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Status of municipal heat supply in Ukraine: challenges and solutions from the bottom up

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Executive Summary

The heating sector in Ukraine consists of centralized, decentralized, autonomous, and individual heating. War damage and ageing infrastructure have led to a degradation of district heating, requiring investments and upgrades towards more distributed, resilient and integrated systems. Furthermore, the ageing infrastructure has been exacerbated by frozen energy price tariffs since the start of the full-scale invasion in 2022, providing a limited revenue to companies and eliminating the financial incentive for firms to maintain a long-term outlook by investing in the infrastructure. Removing this tariff cap will create business opportunities for new firms during the post-war reconstruction, as well as promote long-term investment in infrastructure from existing companies.

Across all regulatory bodies and existing legislation within Ukraine, the tariff policy in the heating sector is inconsistent. Forming a consistent and market-driven policy will promote investment in the heating sector.

Resources and expertise in the heating sector are also limited. Funding support from European countries combined with training programs will be essential, along with sector coupling and increased flexibility in anticipation of electrification. Fully aligning national legislation with EU directives and implementing relevant policies at the local level will facilitate the introduction of innovative technologies and demonstrate Ukraine's commitment to integration into the EU energy market. Based on survey data conducted across six communities, the following recommendations are proposed to improve Ukraine's heat supply:

1. **Invest in decentralized energy systems.** Shift from centralized heat and power sources to decentralized solutions and develop "energy islands" to integrate local generation and energy storage for increased resilience.
2. **Introduce sector coupling & renewable energy integration.** Increase investment and use in heat pump technologies, energy storage, and waste heat recovery. Power-to-Heat (P2H) and flexible cogeneration systems will also increase resilience.
3. **Consistent regulatory & policy reforms.** Updates to regulatory and policy reforms to align Ukrainian regulations with EU energy directives and to attract private sector involvement. Establish municipal energy agencies to streamline reform and coordinate modernization.
4. **Establishing direct financial mechanisms & investment support.** Improve access to funding for municipalities via concessional loans and EU structural funds for modernisation. Promote public-private partnerships and green bonds, as well as implementing targeted subsidies and incentives for renewable heat solutions such as heat pumps and thermal storage.
5. **Capacity building & knowledge transfer.** Support municipal energy managers and technical staff with training programs. Leverage international cooperation and best practices from European cities via successful sector coupling models.

List of Abbreviations

CGU: Cogeneration unit;

CHP: Combined heat and power plant;

EU: European Union;

Gcali: Gigacalorie;

IHP: Individual heating point;

LEP: Local energy plan;

NEURC: National Energy and Utilities Regulatory Commission;

TPP: Thermal power plant;

SECAP: Sustainable Energy and Climate Action Plan;

P2H: Power to heat;

PTES: Pit thermal energy storage;

SCADA: Supervisory Control and Data Acquisition.

1. Introduction

In most of Ukraine's regional centers and industrial cities, heat supply systems and related infrastructure were designed and built to integrate with large energy-generating facilities. Combined heat and power plants (CHP), enterprises producing heat and electricity in a combined manner, were built within the cities or in the immediate vicinity as part of this strategy. In planning the construction of new residential areas or urban redevelopment, large boiler houses for district heating were also built, supplied by natural gas. In satellite towns located next to large coal-fired thermal power plants (TPPs), heat supply systems are centralized and were designed simultaneously with these facilities, mainly in the 1960s and 1970s.

Over the past 20 years, there has been a decrease in the use of district heating systems in Ukraine due to economic and regulatory factors. Today Ukraine's municipal heating sector comprises of four main heating designs: **centralized heating**, where heat is supplied from a CHP or a central boiler house to residential districts; **decentralized heating,** where heat is supplied from smaller boiler houses to buildings connected by a local heating network; **autonomous heating,** where single multi-apartment buildings have their own heating systems; and **individual heating**, where private houses or apartments are equipped with individual boilers.

The current state of district heating in Ukraine is marked by widespread public dissatisfaction, particularly due to poor service quality and lack of hot water, prompting a shift toward individual gas-based heating, which is difficult to reverse. Abandoning centralized systems risks the rapid degradation of infrastructure crucial for the future integration of low-carbon technologies. Despite having skilled personnel, district heating companies are constrained by subsidies that typically cover gas purchases rather than modernization, with some funding decisions appearing corrupt. Furthermore, current tariffs often fail to reflect the full cost of service provision, including infrastructure depreciation and maintenance, while financial transparency remains limited due to concealed operational expenditures.

While the general structure of the heating sector in Ukraine is known, assessing its effectiveness—especially during the war—remains challenging due to the highly localized and diverse nature of its infrastructure. Its effectiveness is further compromised by ageing infrastructure, high heat losses, war-related vulnerabilities, regulatory and institutional barriers, financial constraints, and lack of integrated energy planning.

Operation and maintenance of these systems is also a concern. In many Ukrainian communities with remaining district heating systems problems arise with maintenance due to moral and physical deterioration, as well as a lack of funds resulting from fixed ("frozen") tariffs for households. These frozen tariffs have not been revised for a long time and no longer provide a profit incentive for enterprises to continue. Additionally, in times of war

such systems remain vulnerable to threats associated with attacks on critical infrastructure. This is demonstrated by towns such as Dobrotvir and Ukrainka, for which the only source of heat supply was large TPPs, alongside which the respective satellite towns with centralized heat supply systems were built.

