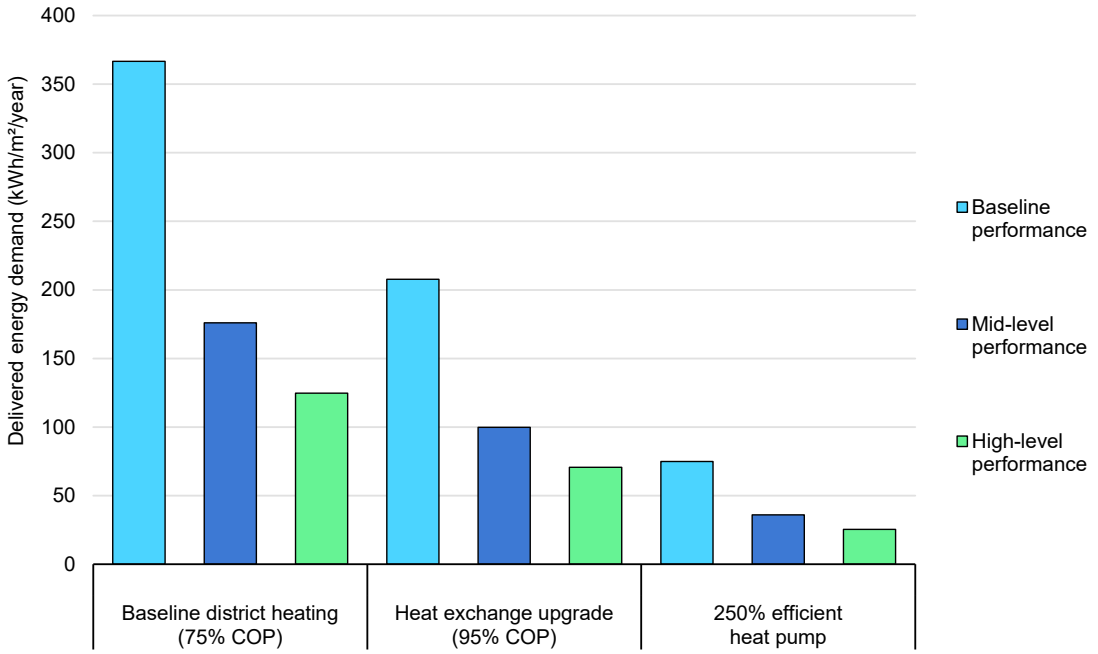
Overall, the analysis indicates that ambitious upgrade packages for Ukraine's Stalin-era residential building stock through can simultaneously reduce long-term energy demand, strengthen energy security, improve resilience and lower lifecycle costs. However, achieving these benefits at scale will require balancing technical ambition with affordability, financing capacity and the speed of implementation.

IEA. CC BY 4.0.

Khruschevka

The Khruschevka-464A is one of the most common residential building archetypes in Ukraine and across the former Soviet Union. Constructed primarily between the late 1950s and 1970s, these five-storey prefabricated panel buildings were designed as a rapid and low-cost solution to address the housing shortages that followed the Second World War. Although they successfully provided housing on a large scale, their construction standards reflected the technical and economic constraints of the time. As a result, many Khruschevka buildings have poor insulation, significant thermal bridges, ageing windows and inefficient heating systems, leading to high energy consumption and poor thermal comfort. Given their prevalence in Ukrainian cities and substantial energy-saving potential, Khruschevka buildings are an important target for large-scale renovation and reconstruction programmes.

Delivered energy demand by upgrade package for a typical Khruschevka-type building



IEA. CC BY 4.0

Notes: COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

IEA. CC BY 4.0.

Delivered energy demand and energy savings by upgrade, Khruschevka-type building

Envelope performance	Heating system option							
	Baseline district heating (75% COP)			Heat exchanger upgrade (95% COP)			250% efficient heat pump	
Baseline	367			208			75	
Mid-level		176			100			36
High-level			125			71			25
Energy savings (kWh/m² per year)		191	242	159	267	296	292	331	341
Energy savings (%)		52%	66%	43%	73%	81%	80%	90%	93%

Notes: Energy savings are measured against the baseline. COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

The assessment shows that both envelope improvements and heating system upgrades can substantially reduce delivered energy demand in a typical Khruschevka-464A building, although their relative contributions differ significantly.

With baseline district heating conditions and an assumed system efficiency of 75%, delivered energy demand falls from approximately 365 kWh/m² per year in the baseline case to around 175 kWh/m² per year with mid-level envelope performance upgrades and to approximately 125 kWh/m² per year with high-level envelope performance upgrades. These reductions of roughly 50% and 65%, respectively, demonstrate the significant impact of improved insulation, high-performance windows and enhanced airtightness in reducing thermal losses.

Upgrading heat exchangers further reduces delivered energy demand across all envelope performance levels. Under this package, energy demand falls to approximately 210 kWh/m² per year with the baseline envelope, 100 kWh/m² with mid-level envelope upgrades and 70 kWh/m² per year for high-level envelope upgrades. These results show that modernising heat delivery systems can complement envelope upgrades and deliver additional energy savings.

The largest reductions in delivered energy demand are achieved through heating electrification using high-efficiency heat pumps. Replacing conventional district heating with a heat pump reduces delivered energy demand to approximately 75 kWh/m² per year, even without significant envelope improvements, saving nearly 80% relative to the baseline. This reflects the substantial efficiency advantage of heat pumps over conventional heating systems. Combining heat pumps with mid-level envelope upgrades reduces delivered energy demand further, to around 40 kWh/m² per year, while the most ambitious upgrade package, combining a heat pump with high-performance envelope upgrades, lowers energy

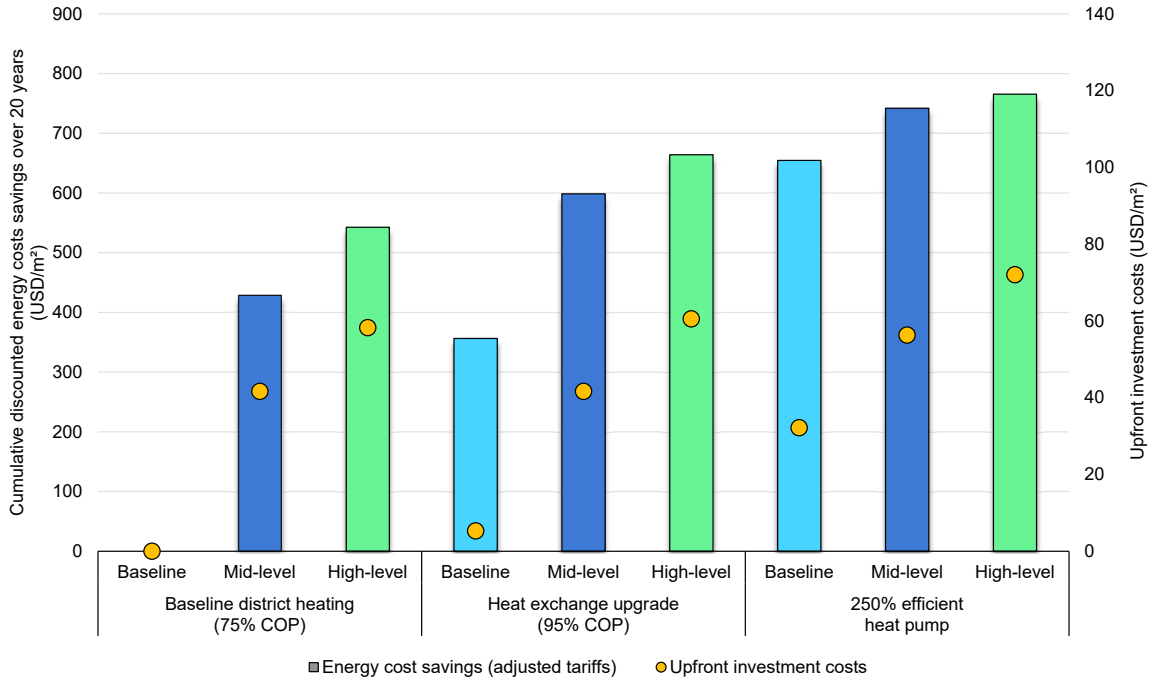
IEA. CC BY 4.0.

demand to approximately 25 kWh/m². This represents an overall reduction of more than 90% relative to the baseline.

The results show that heating electrification through heat pumps is the main driver of reductions in final delivered energy consumption for this archetype. Envelope improvements remain an important complementary component: deep retrofits reduce thermal demand and peak heating loads, improve thermal comfort and allow heating systems to operate more efficiently.

The findings suggest that substantial energy savings are possible through multiple upgrade pathways. Moderate envelope improvements alone can halve delivered energy demand, while combining envelope upgrades with heating system modernisation delivers progressively larger benefits. The highest-performing upgrade packages, which combine advanced envelope improvements with heat pumps, bring the building close to near-zero energy performance. These results highlight the potential to transform Ukraine's ageing Khruschevka housing stock into a highly efficient, resilient and low-carbon asset.

Cumulative discounted energy cost savings and upfront retrofit costs by building-envelope and heating-system upgrade for a typical Khruschevka-type building



IEA. CC BY 4.0

Notes: COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

The assessment shows that all upgrade packages deliver lifecycle energy cost savings relative to the baseline Khruschevka building, although the magnitude of

IEA. CC BY 4.0.

savings and required upfront investments vary significantly depending on the combination of envelope and heating system improvements.

With baseline district heating (75% efficiency), envelope-focused upgrades deliver energy cost savings of approximately USD 80/m² over 20 years with mid-level envelope performance and around USD 100/m² with high-level envelope performance. These results show that reducing thermal losses through improved insulation, windows and airtightness can substantially reduce energy costs even without upgrading the heating system.

Improving heating system efficiency through heat exchanger upgrades (95% coefficient of performance) further increases lifecycle savings across all envelope performance levels. Cumulative discounted savings rise to approximately USD 65/m² with the baseline envelope, USD 110/m² with mid-level envelope performance and around USD 125/m² with high-level envelope performance. These results show that modernising heat delivery systems can provide additional financial benefits when combined with thermal improvements.

The greatest cumulative energy cost savings are achieved by upgrade packages incorporating high-efficiency heat pumps. Even without significant envelope improvements, replacing conventional district heating with a heat pump generates cumulative discounted savings of approximately USD 230/m² over the assessment period. Combining heat pumps with mid-level or high-level envelope upgrades further increases savings to around USD 260-270/m², delivering the greatest lifecycle cost savings among the packages analysed.

The results indicate that heating electrification through heat pumps is the main driver of long-term energy cost savings in this archetype. This reflects the substantial reduction in delivered energy demand achieved by heat pumps and the large share of total building energy consumption accounted for by heating. Envelope improvements remain an important complement, reducing thermal demand and improving the overall heating system performance. However, their additional contribution to energy cost savings is smaller once high-efficiency heat pumps are installed.

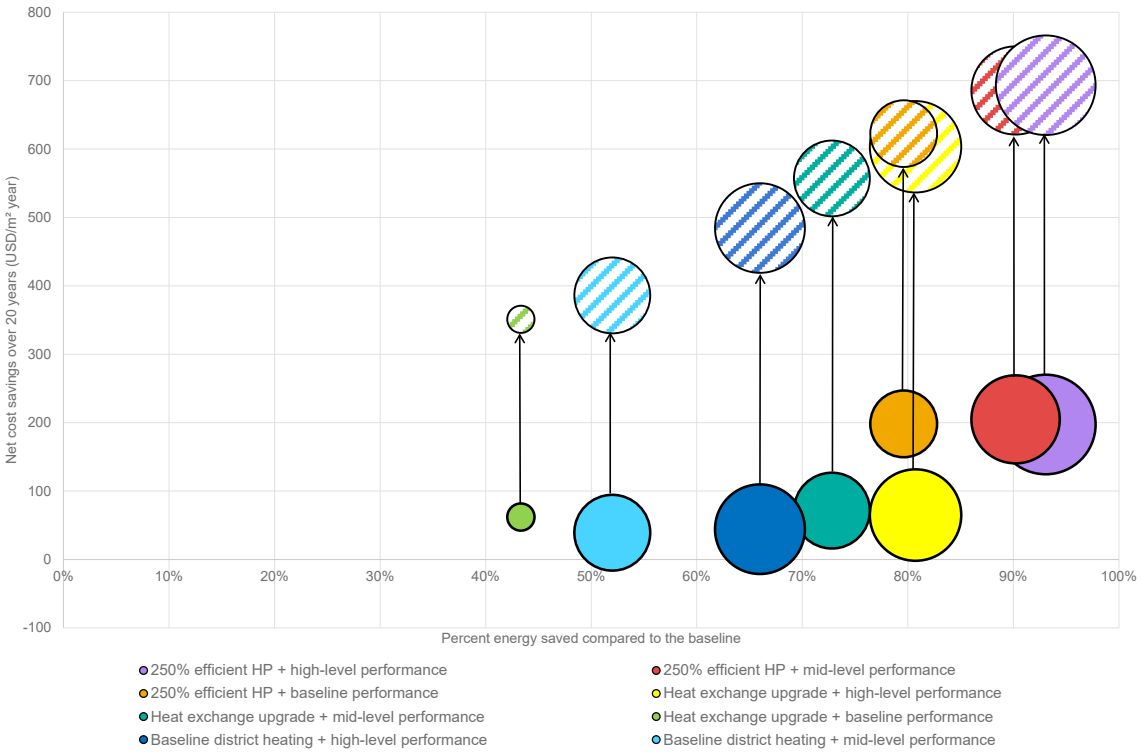
The analysis also highlights trade-offs between upfront investment costs and lifecycle savings. Upgrade packages involving moderate envelope improvements typically require investments of approximately USD 40-60/m², while high-level envelope upgrades raise costs to approximately USD 60-75/m². Heat pump-based packages require greater initial investments than heat exchanger upgrades but deliver substantially higher long-term savings. Unlike the Stalinka archetype, the additional cost of deeper envelope improvements in this archetype is relatively modest compared with the resulting increase in cumulative savings, making more ambitious renovation pathways more attractive.

IEA. CC BY 4.0.

These results are based on current regulated residential energy tariffs in Ukraine. Under higher, more cost-reflective tariffs, all upgrade packages would deliver greater financial benefits, with the largest gains expected from heat pump-based solutions because of their substantial reductions in delivered energy consumption.

Overall, the findings suggest that Khruschevka buildings offer particularly attractive opportunities for energy-efficient reconstruction and renovation. While envelope improvements can deliver meaningful lifecycle savings, the greatest benefits come from integrated upgrade packages that combine thermal modernisation with heating system electrification. Such packages can significantly reduce energy costs, improve affordability and comfort for residents, and support Ukraine's longer-term energy security and decarbonisation objectives.

Energy savings and net cost savings over 20 years under the current and increased energy tariffs for a typical Khruschevka-type building



IEA. CC BY 4.0

Notes: HP=heat pump. The size of each bubble indicates the amount of upfront investment required for any given upgrade. Bubbles with a patterned fill show the results with increased energy tariffs, while solid bubbles reflect current energy tariffs.

The assessment shows that all upgrade packages deliver positive energy savings and net lifecycle benefits compared with the baseline Khruschevka building. However, the financial returns vary significantly depending on the technical ambition of the upgrade package and the assumed energy tariffs.

IEA. CC BY 4.0.

The results confirm that heating electrification through high-efficiency heat pumps is the primary driver of reductions in delivered energy consumption. Heat pump-based upgrade packages achieve energy savings of approximately 80%, even without significant envelope improvements. Combining heat pumps with mid- or high-level envelope performance increases energy savings to approximately 90-95%, making these the highest-performing upgrade packages in the assessment.

Under current residential energy tariffs, however, these substantial reductions in energy demand do not always translate into proportionally large financial benefits. Upgrade packages focused on envelope improvements achieve energy savings of approximately 45-55% relative to the baseline building and deliver net lifecycle savings of around USD 40-60/m² over the 20-year assessment period. These packages benefit from relatively modest upfront investment requirements and therefore deliver positive financial returns despite current low energy prices.