Prior to the destruction of the TPPs and damage to the networks, the satellite towns had been receiving heat supply services from the energy companies that operated these facilities, which eventually became targets in the war. Accordingly, there was no incentive to create a unique utility company in these cities. Therefore, the local authorities found themselves in a situation to either create such an enterprise on their own or engage an external service provider willing to invest in new generating capacity, reconstruction, and modernization of utility networks.

To provide a foundational understanding of the current state of municipal heat supply across Ukrainian communities, the authors conducted a series of interviews with representatives of municipal administrations and utilities in six different cities across the spectrum of population size, location and existing infrastructure. Table 1 in Annex presents key information gathered from interviews, including reports on energy infrastructure damage, critical risks to heat supply for each community, ongoing local challenges, and examples of support in action.

Data collection was carried out through interviews with community representatives and desk research. Communities were selected to demonstrate completely different energy supply conditions, in particular: 1) degree of risk – frequency of shelling of infrastructure in the region; 2) scale – population size; 3) type of heat supply – local, centralized, or mixed heating systems; 4) dependence on external service providers – presence of a local utility company, receipt of services from external heat supply companies. This approach made it possible to identify the main existing models of heat supply in communities in Ukraine, analyze and compare heat supply conditions under different models, and ultimately identify common problems in the heat supply sector in Ukraine as a whole.

The general observation is that Ukrainian municipalities often lack institutional capacity and availability of human capital for the redevelopment of municipal heating systems and subsequent maintenance. Problems with the installation and maintenance of individual heating points (IHP) are very illustrative in this regard.

IHP is a key component in a district heating system, typically found in buildings or facilities connected to a central heating network, which functions as the interface between the central heating supply and the internal heating system of the building. In Ukraine, IHPs are not installed on all buildings connected to the central heating network, but in those buildings where IHPs are installed, they are often not configured properly and poorly maintained. According to reports, 90% of the IHPs installed are not properly configured (Ukrainian Energy, 2022). This leads to inefficient heat distribution and excessive energy use by end consumers in multi-apartment buildings. Furthermore, the already installed IHPs are not

properly maintained due to employee negligence and a lack of equipment maintenance knowledge. As such, improper maintenance of the equipment may also result in energy losses and higher costs for consumers.

This problem of ageing infrastructure can be addressed both top-down, via consistent regulatory and policy reforms, and bottom-up, through capacity building and the introduction of integrated energy planning. Large-scale investment in infrastructure modernization will require considerable domestic and international investment, which can be enabled by transitioning to a market-based heating tariff system and liquidation of cross-subsidies.

War-related vulnerabilities, such as the destruction of centralized power, heat generation sources, and supporting infrastructure, can be mitigated through the deployment of decentralized solutions and innovative technologies (e.g., biomass solid fuel boilers, heat pumps, cogeneration units).

This paper investigates the main challenges Ukrainian municipalities face in the heating sector, including the consequences of Russian aggression and attacks on energy infrastructure. It also aims to facilitate discussions on meeting challenges and identifying implementable solutions for resilient heat supply systems based on modern technologies and integrated energy planning.

In 2025, the discontinuation of substantial support previously provided by the United States Agency for International Development (USAID) creates a gap that needs to be closed by other donors and organisations. The USAID Energy Security Project (ESP), launched in 2018, has played a key role in supporting reforms in Ukraine's district heating sector through policy advice, technical assistance, and regulatory development. Its 2020 White Paper, *Transforming District Heating in Ukraine: Assessment and Recommendations*, provided a comprehensive diagnosis of systemic inefficiencies and outlined reform pathways, including tariff reform, energy efficiency, and improved governance (USAID ESP, 2020). Another important ESP report, titled *"Assessment of Individual Heat Substation Installation Practices and Efficiency in Ukraine"* examined the outcomes of IHP installations across 13 Ukrainian cities (USAID ESP, 2021). It found that such installations had significantly improved energy efficiency, reduced household heating costs, and enhanced user control over indoor temperatures. The report also identified inconsistencies in installation practices and performance levels, recommending standardized procedures and improved data collection.

Although highly relevant for pre-war modernisation efforts, the ESP's White Paper and IHP assessment report do not account for the widespread infrastructure damage caused since 2022. Since then, the full-scale Russian invasion and subsequent damage to infrastructure have drastically altered conditions. As a result, updated assessments and new research are

essential to guide district heating sector recovery and modernization in the current wartime and post-war context.

2. Main challenges

2.1 Ageing infrastructure and high heat losses

In many Ukrainian communities, district heating systems remain in place as an efficient form of energy distribution. However, proper maintenance of such systems is a serious challenge due to their physical deterioration and the level of management capacity, which varies considerably among communities. According to the Energy Map portal, as of 2020, the total length of heating networks in Ukraine in operation for over 25 years was 9,346 km, with 7,334 km (or 78%) requiring reconstruction or replacement. Due to network deterioration, heat losses averaged 13%, reaching up to 30-40% in some regions (Energy Map, 2021).

The deterioration of the district heating systems occurred largely from severe infrastructure underinvestment due to fixed ("frozen") heating tariffs for the population. The tariff freezes were briefly lifted in August 2020, but then reinstated after the beginning of the full-scale Russian invasion in 2022 (Cabinet of Ministers of Ukraine, 2022). This tariff rate did not account for the operational costs required for infrastructure maintenance and did not generate sufficient revenue for reinvestment in infrastructure modernization and expansion.

Therefore, the deteriorating state of the central heating system drove a shift in heating practices, which has persisted for the last 20 years, of a reduced reliance on central heating. As the system's inefficiencies and maintenance issues increased, many households turned to alternative heating sources or adopted individual heating systems, seeking more reliable and cost-effective solutions.

To ensure the continued viability of central heating infrastructure in Ukraine, significant modernization efforts are crucial. This modernization can be achieved through domestic or international investments or by lifting the moratorium on fixed tariffs. This would allow domestic prices to align with international market rates, ensuring the profitability of the central heating systems. It should be noted that such a situation was observed previously in August 2020, when private consumers were given the opportunity to choose heat suppliers. When this tariff system was liberalized in 2020, utilities began to see profit and invested in the heating systems.

After the full-scale invasion, tariff liberalization was rolled back and the government introduced a moratorium on increasing prices on energy services for the population. As a result, many heating utilities lack sufficient funds for basic functioning, as well as investments for renovation and modernization.

At the same time, the ongoing war has led to widespread destruction of gas infrastructure, including damage to pipelines, storage facilities, and production capacities. This has made gas-dependent solutions, such as central heating, unsustainable and high-risk. The devastation exposed the limitations of relying on fossil gas, both from the immediate security of supply and long-term feasibility. As a result, the future of central heating lies in adopting alternative technologies. These technologies are more efficient, cost-effective, resilient, and adaptable to current and post-war conditions.

2.2 Widespread destruction of heat generation sources and supporting infrastructure

Before the war, heat in Ukraine was primarily produced by boiler houses, combined heat and power plants, thermal power plants, secondary heat energy sources and, to a minimal extent, nuclear power stations. In most oblast centres and industrial cities, heating systems and corresponding infrastructure were built in connection with large energy-generating facilities. As a result, large natural gas boiler houses for district heating were typically built for new residential developments or urban redevelopment projects. Alternatively, CHP stations needed for the provision of electricity, hot water, and heating in cities were located either within the cities or in their immediate vicinity. Satellite towns, however, typically relied on a single heating source—a large coal-fired thermal power plant—to supply the entire district heating system. These towns were pre-planned with a settlement built around the plant.

As a result of the destructive targeting of thermal power plants, consumers have been at risk of heat supply interruptions, and the introduction of local alternatives for heat supply is difficult. Despite the possibility of setting up a backup power supply for city consumers, the power grid is targeted in attacks, leading to blackouts in different regions. Under this environment, the technical condition and insufficient capacity of temporary power supply schemes fail to meet the basic needs of consumers.

Due to their structure, Ukrainian district heating systems became highly vulnerable during the war and sustained significant damage from attacks on critical infrastructure. As a result, consumers were exposed to the threat of heat supply interruptions. In 2024 alone, Russia carried out 13 large-scale coordinated attacks on Ukraine’s energy infrastructure, causing significant damage to thermal power plants and boiler houses (Janowski, 2024). Notably, since the start of the war, 18 large CHP plants have been severely damaged or destroyed, along with more than 800 boiler houses, 152 central heating points, and 354 kilometers of district heating pipes (World Vision Ukraine, 2024).

In the first months of 2025, Russia has intensified attacks on Ukraine's gas infrastructure, with a particular focus on gas production facilities. These large-scale strikes impacted gas extraction and processing capabilities, posing a serious threat to the country’s energy security. Additionally, in February 2025, targeted attacks on heating infrastructure in

southern Ukraine, particularly in Mykolaiv and Odesa, left many residents without adequate heating for an extended period. These attacks underscore a deliberate strategy to disrupt Ukraine's critical energy systems, exacerbating humanitarian challenges during the winter months. The impact of each attack varies depending on its location and severity, presenting distinct challenges, requiring tailored solutions.

Due to the disruption of manufacturing facilities utilizing gas as fuel for their operation, private consumers became the primary customer base of utility companies. Before the war, industrial consumers played a crucial role in ensuring financial stability for utility companies, as they were a reliable revenue source for modernization and infrastructure improvements. However, many industries were destroyed during the war, leading to the loss of these stable and high-volume payments, which led utility companies to focus on private consumers, who may lack financial discipline and the means to make regular payments.

2.3 Complex and fragmented regulatory system

Interviews with local government officials and utility company representatives identified the complex, incomplete, and fragmented regulatory system as the primary barrier for investment in the district heating sector. Specifically, they mentioned the issue of licensing, complex division of responsibilities, and the subsidized fixed tariffs for all households. Problems that arise from the non-alignment of the existing legal and regulatory frameworks with EU legislation.

The heating sector in Ukraine is regulated in accordance with the following legal acts:

- "***On Heat Supply***" – This is the fundamental law that defines key terms, principles, operating conditions, and regulatory mechanisms for the sector. This includes the division of activities into production, transportation, and supply of thermal energy; the use of various generation; the directive of district heating using CHP plants and boilers; the diverse ownership of heating facilities; and the seasonality in production and consumption.
- "***On the National Commission for State Regulation in the Spheres of Energy and Utilities***" (NEURC, or the Regulator) – This law defines the Regulator's authority to set tariffs and oversee the sector's compliance with legislation.
- "***On Housing and Communal Services***" – This law regulates the relationships involved in providing services within the district heating sector.
- "***On State Regulation of Communal Services***" – This law establishes the legal framework for state regulation in the utilities sector, including licensing of specific activities.
- "***On Local Self-Government***" – This law defines the authority of local self-government bodies to set tariffs for thermal energy.

These legislative packages define the division of powers to regulate the heat supply sector between the Regulator and local governments, which in turn also divide the powers among themselves, regional state administrations, and local councils (executive bodies of city, town, and village councils). These complex and imperfect state regulations with overlapping responsibilities creates barriers for investments in the heating sector.