Upgrade packages combining heat exchanger upgrades with envelope improvements increase energy savings to approximately 75-80%. However, under current tariff conditions, net lifecycle savings remain relatively modest, generally below USD 100/m². This reflects the limited financial value of energy savings when residential tariffs remain regulated and significantly below market levels.

Upgrade packages incorporating heat pumps deliver the highest net savings under current tariffs, generating net lifecycle savings of approximately USD 200/m² while achieving the largest reductions in delivered energy demand. These results suggest that heat pump deployment can offer a compelling combination of energy and financial benefits, particularly when combined with envelope improvements.

Comparing current and higher tariff scenarios highlights the strong influence of energy prices on renovation economics. Higher tariffs substantially improve the financial attractiveness of all upgrade packages — with the largest gains seen in those delivering the greatest energy savings, particularly packages combining heat pumps with mid- or high-level envelope performance. For these packages, net lifecycle savings increase from approximately USD 200/m² under current tariffs to around USD 650-700/m² under the higher-tariff scenario.

The analysis suggests that gradual shift toward more cost-reflective energy prices could significantly strengthen incentives for deep renovation and heating electrification in Ukraine. Although higher tariffs improve the economic attractiveness of all upgrade packages, they particularly favour more ambitious renovation pathways, which deliver greater savings by avoiding larger volumes of future energy consumption.

The results also illustrate important trade-offs between upfront investment requirements and long-term benefits. Deep upgrade packages require larger

IEA. CC BY 4.0.

capital investment but deliver the greatest energy savings and highest net lifecycle returns. Medium-depth upgrade packages appear to offer a particularly attractive balance between energy savings, financial returns and investment requirements, potentially making them well-suited to large-scale deployment where financing is constrained.

Beyond direct economic benefits, the highest-performing upgrade packages provide important resilience advantages in Ukraine. Buildings with efficient envelopes and heat pumps, potentially combined with rooftop solar and energy storage, are likely to maintain thermal comfort longer during outages, reduce dependence on disrupted fuel supply chains and better integrate with increasingly decentralised and renewable-based energy systems.

Overall, the findings indicate that integrated upgrade packages combining envelope improvements with heating system electrification offer the strongest long-term value for the Khruschevka archetype. These packages can substantially reduce energy demand, lower lifecycle costs, strengthen energy security and support Ukraine's broader reconstruction and decarbonisation objectives.

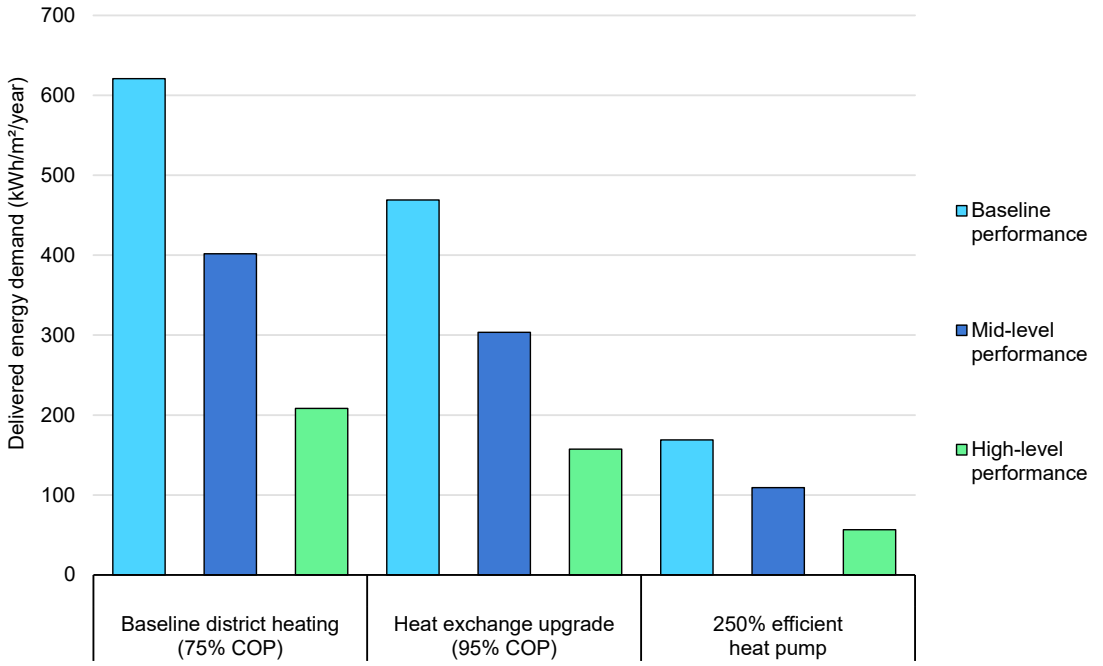
Private house

Detached single-family houses account for a significant share of Ukraine's residential building stock, particularly in rural and peri-urban areas. The archetype analysed represents typical one-storey houses constructed in the 1960s and 1970s, when energy efficiency was a minor consideration in residential construction. These buildings generally have poorly insulated walls and roofs, ageing windows, significant heat losses and high heating demand. Compared with multi-apartment buildings, detached houses have a much larger external envelope relative to their floor area, making them particularly susceptible to heat loss through walls, roofs and floors.

As a result, this archetype has substantially higher energy consumption than the Stalinka and Khruschevka archetypes analysed previously. However, its high baseline energy demand also creates considerable opportunities for savings through thermal modernisation and heating system upgrades. Detached houses offer greater flexibility for installing technologies such as heat pumps, rooftop solar and battery storage, making them an important part of Ukraine's long-term building decarbonisation strategy.

IEA. CC BY 4.0.

Delivered energy demand by efficiency upgrade package in a typical private house



IEA. CC BY 4.0

Notes: COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

Delivered energy demand and energy savings by upgrade in a typical private house

Envelope performance	Heating system option								
	Baseline district heating (75% COP)			Heat exchange upgrade (95% COP)			250% efficient heat pump		
Baseline	621			469			169		
Mid-level		402			304			109	
High-level			208			157			57
Energy savings (kWh/m² per year)		219	413	152	317	464	452	512	564
Energy savings (%)		35%	66%	24%	51%	75%	73%	82%	91%

Notes: Energy savings are measured against the baseline. COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

The assessment shows that the baseline detached house has the highest delivered energy demand of the residential archetypes analysed, potentially exceeding 600 kWh/m² per year. Unlike the Stalinka and Khruschevka archetypes, where heating system upgrades were the main driver of energy savings, the detached house's energy performance depends much more heavily on its envelope.

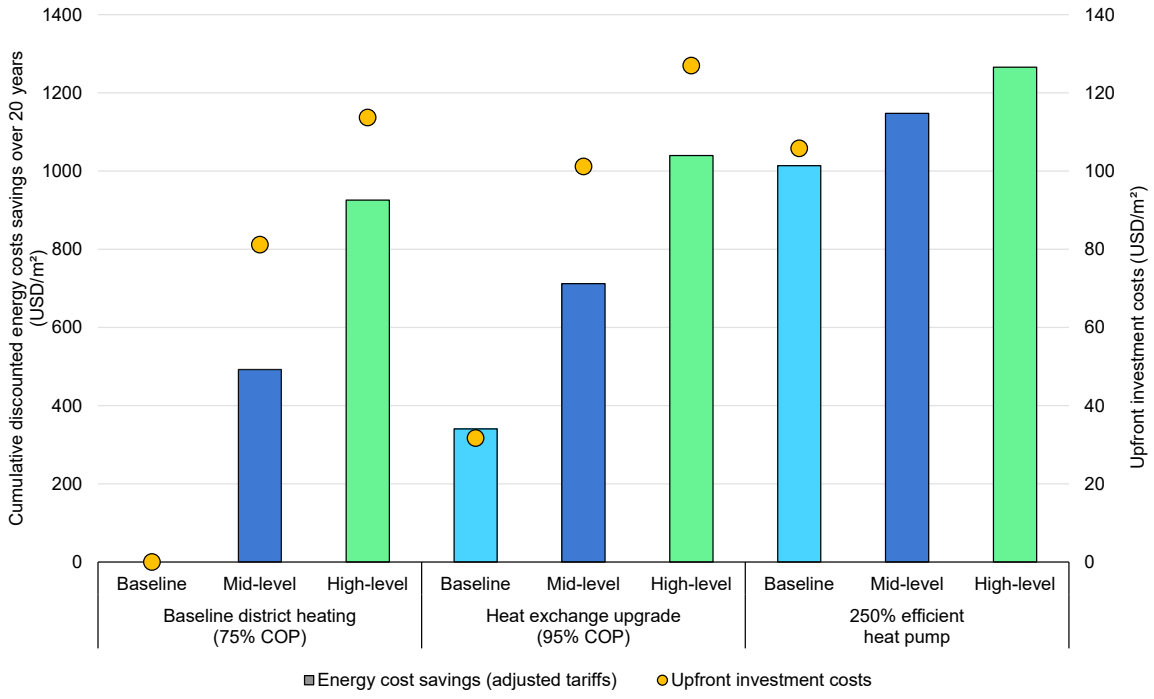
IEA. CC BY 4.0.