In practice, the regulation in the field of heat supply is carried out taking into account the peculiarities of how heat supply systems operate, in accordance with Article 5 of the Law of Ukraine "On Heat Supply" such as:

- the division of economic activity in the heat supply sector into production, transportation, and supply of heat energy;
- the various technologies for heat production, including technologies for combined heat and power production and the use of unconventional or renewable energy sources;
- centralized supply of heat to consumers from thermal power plants and boiler houses that are part of the integrated energy system of Ukraine;
- the existence of heat supply facilities of various forms of ownership;
- the seasonal differences in heat production and consumption throughout the year;
- the special status of natural monopolies in the heat supply sector.

On a national level, the Regulator develops and approves license conditions in the heat supply sector. At the same time, both the Regulator and regional administrations are authorized to issue licenses, but only for certain categories of producers as specified by law.

Likewise, all activities in the district heating sector are subject to licensing, apart from the heat that is generated for private use, the heat generated by CGUs (with a maximum capacity of 5 MW) used as a backup energy source for critical infrastructure facilities, public utility infrastructure, and social sector institutions (e.g. educational and healthcare facilities).

Licensees of the NEURC include heat producers at thermal power plants, thermal power plants, nuclear power plants, and cogeneration plants. This licensing by regional administrations is carried out (1) on a territorial basis, depending on the location of facilities or heating networks in the respective region of Ukraine, and (2) by a certain type of energy source for heat production - using non-traditional or renewable sources. The regulator forms and sets prices and approves investment programs exclusively for the NEURC's licensees, while also monitoring their compliance with license conditions.

Local councils will set tariffs for licensees and approve investment programs. At the same time, regional administrations monitor compliance with license conditions. That is, in case of violations, regional administrations can respond to them and take measures.

The licensing of hot water supply activities is not separately defined in the current legislation. Instead, the NEURC develops and establishes licensing conditions for conducting business activities in a centralized water supply and centralized sewage. The NEURC's licensees provide water to regions of more than one hundred thousand people, and the volume of services sold amounts to: for centralized water supply, greater than three hundred thousand cubic meters per year; for centralized wastewater disposal, greater than two hundred thousand cubic meters per year. Smaller licensees for volume and territory are controlled by regional state administrations and tariffs are set according to the same division of powers in the heat supply sector.

2.4 Tariff policy issues

The installation of new decentralied heat supply systems in cities to replace central sources of generation destroyed or significantly damaged may involve a partial use of existing infrastructure, such as heat distribution networks. However, for financial viability any such projects necessitates a reviewing and setting of new tariffs for consumers, including households.

For the TPP satellite towns, such as Ukrainka and Dobrotvir, heat tariffs for residential consumers are currently set at a relatively low level of 630 UAH/Gcal (13,84 Euro/Gcal). With this, local residents are accustomed to low-cost heating and hot water prices, utilizing waste heat from the TPPs located in these towns. With new projects, the cost for renovated or newly created systems will increase by an estimated three times these current tariffs, which are already out of date. This leads to a significant increase in heat tariffs for consumers, with the risk of policy rejection by the population and other related negative consequences. This is particularly undesirable given the economic instability and security risks under martial law.

Currently, the legal framework outlined in "On Peculiarities of Regulation of Relations in the Natural Gas Market and in the Field of Heat Supply during the Martial Law and Further Restoration of Their Functioning" stipulates that during martial law in Ukraine and up to six months after the month of termination, it is prohibited to increase tariffs on heat energy, natural gas, or hot water supply for the population. Therefore, attention should be paid to the formation of tariffs for facilities that produce heat from alternative energy sources.

Of these alternative sources, biomass heat producers have a tariff for households and budgetary organizations amounting to 90% of the tariff for natural gas production (Про теплопостачання (On Heat Supply), 2005). This leads to unequal conditions between fossil fuel heating and biomass heating revenues and is an additional factor discouraging potential investors from implementing biomass boilers and other alternative heat source projects in communities.

Therefore, the tariff policy in the heating sector is inconsistent. Multiple legislative regulations include conflicting regulations with different criteria for different licensees in the sector. The legislation is also frequently changed, negatively affecting investment attractiveness due to an unstable revenue risk.

In general, it can be noted that there is not a well-established heat supply market in Ukraine, and it is necessary to create and enshrine in law a market model with uniform rules clear to all players and consumers. For more details on this distribution of powers between the regulatory authorities in the heat supply sector of Ukraine, see Table 2 in Annex.

Case study illustrating inadequate separation of responsibilities between regional and local authorities

The ability to secure funding for local heating systems by some cities is further complicated by inadequate separation of powers and responsibilities between regional and local authorities.

For example, the city of Chortkiv faced the urgent need to secure resources for the establishment of its local heating system. In Chortkiv, heating for 32 administrative buildings is provided centrally by *Ternopilteplokomunenergo*, a municipal heating facility operated by the Ternopil Regional Council, which is in charge of licensing and oversight. Ternopilteplokomunenergo is not subordinate to the Chortkiv City Council.

However, Ternopil Regional Council already owns six boiler houses located within the community's territory and due to this, it is extremely difficult to influence or adjust the operation of an externally owned heating facility. The Ternopilteplokomunenergo requires major capital repairs and network maintenance and the company claims that such investments are unprofitable, leaving local communities with no viable solution for heat supply. This problem has been in place for multiple years, which triggered the late start to the heating season and poor service quality in the city.