Under baseline heating conditions, mid- and high-level envelope upgrades reduce delivered energy demand by approximately 35% and 66%, respectively. These savings are substantially greater than those observed in the multi-apartment archetypes. This reflects the high degree of heat loss associated with detached homes, which have a much larger external surface area relative to their floor area.

Improving heating system efficiency through heat exchanger upgrades further reduces delivered energy demand, while switching to high-efficiency electric heat pumps delivers the greatest overall savings. Even without envelope improvements, heat pump deployment reduces delivered energy demand by approximately 73% relative to the baseline. Combining heat pumps with mid- and high-level envelope upgrades increases savings to approximately 82% and 91%, respectively.

The results suggest that neither thermal modernisation nor heating system upgrades alone are sufficient to unlock the full energy-saving potential of this archetype. High-level envelope improvements can achieve savings approaching those delivered by heat pumps alone, but the greatest reductions come from combining both measures. This highlights the importance of integrated upgrade packages that address both heat demand and heating system efficiency.

Cumulative discounted energy cost savings and upfront retrofit costs for different efficiency upgrades of building envelope and heating system in a typical private house



IEA. CC BY 4.0

Notes: COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

IEA. CC BY 4.0.

The analysis indicates that detached houses offer the greatest potential for lifecycle energy cost savings among the residential archetypes analysed. Their high baseline energy demand means that each unit of energy saved translates into greater reductions in energy expenditure over time.

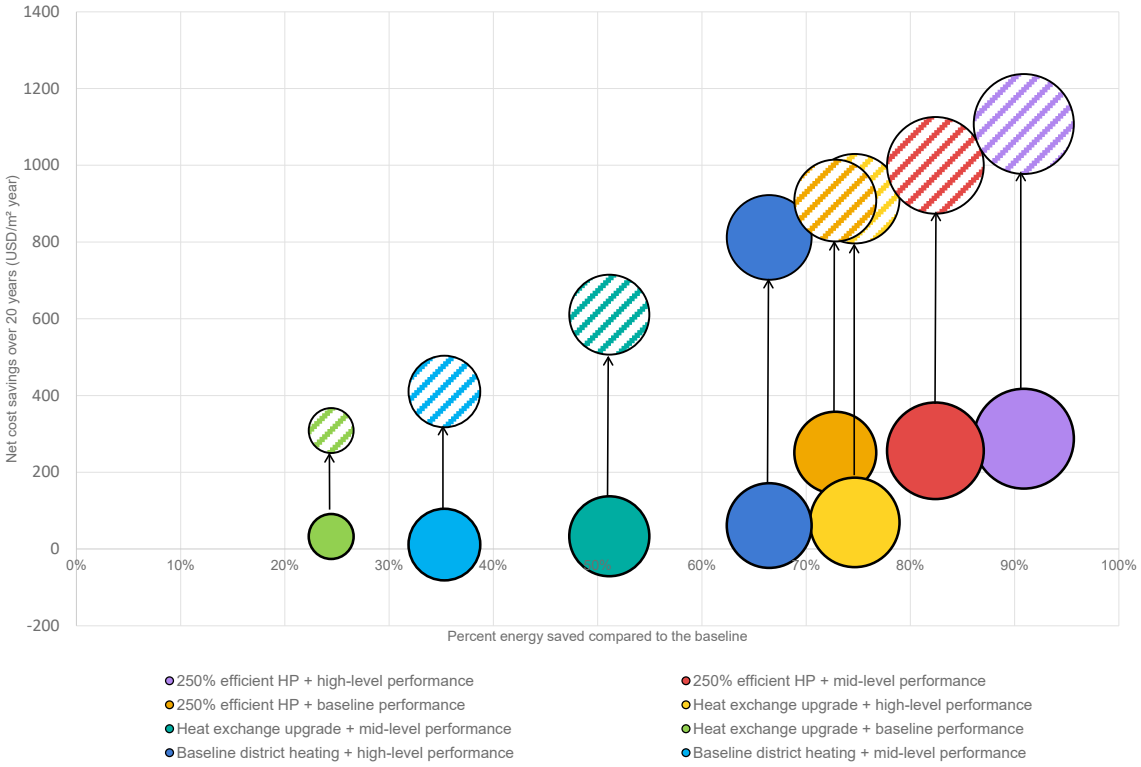
Under baseline heating conditions, envelope-focused upgrade packages deliver cumulative discounted energy cost savings of approximately USD 50-100/m² over the 20-year assessment period. Heat exchanger upgrades increase these savings further, while heat pump-based upgrade packages deliver the greatest financial benefits, generating savings of approximately USD 360-445/m², depending on the level of envelope performance.

These higher savings come with greater upfront investment requirements than in multi-apartment buildings, reflecting the larger external surface area of detached houses and the more extensive renovation work required. However, unlike the apartment archetypes, where medium-depth upgrades often offer the most favourable balance between investment costs and lifecycle savings, detached houses continue to benefit substantially from deeper renovation. The additional savings from high-level envelope improvements remain significant relative to the extra investment required.

Overall, the results suggest that detached houses offer significant potential for deep renovation, with comprehensive upgrade packages delivering substantial energy savings and strong long-term financial returns.

IEA. CC BY 4.0.

Energy savings and net cost savings over 20 years under the current and increased tariffs for a typical private house



IEA. CC BY 4.0

Notes: HP=heat pump. The size of each bubble indicates the amount of upfront investment required for any given upgrade. Bubbles with a patterned fill show the results with increased energy tariffs, while solid bubbles reflect current energy tariffs.

The relationship between energy savings and lifecycle economics differs from that observed in the multi-apartment archetypes. Because detached houses have substantially higher baseline energy consumption, even moderate reductions in energy demand translate into significant financial savings.

Under current tariffs, envelope-focused upgrade packages deliver energy savings of approximately 35-66% but deliver relatively modest net lifecycle savings. By contrast, packages combining heat pumps with mid- or high-level envelope improvements achieve energy savings of approximately 82-91% and net lifecycle savings of around USD 250-300/m². These results rank among the highest observed across all the residential archetypes analysed.

The higher-tariff scenario further strengthens the economic case for comprehensive renovation. Net lifecycle savings increase substantially across all upgrade packages, reaching approximately USD 800-1 100/m² for the most ambitious renovation pathways. The largest gains are achieved by packages that combine deep envelope improvements with heat pumps, reflecting their potential to avoid substantial future energy consumption.

IEA. CC BY 4.0.

The detached house also shows the greatest sensitivity to energy prices among the archetypes analysed. Under the higher-tariff scenario, net lifecycle savings for the most ambitious upgrade packages increase almost fourfold compared with current tariffs. This highlights the significant impact of future tariff reforms on the financial attractiveness of deep renovation and heating electrification for this housing segment.