To solve the problem, in 2024 local authorities agreed to transfer these boiler houses to the balance of the Chortkiv municipality after conclusion of the 2024/2025 heating season. The city of Chortkiv subsequently plans to establish a new municipal utility company to run there boiler houses by May 2025. Yet, Chortkiv's intention to establish a municipal utility company are further complicated by insufficient resources to plan, draft, establish, finance, and operate this utility company. Despite the challenges, the potential advantages of this solution are that the municipality's own utility company will allow for better management of the heat supply and increased service to residents in the long term.

However, to start this process and meet deadlines for the new heating season in autumn of 2025, the municipality must overcome many challenges: setting up a new enterprise, attracting qualified personnel, obtaining the necessary permits and licenses, planning and developing a renewed heating system in the city. The risks of not accomplishing these actions in time are high.

This example is not unique to the Chortkiv community. Such challenges exist for many communities in Ukraine that must ensure the development of local energy supply in forming a new utility company.

2.5 Lack of resources and trained personnel

To address the challenges of unstable heat supply and deterioration of district heating systems, many Ukrainian cities are forced to gradually transition to autonomous local heating systems. These systems use local fuels for administrative buildings and critical infrastructure (e.g., medical facilities, utilities), while residents in private homes are independently switching to individual heating systems of gas or solid fuel boilers.

Both implementing new local heating systems and modernizing existing district heating systems present labour-related challenges. These challenges may come from installation and maintenance of individual heating points (IHPs), as well as lack of resources and trained personnel to develop and implement local energy plans (LEPs).

This shortage of skilled professionals for the design, installation, and maintenance of local heating networks stems from an overreliance on public and private energy companies that previously provided these services. This shortage is further exacerbated by the military drafting of men combined with the high gender gap present in these professions. Ukraine currently faces widespread labour shortages in many industries due to general mobilization and the migration of skilled workers, exacerbating this challenge of finding sufficient qualified personnel.

Prior to the full-scale invasion, the energy companies operated large TPPs and heating networks in satellite towns, as well as CHPs in larger cities. However, the war led to the destruction and damage of many CHPs, TPPs and heating networks, leaving local authorities with critical challenges to continue supplying heat services.

Now municipalities must seek alternative heating arrangements to ensure readiness for the next heating season. They face the need to either create a locally-run utility company or attract an external service provider willing to invest in new generating capacity and the repair of utility networks. This first case requires a development of workforce independently—often from scratch—substantially complicating the process. Two key challenges arise in this context:

1) A limited institutional capacity of local authorities to establish, manage, and operate this newly installed utility company.
2) A shortage of skilled labour needed to develop, maintain, and operate the heating infrastructure effectively.

Where heating infrastructure was destroyed or significantly damaged as a result of Russia's attacks, full-scale redevelopment of district heating systems might be needed, requiring high capital and labour-intensive efforts.

Needed Assistance:

- Capacity development and international technical assistance.
- Expert support to local managers in developing and implementing plans for the transition from regional to local heating and utility enterprises, with the creation of appropriate conditions for their technical maintenance and development.
- Creating frameworks for public-private partnerships.
- Professional training programs for local employment.

3. First steps towards resilient heating in Ukrainian cities

3.1 Integration of cogeneration units into heating systems

Some Ukrainian communities are already able to take advantage of technical (grant) assistance from other governments, which provides, among other things, equipment for cogeneration units, CGUs. Such projects allow communities to address the need for electricity in the first place during periods when blackout schedules are applied.

In practice, heat generated from TPPs is partially used or, in some cases, lost without the integration of the CGUs into existing heating networks. It is noteworthy that even local experts from the utilities implementing such projects refer to the heat from the CGUs as a by-product. This emphasizes that the main purpose of municipalities for the implementation of such projects is the backup power supply for individual consumers in the city (critical infrastructure, social facilities, etc.). This is due to the lack of economic attractiveness of simultaneous backup power supply to consumers and the sale of heat energy. This is exacerbated by the lack of conditions for bringing household tariffs for heat and hot water to prices matching market prices. Under such conditions, utilities in large cities can afford to operate only as they are able to combine different types of energy activities and, therefore, receive adequate revenues compared to the capacity of small communities.

The use of CGUs is a practical and scalable solution for communities of different size (number of residents) and geography (distance to the frontline). Given the risks of shelling, distributed generation facilities in modular design present lower risks of targeting compared to large thermal power plants with large-scale technological units (TPPs and CHPs). At the same time, the implementation of decentralized solutions may require different efforts, depending on the characteristics of the community.

The challenges and peculiarities in planning and implementing CGU projects and energy islands, as encountered by interviewed municipalities are:

- Firstly, the grantor or donor provides only the main equipment of the CGU, not including related materials and components necessary for the integration of the units into existing municipal infrastructure. This does not cover the work to ensure the connection of the plants to external gas, heat, and electricity networks. Therefore, all major design decisions and work related to the installation of equipment and ensuring the readiness of these facilities for operation must be provided by the local government.
- Secondly, the municipality must take care of the conditions for further operation and maintenance of the facility. This includes maintenance of specific equipment, professional staff, permits, fuel and related materials, etc. Therefore, such facilities are usually operated by utilities with relevant experience in the energy and utilities sectors. Those cities that lack previous experience in utility companies and face major administrative challenges.
- Thirdly, in addition to the ability to perform certain functions for the implementation and subsequent operation of such facilities, there is the issue of economic feasibility. Currently, the practice of developing resilient financial models under the existing conditions of Ukrainian legislation is in early stages. e.g. Vinnytsia will likely be one of the first communities to share this mechanism and experience with other Ukrainian cities.
- Fourthly, consider the example of Ukrainka, which shows another distinctive feature of TPP satellite cities, namely the lack of sites for CGU foundations within the compact city. Due to dense development and the specifics of the engineering networks within the city, the implementation of such a project is currently difficult. leads to cases where the integration of CGUs into existing heating networks is associated with technical challenges and/or requires significant additional costs.