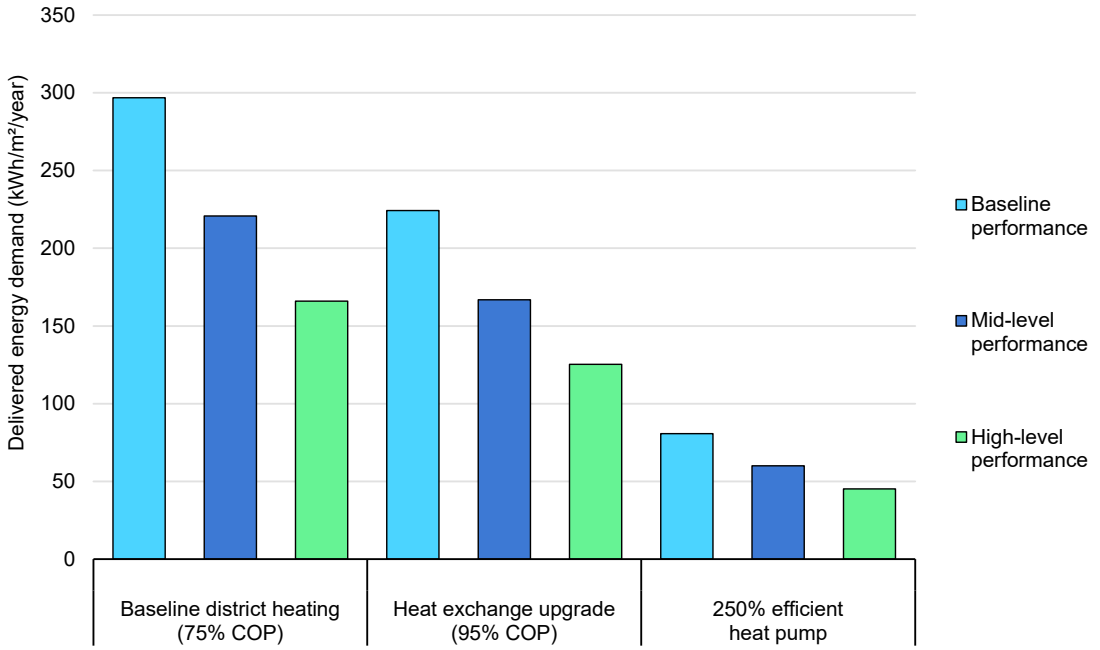
Overall, the findings suggest that detached houses offer some of the most significant opportunities to reduce residential energy demand in Ukraine. Given their high energy consumption and substantial savings potential, deep renovation of single-family homes could play an important role in reducing national energy demand, strengthening energy security and supporting Ukraine's long-term reconstruction and decarbonisation objectives.

School building

Schools are one of the largest categories of public buildings in Ukraine and play a critical role in reconstruction efforts. The archetype analysed represents a typical three-storey school built during the 1960s and 1970s. Like many public buildings from this period, it predates modern energy efficiency requirements and typically has poorly insulated walls and roofs, inefficient glazing and high ventilation and heating requirements. Given their large floor areas, long operating hours and public ownership, schools offer significant opportunities to reduce energy costs while improving indoor comfort and learning environments.

IEA. CC BY 4.0.

Delivered energy demand by efficiency upgrade package for a typical school building



IEA. CC BY 4.0

Notes: COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

Delivered energy demand and energy savings by upgrade package for a typical school

Envelope performance	Heating system option							
	Baseline district heating (75% COP)		Heat exchange upgrade (95% COP)			250% efficient heat pump		
Baseline	297		224			81		
Mid-level	221		167			60		
High-level	166		125			45		
Energy savings (kWh/m² per year)	76	131	73	130	171	216	237	252
Energy savings (%)	26%	44%	24%	44%	58%	73%	80%	85%

Notes: Energy savings are measured against the baseline. COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

The assessment shows that the baseline school building has a delivered energy demand of approximately 300 kWh/m² per year, lower than the detached house but comparable to the multi-apartment buildings analysed previously.

Compared with the residential archetypes, envelope improvements alone deliver more modest reductions in energy demand. Under baseline heating conditions, mid- and high-level envelope upgrades reduce delivered energy demand by

IEA. CC BY 4.0.

approximately 26% and 44%, respectively. This suggests that, in large public buildings such as schools, heat losses through the building envelope account for a smaller share of total energy demand than in detached houses.

Heating system efficiency improvements deliver comparable benefits. Heat exchanger upgrades reduce delivered energy demand by approximately 24% with the baseline envelope, while combining these upgrades with high-level envelope improvements increases savings to approximately 58%.

The largest reductions come from electrifying heating with high-efficiency heat pumps. Even without envelope improvements, heat pumps reduce delivered energy demand by approximately 73% relative to the baseline. Combining heat pumps with mid- and high-level envelope upgrades further increases savings to approximately 80% and 85%, respectively.

Unlike the detached house archetype, where deep envelope retrofits play a dominant role, the results for schools show a more balanced contribution from envelope improvements and heating system upgrades. The best-performing packages combine both measures, although the additional savings from upgrading the envelope from mid- to high-level performance are smaller than for the residential archetypes.

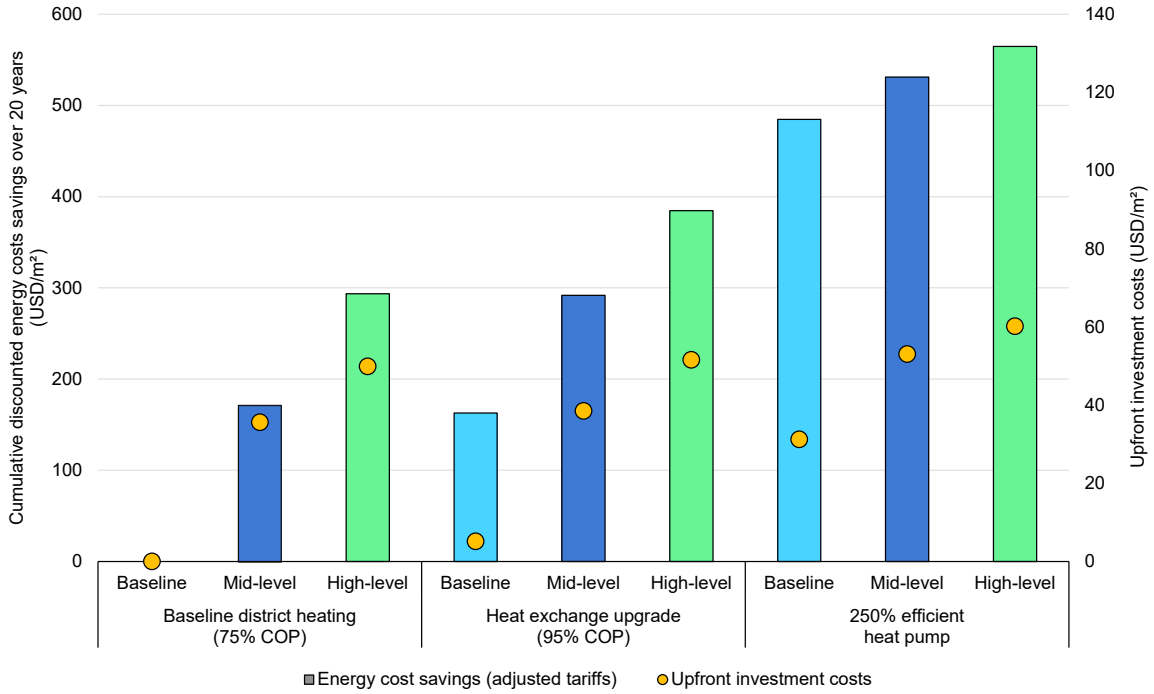
The analysis shows that schools can achieve substantial lifecycle energy cost savings despite lower percentage reductions in energy demand than detached houses. This reflects the large floor areas and the substantial amount of energy they consume over their operational lifetimes.

Under baseline district heating conditions, envelope-focused upgrade packages deliver cumulative discounted energy cost savings of approximately USD 30-55/m² over the 20-year assessment period. Adding heat exchanger upgrades increase these savings to approximately USD 55-75/m², depending on the level of envelope performance.

Heat pump-based upgrade packages deliver the greatest financial benefits. Even without envelope improvements, they deliver cumulative discounted savings of approximately USD 170/m² over 20 years. Adding mid- or high-level envelope improvements increases these savings to approximately USD 185-200/m².

IEA. CC BY 4.0.

Cumulative discounted energy cost savings and upfront retrofit costs for different energy efficiency upgrades of building envelope and heating system in a typical school



IEA. CC BY 4.0

Notes: COP = Coefficient of performance. A heat pump operating at 250% efficiency delivers 2.5 units of heat for every unit of electricity consumed.