3.2 Peculiarities of the use of CGUs in outage conditions

Despite the fact that the use of CGUs for the needs of critical infrastructure facilities has become a common solution in communities, practice shows some problem areas and shortcomings.

The CGUs connected to the power grids may not solve the issue of power supply to consumers (critical infrastructure, social facilities, etc.) in the event of blackouts. Grid sections with connected CGUs may be subject to disconnection in cases of exceeding electricity consumption limits or during emergency shutdowns due to damage to the power system caused by shelling. The distribution system operator is not obliged to apply hourly outage schedules if locally distributed generation covers (ensures) at least 80 percent of the consumer load according to the list determined by the Cabinet of Ministers of Ukraine

(CMU), which includes objects of strategic importance (critical infrastructure, defense, special communications, etc.). At the same time, socially important consumers and the household population in most cases do not fall under this rule and may face disconnections.

Under the current conditions, the solution of CGUs does not prevent the absence of heat in certain neighbourhoods of the city in the event of prolonged outages. After all, some remote boiler houses not connected to the autonomous "island" power system with the CGUs cannot operate due to the de-energised pumping equipment. The new CGUs also cannot currently function as basic production equipment due to the lack of an established economic model.

Currently the installation of CGUs in communities is carried out mainly as a source of backup power supply for critical infrastructure facilities. On the one hand, this has the advantage of increasing the reliability of power supply to individual consumers in the city. On the other hand, it raises the question of the efficiency and sustainability of these solutions, as the plants are used primarily for electricity supply with the heat generated considered a by-product. Given the temporary nature of its supply, sustainability of such a solution is not guaranteed as a heat supply of local consumers.

At the same time, utilities that accept CGU equipment must have the resources to design, install, connect to local networks, train staff, and cover related costs. Among other things, there are additional contractual obligations for maintenance, which local specialists are unable to perform without substantial training. For enterprises, these additional costs will increase the cost of producing and supplying heat to consumers, and prevent investment given the moratorium on raising heat prices for household consumers during the war.

Thus, the issues of economic models and investment attractiveness for diversifying heat sources and technologies remain open.

3.3 Use of local fuels and heat pumps

Many active communities are finding more opportunities to adopt alternative heating solutions in the face of military to gas storage facilities and gas distribution networks. Alongside natural gas-fired heat-generating facilities, the practice of using alternative fuels available locally is spreading in greater volumes, mainly via solid fuel boilers.

Almost all cities surveyed have experience in using biomass boilers (wood chips, pellets, firewood). Among other things, these cities aim to ensure the implementation of local development strategies and energy plans to provide diversification of energy sources and reduction of CO_2 emissions. The move to automated boiler operations is also being favourably received by local experts, as it reduces operating costs and improves safety by reducing staff. This practice is already widespread among many Ukrainian communities.

In contrast, the city of Stryi presents a rare case among Ukrainian communities of the use of a heat pump, in which the heat pump is integrated into the existing local system for heat energy and hot water supply (16 m cubic meters per day) supplied simultaneously to different buildings of a medical institution. This example shows the possibility of solving the issue of hot water supply for small buildings in communities by the existing local utility company, without involving outside specialists.

Another interviewed municipality, Chortkiv is looking for resources of not only funding, but also a professional team for the complete transfer, maintenance, and management of existing boiler houses from the regional utility company to the local level with implementation of biomass and heat pump projects. With this, Chortkiv is interested in developing municipal energy both institutionally and technically.

3.4 Efforts for creating resilient local energy systems

In the context of frequent attacks on Ukraine's centralized energy infrastructure, including main electricity substations and gas facilities, the creation of "energy islands" - local energy systems capable of operating separately and autonomously - has become particularly relevant.

Distributed generation projects with energy islands are becoming a trend for Ukrainian municipalities in these times of war, and considered by both large cities and small communities. For example, the city of Dolyna is developing the concept of a project combining different energy sources within a newly created microgrid. The next steps for this project is to procure funding for a feasibility study and proceeding implementation. At the same time, there is the concern of financially attractive models for such projects and implementation barriers from existing challenges.

Even single-site projects with one or more cogeneration units in small towns such as Dobrotvir and Stryi require careful assessment and planning of operating costs to account for maintenance and service. Given the current tariff policy and regulation in the heat sector, these projects are primarily aimed at ensuring energy supply to critical infrastructure and supporting the operation of utilities in emergency conditions. However, currently they remain insufficiently economically attractive for permanent participation in the grid and provision of ancillary services.

The issue of an optimised combination of electricity and heat supply technologies is not currently discussed in local energy plans, even when taking into account the flexibility and efficiency of energy use and the development of new financial models for their economic feasibility. For Ukraine, sector coupling presents a completely new level of municipal energy planning that must be developed in terms of methodological, regulatory and institutional support.

Practice shows that in many cities, individual heating points are not installed in all buildings connected to local heating networks. This leads to an inefficient heat distribution and an excessive use of heat by end-users in apartment buildings.