The results indicate that the additional energy cost savings from deeper envelope upgrades diminish once heat pumps are installed. This suggests that, from a purely economic perspective, combining moderate envelope improvements with efficient heating technologies may offer a favourable balance between lifecycle savings and investment costs for many school buildings.

The relationship between energy savings and lifecycle economics differs from that of the apartment and the detached-house archetypes. Although schools can achieve substantial reductions in energy demand, the financial returns of different upgrade packages are strongly influenced by their relatively high upfront investment requirements.

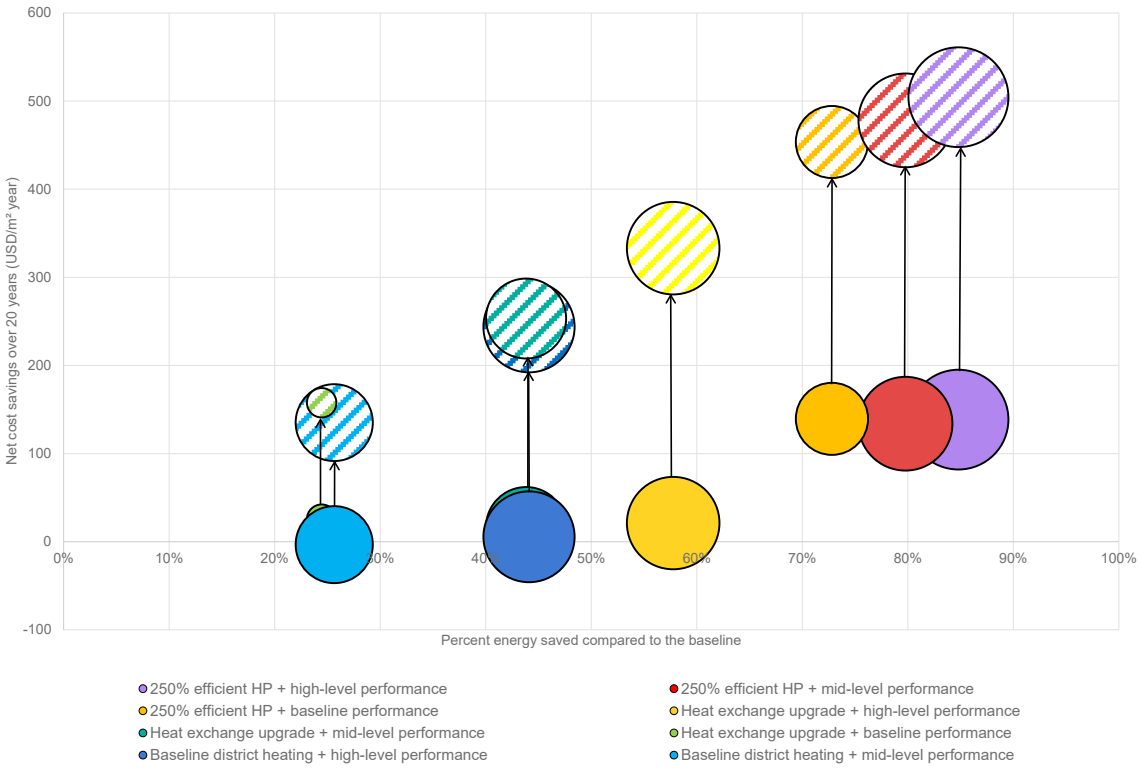
Under current tariffs, envelope-focused upgrade packages deliver modest net lifecycle savings despite requiring substantial upfront investment. Packages that include heat exchanger upgrades offer slightly better financial returns, but these remain constrained by low, regulated energy prices.

The strongest financial performance is achieved by upgrade packages incorporating heat pumps. Under current tariffs, these packages deliver net lifecycle savings of approximately USD 140-150/m² while reducing energy

IEA. CC BY 4.0.

demand by 73-85%. They outperform all other renovation pathways in both energy savings and financial returns.

Energy savings and net cost savings over 20 years under the current and increased tariffs for a typical school building



IEA. CC BY 4.0

Notes: HP=heat pump. The size of each bubble indicates the amount of upfront investment required for any given upgrade. Bubbles with a patterned fill show the results with increased energy tariffs, while solid bubbles reflect current energy tariffs.

Under the higher-tariff scenario, all upgrade packages become substantially more economically attractive. Net lifecycle savings increase to approximately USD 250-500/m², depending on the level of ambition, with the largest gains achieved by packages combining heat pumps with improved envelope performance. As in the residential archetypes, higher energy prices increase the financial value of avoided energy consumption and strengthen case for deep renovation.

Overall, the findings suggest that schools offer significant opportunities for energy-efficient reconstruction. Improving building envelopes can significantly enhance comfort and reduce heating demand, but modernising heating systems and electrification offer the greatest potential for energy and cost savings. Given the number of public buildings in need of renovation across Ukraine, combining these measures could substantially reduce public-sector energy bills while improving learning environments and strengthening energy security as well as long-term resilience.

IEA. CC BY 4.0.

Policy recommendations for improving energy efficiency

Ukraine's reconstruction presents a historic opportunity to turn one of Europe's most energy-intensive and vulnerable building stocks into a modern, resilient and low-carbon sector aligned with the European Union's energy and climate goals. Rebuilding war-damaged buildings to high energy performance standards could cut energy demand and long-term costs, strengthen energy security, improve thermal comfort and public health, and reduce the need for future investment in energy infrastructure.

Reconstruction is taking place under extraordinary conditions, including damaged infrastructure, labour shortages, fiscal constraints and ongoing security risks. Embedding decarbonisation and resilience goals in immediate reconstruction policy can help address urgent needs while laying the foundations for a lower-carbon, more resilient building stock. A phased package of regulation, information and incentives can prevent inefficient building practices from becoming entrenched, while also supporting the widespread adoption of near-zero-energy buildings, electric heating and grid-interactive technologies.

Cross-cutting priorities

Energy efficiency would need to become a core principle of all publicly funded reconstruction and renovation programmes in Ukraine. Rebuilding damaged buildings to outdated standards would risk locking in excessive energy demand, high heating costs and additional retrofit needs for decades. An "efficiency-first" approach to building reconstruction and renovation – prioritising cost-effective reductions in energy demand before expanding energy supply infrastructure – can support optimal energy system design.

The archetype analysis shows that integrated upgrade packages combining thermal modernisation and heating system improvements can lower delivered energy demand by 80-90% in representative Ukrainian buildings while generating substantial lifecycle cost savings and bringing energy performance closer to that of near-zero energy buildings. Although the relative importance of individual measures varies by building type, the most effective renovation pathways consistently combine building-envelope improvements with efficient heating technologies. Reconstruction and retrofit efforts would therefore deliver better results through integrated upgrade packages than through isolated efficiency measures.

IEA. CC BY 4.0.

Ukraine's large stock of Soviet-era multi-apartment buildings deserves particular attention. Many share similar construction characteristics and technical deficiencies, making standardised upgrade packages a promising way to achieve substantial energy savings, realise economies of scale and support industrialised renovation and typology-based reconstruction programmes. Detached houses, which account for a significant share of residential energy consumption, often require more extensive envelope improvements because of their larger exposed surface area and greater baseline heat losses.

Ukraine could also develop a national framework to assess whether heavily damaged buildings should be renovated or rebuilt. Criteria could include structural integrity, lifecycle costs, potential energy performance improvements, urban planning priorities and social value. This would help direct reconstruction funding to where it is most effective and avoid demolishing buildings with strong retrofit potential.

Reconstruction policies can combine ambitious energy performance standards with targeted financial support to address affordability and upfront costs. Concessional finance, grants, guarantees and social protection measures would serve to support deep renovation at scale while shielding vulnerable households from rising energy costs.

Energy efficiency policies may also bolster wartime resilience and prepare for future crises. Buildings with high-performance envelopes, efficient heating systems, rooftop solar, battery storage, smart controls and demand-response capabilities can maintain safer indoor conditions during outages. This would also ease pressure on damaged energy infrastructure and increase flexibility across the energy system.

Regulation

Near-term priorities (0 to 3 years)

Ukraine could benefit from introducing minimum energy performance requirements for state- and donor-funded reconstruction projects, including major emergency repairs. Even when rebuilding quickly during wartime, replacing damaged assets with inefficient technologies is best avoided where possible. Publicly funded emergency reconstruction may therefore aim to meet minimum standards for insulation, airtightness, high-performance glazing and heating efficiency, with flexibility where conditions make this difficult.

Ukraine could also prioritise deployment of proven, low-cost measures that deliver immediate energy savings. In multi-apartment buildings connected to district heating networks, these include individual heating substations, balancing systems

IEA. CC BY 4.0.

and weather-compensated controls. The archetype analysis suggests that such measures can cut energy consumption by more than 20% at relatively low cost, making them particularly attractive in the early stages of reconstruction. Standardised renovation and reconstruction packages for common building types would also help municipalities and reconstruction agencies deploy high-performance solutions more rapidly and consistently.

Implementing the recently adopted nZEB framework is a short-term option that could deliver substantial savings. While Ukraine introduced near-zero energy building requirements in 2025, practical implementation guidance, standardised compliance procedures and enforcement mechanisms remain under development. The government could prioritise preparation of technical guidance documents, standard project templates and simplified compliance pathways for municipalities and reconstruction agencies.

Ukraine could also accelerate deployment of industrialised and prefabricated reconstruction methods that deliver high thermal performance, consistent quality and faster construction. Modular and prefabricated solutions may be particularly suitable in heavily damaged regions, for housing that transitions from temporary to permanent, for schools, healthcare facilities and common residential building types. These methods could also help address labour shortages, reduce construction waste and improve energy performance consistency.

Furthermore, by strengthening resilience considerations in reconstruction standards – including the ability to maintain safe indoor conditions during outages, integrate with decentralised renewable energy systems and accommodate future smart-grid technologies – new and rebuilt buildings could be better placed to withstand supply disruptions and support a more flexible, secure power system.

Medium-term priorities (3 to 7 years)

Regulatory frameworks can play a role in supporting heating electrification alongside improvements in building performance. Ukraine could consider progressively tightening building energy codes and extending mandatory nZEB requirements to more categories of buildings. Public buildings and large developments offer a natural starting point, followed by residential and commercial buildings.

Regulatory frameworks may benefit from adopting integrated whole-building performance approaches rather than focusing solely on individual building components. This could include stronger requirements for building envelope performance, ventilation with heat recovery, airtightness, smart controls, renewable energy integration and operational energy performance.

IEA. CC BY 4.0.

Minimum energy performance standards for existing buildings undergoing major renovation could also be introduced gradually, particularly for the least efficient multi-apartment and public buildings, where the potential for energy savings is greatest. These could include requirements for individual heating substations, balancing systems, weather-responsive controls and renewable-ready infrastructure.

Given the significant wartime damage to district heating systems, Ukraine could also develop a phased strategy to decarbonise space heating through electrification and the use of renewable and waste heat. Options may include support for district-scale heat pumps, hybrid heating systems and low-temperature district heating networks.

The analysis indicates that heat pumps consistently deliver the largest reductions in delivered energy consumption and lifecycle energy costs across most building archetypes. Building regulations, technical standards and permitting procedures that facilitate wider adoption of heat pumps in both new buildings and major renovations are thus likely to deliver stronger results.

Public procurement procedures that place greater weight on lifecycle cost and energy performance rather than the lowest upfront cost can help ensure that reconstruction investments deliver lasting savings and high-quality outcomes.

Ukraine could pursue a two-pronged approach to decarbonising space heating. In dense urban areas where district heating remains technically and economically viable, priorities should include modernising networks, integrating renewable and waste heat sources, deploying heat pumps at scale and transitioning to lower-temperature systems. In areas where district heating infrastructure has been severely damaged or is uneconomic to restore, decentralised heat pumps may offer a more cost-effective alternative.

Long-term priorities (7 years and beyond)

Ukraine could gradually align its buildings policy with the European Union's revised Energy Performance of Buildings Directive and its emerging zero-emission building standards.

This may include mandatory operational energy performance standards, disclosure of actual energy performance, consideration of embodied carbon and stronger requirements for buildings to interact with the power grid and adjust energy use to help maintain electricity system stability.

This could, for instance, involve new buildings progressively meeting full nZEB or zero-emission standards, incorporating renewables, storage, smart controls and demand-response capabilities. Large urban reconstruction projects could develop into highly efficient, grid-interactive districts that reduce peak electricity demand and help integrate variable renewable energy.

IEA. CC BY 4.0.

Ukraine could also establish a long-term roadmap for full decarbonisation of district heating through renewable energy, large-scale heat pumps, waste heat recovery and smart thermal grids.

Information

Near-term priorities (0 to 3 years)

Improving the availability and quality of building data is an important element for reconstruction and building planning. Ukraine's National Database of Energy and Operational Characteristics of Buildings provides an opportunity to centralise information on building energy performance, technical characteristics and actual energy use.

This system could be linked to the State Register of Damaged and Destroyed Property and digital reconstruction platforms such as DREAM, helping to prioritise investments in reconstruction that are based not only on physical damage assessments, but also on energy-saving potential, operational costs and long-term resilience.

Municipalities and reconstruction agencies could also be provided with rapid energy assessment protocols to identify priority renovation opportunities in damaged buildings and public infrastructure.

Large-scale workforce training can support the supply of qualified labour. This includes architects, engineers, energy auditors, installers, construction workers, municipal officials, housing associations and facility managers. Training could focus on construction quality, thermal bridge prevention, airtightness and the commissioning and operation of advanced engineering systems.

Public information campaigns could also raise awareness of the benefits of energy efficiency improvements, particularly for affordability, thermal comfort, resilience and health.

Medium-term priorities (3 to 7 years)

Ukraine's government could develop standardised renovation packages for common building types, including Soviet-era multi-apartment buildings, detached houses and public buildings such as schools. The archetype analysis shows that most effective upgrades vary by building category. Standardised technical packages would help municipalities and building owners identify the most cost-effective combinations of envelope improvements, heating system upgrades and renewable energy technologies.

IEA. CC BY 4.0.

A national energy “passport” system could enable digital tracking of an individual building’s renovation history, improvements in energy performance and interactions with the electricity grid over time.

The government could also develop standardised upgrade packages for common residential building types, particularly prefabricated Soviet-era apartment blocks. Standardised solutions reduce design complexity, speed implementation and improve quality assurance across large-scale renovation programmes.

Demonstration projects and pilot districts remain central to this phase. Ukraine could establish nZEB projects across different climate zones and building types, including hospitals, schools, offices and residential buildings. These projects could serve as demonstration sites, training centres and testbeds for cost-optimal renovation approaches, showcasing the benefits of integrated upgrade packages and generating evidence to guide wider deployment.

Strengthening municipal capacity can support regional uptake. Many municipalities currently lack the technical and administrative resources to prepare, procure and oversee complex renovation projects. Expanding regional technical assistance centres and project preparation facilities could help improve implementation and accelerate deployment at scale.

Long-term priorities (beyond 7 years)

Ukraine could gradually introduce systems to verify actual energy performance using measured consumption data rather than relying solely on design calculations.

Buildings receiving public funding could be required to report energy performance periodically, verifying actual savings and strengthening accountability among developers, service providers and building owners.

The national building database could eventually evolve into a broader strategic planning platform supporting urban energy planning, heat planning, grid integration and long-term decarbonisation strategies. Combined with smart metering and digitalisation, it could also support advanced demand-response programmes and integrate buildings into future smart energy systems.

Incentives

Near-term priorities (0 to 3 years)

Financial support mechanisms are generally most effective when they prioritise measures that combine high energy-saving potential with resilience and affordability benefits. The analysis indicates that comprehensive renovation

IEA. CC BY 4.0.

approaches deliver the largest reductions in energy demand and the greatest lifecycle savings, particularly when they include heating electrification through highly efficient heat pumps.

Programmes could include roof and basement insulation, high-performance windows, improved airtightness, individual heating substations, weather-responsive controls, rooftop solar, battery storage and heat pumps where technically appropriate.