In addition, inefficient maintenance of existing IHP has been a problem. Due to the negligence of employees or lack of knowledge about the settings of IHP equipment during preparation for the heating season, heat losses can increase. Accordingly, as heat losses increase, this also leads to an increase in consumer costs. Such mistakes should not be repeated in the future, especially when communities take initiatives to re-develop heating networks and install new sources of heat generation.

Along with concerns of energy efficiency in communities, the issue of implementing local energy management systems also requires attention. Among the communities surveyed in this study, some are without an energy manager. The absence of energy monitoring and quality energy management at the local level can significantly impair the quality of local energy planning and development in various sectors.

Additionally, climate neutrality goals are affected by these deficiencies. Currently, the key document defining how a community will achieve CO_2 emission reduction targets as part of its participation in the Covenant of Mayors is the Sustainable Energy and Climate Action Plan (SECAP). Unfortunately not all communities, especially small towns, have the resources to develop such documents further impeding climate neutrality goals.

The Law of Ukraine "On Energy Efficiency" requires all communities to develop local energy plans (LEPs) approved by November 2025. According to the defined methodology, each community must define sustainable energy development goals with a planning horizon of 10 years across thirteen different sectors. The process of developing these documents by the communities is in the early stages, but unlike the SECAP under the voluntary Covenant of Mayors, the LEPs are mandatory. The goals of this sustainable energy development are to increase energy efficiency and develop renewable energy sources. The practice of developing these LEPs is still quite small, as it is a new task for these communities and there is a lack of specialists who can quickly transfer experience in the methodology and quality of the plan.

3.5 Situation with access to finance

The installation of local heating systems requires a sizable investment and, in times of war, securing funding for such projects is particularly challenging. This is especially problematic for small cities, whose authorities are reluctant to invest their local budgets or increase risks from loans, as doing so could exacerbate local budget deficits and may violate debt restrictions. Instead, small communities primarily rely on grants and international projects to provide technical assistance. While grants and international assistance are the primary

funding sources, the Cabinet of Ministers also provides funding via the reserve fund to executive bodies that in turn sponsor the installation of local heating systems.

However, access to this state funding is not universal and varies depending on the region and community. Bureaucratic "red tape" barriers pose a significant challenge for some applicants, who encounter communication difficulties. Official correspondence with executive authorities may continue for months, leaving local authorities without a response on funding allocation for their projects. At the same time, the success of cities like Dobrotvir and Burstyn, which managed to secure budgetary funding from the state, shows promise. Specifically, 470 million UAH were allocated from the reserve fund to ensure backup heat supply in these two cities affected by missile strikes (Tumanova, 2024). However, no specific national program is in place to support the resilience of municipal heating; rather, the funds were allocated directly to the cities in need.

Attracting private investment is likewise difficult during the war, as concerns of investment attractiveness and guarantees regarding return on investment present a higher risk to investors. Furthermore, the existing regulatory framework offers insufficient incentives to encourage private investment in this sector.

Needed Assistance (International):

- Funding for the modernization of local heating infrastructure (e.g., EU structural funds, loans and grants from EU and other international partners);
- Technical assistance and technology transfer to develop local expertise, skilled labour and local manufacturing.

Needed Assistance (Domestic):

- Locally tailored strategies to minimize costs and employ economies of scale;
- National funding for the modernization of local heating infrastructure (e.g., PPP, green bonds, financing framework of cost-reflective-tariffs, domestic grants and loans (e.g., from the decarbonization fund)).

4. Introducing the "Sector Coupling" concept to Ukraine

***Potential role models*:** Taarnby (Denmark), Hamburg (Germany), Heerlen (Netherlands), Copenhagen (Denmark), Vienna (Austria), Helsinki (Finland), Malmö (Sweden), Neu-Isenburg (Germany), Dronninglund (Denmark).

Sector coupling involves integrating and coordinating various energy sectors, including both energy end-use and supply sources – typically heating, industry, mobility and electricity. In

a coupled system, these sectors are interconnected to reduce greenhouse gas emissions, facilitate energy exchange, and to enhance overall efficiency, flexibility, security, and supply resilience (GridX, 2024). In the context of municipal energy systems, coupling requires not only the integration of heating and electricity technologies, but also a better overall usage of variable energy sources, such as solar and wind, to create a decarbonized, sustainable and cost-effective solution.

Heat pumps, flexible cogeneration units, thermal energy storage, and direct electricity-to-heat conversion are coupling solutions that may be utilized to optimize heating.

- Large heat pumps may be integrated into the district heating networks to provide a stable heat supply, while hybrid systems may be combined with regular boilers to efficiently meet peak demand.
- Flexible cogeneration units may adjust their output to meet varying electricity and heat demands while utilizing various fuels, such as gas, biomass, organic waste, biogas, or biomethane.
- Thermal energy storage systems complement cogeneration technologies by storing excess heat for later use. Short-term storage solutions (e.g., hot water tanks) accommodate daily demand fluctuations, while long-term storage solutions (e.g., water pit thermal energy storage (PTES) systems) help to manage seasonal demand fluctuations.
- Direct conversion of renewable electricity into heat, a useful measure for grid stabilization, requires the usage of electric boilers and modern resistive heaters coupled with thermal energy storage for an optimal heat supply.

Electrification is central to the coupling of sectors, with technologies such as heat pumps, energy storage and flexible cogeneration reducing emissions and helping to balance the grid. This approach allows for a flexible transition from fossil fuels to renewables, increasing the energy efficiency, security, and resilience of the energy supply while contributing to decarbonization efforts. Intermittent generation increases with the greater utilization of the potential of stochastic sources such as solar and wind power, which have irregular power generation schedules. Coupling is therefore achieved by converting electricity into heat during hours of surplus, as well as by using flexible energy conversion and storage technologies to allow balancing the operation of heat and power supply systems.