Expansion of Ukraine's Energy Efficiency Fund (EEF) programmes, including ENERGODIM, GreenDIM and VidnovyDIM, could place greater emphasis on energy-efficient reconstruction and renovation, while continuing to support the rapid deployment of low-cost measures such as individual heating substations, balancing systems and controls in buildings connected to district heating networks. Particular attention should be given to vulnerable households, internally displaced persons and heavily damaged municipalities.

Public buildings, particularly schools, hospitals and municipal facilities, could be prioritised as early candidates for deep renovation, supported by financial incentives through international organisations and donor frameworks. These buildings offer significant energy-saving potential and direct benefits for public services, while visibly demonstrating the feasibility of advanced renovation approaches.

Ukraine could also establish dedicated financing facilities for emergency reconstruction and retrofitting to support the rapid deployment of energy-efficient modular and prefabricated housing in war-affected regions.

Given the scale of Ukraine's reconstruction needs, concessional finance, guarantees and grants remain in the early stages. International donors and development finance institutions could help reduce investment risks and mobilise private capital through blended finance, with conditions requiring funds to be allocated to energy efficiency improvements.

Medium-term priorities (3 to 7 years)

As market and institutional capacity improves, Ukraine could increasingly use grants alongside soft loans, revolving funds, green mortgages and energy service company models to mobilise private capital for deep renovation.

Financial support should increasingly favour comprehensive renovation packages over isolated measures. Higher rates of support could be offered for projects that substantially reduce delivered energy demand, integrate renewable energy and measurably improve resilience.

IEA. CC BY 4.0.

Gradual tariff reform will also become increasingly important. Current wartime tariff protections reduce incentives for investment in energy efficiency and electrification. Over time, the transition to more cost-reflective pricing, combined with targeted social protection and support for thermal modernisation, could improve the financial viability of deep renovation and heat pump deployment while protecting vulnerable households.

Ukraine could additionally support the development of domestic manufacturing capacity for insulation materials, high-performance windows, prefabricated building components and heat pumps. This would reduce import dependence, create local jobs and strengthen supply-chain resilience during reconstruction.

Long-term priorities (beyond 7 years)

Support mechanisms could increasingly favour performance-based incentives linked to verified operational savings rather than predicted performance. Incentives would also reward verified energy savings, demand flexibility, peak-load reduction and the integration of buildings into smart energy systems. This would strengthen accountability, improve renovation quality and help ensure that publicly funded projects deliver the expected energy and financial benefits in practice.

Green bond markets, utility obligation schemes, on-bill financing and long-term, interest-free efficiency loans could become increasingly important tools for financing large-scale renovation and electrification efforts.

Ultimately, Ukraine's reconstruction offers an opportunity not only to rebuild damaged buildings, but also to modernise the country's building stock and energy system. A comprehensive policy package combining regulation, information and incentives can help ensure that reconstruction delivers lasting benefits for energy security, affordability, resilience and climate objectives while supporting Ukraine's broader pathway toward European integration.

IEA. CC BY 4.0.

Conclusion

The analysis presented in this report shows that Ukraine's reconstruction offers a unique opportunity not only to replace damaged buildings, but also to modernise the country's building stock and reduce its long-term energy demand. Across the building archetypes assessed, integrated upgrade packages combining envelope improvements and heating system modernisation consistently delivered the greatest benefits, reducing delivered energy demand by up to 80-90% while generating substantial lifecycle energy cost savings. Although the optimal combination of measures varies by building type, heating electrification through high-efficiency heat pumps emerged as the main driver of energy and cost savings in most cases. Deep envelope improvements also remain essential, particularly for detached houses and other buildings with high thermal losses, where they can significantly reduce heating demand and improve overall system performance.

The findings also show that substantial gains can be made through lower-cost interventions. Individual heating substations, balancing systems and weather-compensated controls, for example, can significantly reduce energy consumption in multi-apartment buildings connected to district heating networks at relatively low upfront cost. Such measures can be a first step toward broader building modernisation, particularly in the early stages of reconstruction.

Scaling up deep renovation and heating electrification will require targeted financial support to address the upfront costs faced by households, municipalities and public institutions. Expanding support schemes for insulation, high-performance windows, heat pumps and building controls can substantially reduce energy consumption and operating costs while improving indoor comfort and resilience. The analysis further indicates that deep renovation becomes more economically attractive with more cost-reflective energy tariffs. Gradual tariff reform, accompanied by targeted social protection and support for vulnerable households, may therefore strengthen incentives to invest in energy-efficient, low-carbon buildings.

Achieving a highly efficient and resilient building stock requires a mix of technical solutions supported by an enabling policy framework. Policy priority options for Ukraine include improving building envelope performance, modernising heating and ventilation systems, deploying heat pumps and integrating renewable energy technologies such as rooftop solar. Digital monitoring, commissioning and verification of operational performance will also be essential to ensure that expected energy savings are realised in practice. Ukraine's recent adoption of nZEB requirements represents an important milestone in this transition and can

IEA. CC BY 4.0.

deliver strong savings through further implementation. A clear roadmap toward mandatory implementation, backed by financing mechanisms, technical guidance and institutional capacity-building, can help transform the building stock at scale.

A comprehensive policy package combining regulation, information and incentives can offer substantial support to this transition. Significant investment in workforce development, local supply chains and institutional capacity can also ensure an adequate supply of skilled professionals, materials and equipment for large-scale renovation and reconstruction. Expanding training programmes for engineers, architects, installers, construction workers, energy auditors and municipal authorities is important as it can improve quality standards, ensuring long-term building performance.

Reconstruction also offers an opportunity to improve energy system resilience and flexibility. Buildings with efficient envelopes, heat pumps, rooftop solar, battery storage and smart controls can maintain safer indoor conditions during outages, ease pressure on damaged energy infrastructure and support the integration of renewable electricity. Combined with the modernisation of viable district heating systems and the continued expansion of smart electricity networks, these measures can strengthen energy security and reduce dependence on imported fossil fuels.

With sustained international support, effective domestic implementation and strong institutional coordination, Ukraine can rebuild damaged infrastructure while establishing a more efficient, resilient and low-carbon buildings sector aligned with European Union objectives. Embedding energy efficiency in reconstruction efforts can reduce future energy costs, improve living conditions, strengthen energy security and lay a lasting foundation for sustainable economic recovery.

IEA. CC BY 4.0.

Abbreviations and acronyms

CHP	Combined heat and power
CO_2	Carbon dioxide
COP	Coefficient of performance
DREAM	Digital Restoration Ecosystem for Accountable Management
EBA	European Business Association
EEF	Energy Efficiency Fund
EEIT	Office of Energy Efficiency and Inclusive Transitions
EU	European Union
GIZ	Gesellschaft für Internationale Zusammenarbeit
HP	Heat pump
HVAC	Heating, ventilation and air conditioning
IEA	International Energy Agency
JSC	Joint stock company
LCSE	Levelised cost of saved energy
nZEB	Nearly zero-energy building
UAH	Ukrainian hryvnia
USD	United States dollar
VAT	Value-added tax
km	Kilometre
kW	Kilowatt
kWh	Kilowatt-hour
kWh/m²	Kilowatt-hours per square metre
m²	Square metre
m³	Cubic metre
Gcal	Gigacalorie
W/m²K	Watts per square metre per degree Kelvin

IEA. CC BY 4.0.

International Energy Agency (IEA)

This work reflects the views of the IEA Secretariat but does not necessarily reflect those of the IEA's individual Member countries or of any particular funder or collaborator. The work does not constitute professional advice on any specific issue or situation. The IEA makes no representation or warranty, express or implied, in respect of the work's contents (including its completeness or accuracy) and shall not be responsible for any use of, or reliance on, the work.



Subject to the IEA's Notice for CC-licenced Content, this work is licenced under a Creative Commons Attribution 4.0 International Licence.

This document, as well as any data and map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
Unless otherwise indicated, all material presented in figures and tables is derived from IEA data and analysis.

IEA Publications International Energy Agency Website: www.iea.org
Contact information: www.iea.org/contact

Typeset in France by IEA - November 2026
Cover design: IEA
Photo credits: © Shutterstock


КВАРТИРИ