The following European cities that have successfully implemented sector coupling, serve as models for Ukraine:

- **Taarnby (Denmark):** In the municipality of Taarnby, located near Copenhagen, a smart energy project was launched as part of a new urban development near the Copenhagen Airport. A combined district heating and cooling system was developed,

centered around a 4.5 MW electric heat pump installed at the local wastewater treatment plant. This system links the electricity, wastewater, heating, and cooling sectors, using waste heat from sewage and ground-source wells to supply both chilled and hot water. A 2,000 m^3 cold-water storage tank functions as a thermal buffer, allowing the system to adjust operations in response to fluctuating electricity prices and heating demand (Ramboll, 2020). By recovering energy that would otherwise be lost, the system exemplifies the principle of circular efficiency: cooling generation results in usable heat, which is then distributed through the heating network. This dual-purpose strategy has resulted in significant cost savings - approximately DKK 80 million (roughly €10.7 million) - compared to deploying separate systems for heating and cooling. Widely recognized as a leading example of sector coupling, the project delivers low-carbon thermal energy to large buildings and the airport while maximizing the use of renewable electricity.

- **Hamburg (Germany):** Hamburg's sector coupling initiative demonstrates how industrial waste heat can be harnessed to decarbonize urban heating. Since 2018, the city has partnered with the Aurubis copper smelter to capture excess heat from the production process and feed it into the district heating network. The core technology - a towering 18-meter, 250-tonne "intermediate absorber" heat exchanger - extracts high-temperature waste heat (~90 °C) in the form of steam and hot water. This is transferred via a 3.7 km pipeline under the Elbe River to supply Hamburg's HafenCity East district. Additional infrastructure, including backup boilers and hot-water storage, ensures system reliability. By connecting the industrial and heating sectors, Hamburg avoids burning extra fuel while significantly reducing emissions and improving energy efficiency. This project, led by a public–private partnership between Aurubis and Hamburg's municipal utility, was made possible through national and EU-level financial support. Funding from KfW and Germany's Federal Ministry for Economic Affairs covered critical upgrades and infrastructure, while alignment with local climate policy ensured regulatory support (KfW Stories, 2018). Recognized as a national flagship by the German Energy Agency, the project now supplies heat to over 15,000 residents and has the potential to meet over 10% of Hamburg's district heating demand. It exemplifies how targeted investment and coordinated governance can unlock large-scale, low-carbon sector integration (CDP, 2020).
- **Heerlen (Netherlands):** The city of Heerlen has pioneered one of Europe's most advanced examples of sector coupling through its fifth-generation district heating and cooling (5GDHC) network, known as the Mijnwater system. This low-temperature thermal grid reuses an abandoned, water-filled coal mine as a vast underground energy reservoir, allowing buildings to exchange heating and cooling through a networked loop. Waste heat from cooling processes or overheated buildings is redistributed to others needing warmth, with surplus energy stored seasonally in the

mine. Decentralized electric heat pumps installed at consumer sites upgrade the shared loop temperature for individual use, allowing the system to operate efficiently and significantly reduce energy loss. Heerlen's approach is a cutting-edge example of sector coupling that dynamically links thermal energy exchange with the electrical grid via heat pumps. Governance of the Mijnwater project evolved from a municipal pilot into a public-private utility, Mijnwater B.V., supported by the Limburg Energy Fund and multiple EU programs such as Interreg and D2Grids. The project currently serves hundreds of dwellings and commercial buildings, displacing natural gas use and reducing thermal demand by up to 50%. As renewable electricity use increases, emissions will continue to fall, making this model a blueprint for low-carbon urban energy. With plans to scale to 120,000 dwellings by 2040 in the surrounding the Parkstad Limburg region, Heerlen's experience shows how local leadership, regional coordination, and smart investment in sector coupling can create scalable and sustainable energy infrastructure (GDECA, 2020).

- **Copenhagen (Denmark):** Copenhagen's district heating system is globally recognized as a model for sector coupling. The city utilizes large-scale heat pumps, waste-to-energy plants, and thermal storage to integrate its heating and power systems. Surplus electricity generated by wind plants is converted into heat using heat pumps, which ensure the efficient utilization of surplus renewable energy.
- **Vienna (Austria):** Vienna's "Smart City Wien" concept incorporates sector coupling through the "Smart Thermal Grid" project. This initiative integrates TPPs, CHPs, and solar thermal systems to optimize energy use across different sectors.
- **Helsinki (Finland):** Helsinki's energy strategy envisions replacing coal-fired thermal power plants with integrated heat pump systems and thermal storages (Helsinki's Hot Heart), utilizing seawater as a heat source. The city also employs thermal storage to retain excess heat from industrial processes and renewable energy sources.
- **Malmö (Sweden):** Malmö has implemented a district heating system that integrates renewable energy sources, residual heat from industries, and large-scale thermal energy storage. The city's approach demonstrates how integrated planning can simultaneously reduce greenhouse gas emissions and enhance energy security.
- **Neu-Isenburg (Germany):** Neu-Isenburg successfully integrated modern technologies like heat pumps with the district heating network through its newly-constructed new data center. The facility can generate up to 50 MW of residual heat, which is utilized to heat residential, commercial, and industrial buildings in the city and surrounding communities. The successful implementation of this concept allowed the data center to lower carbon emissions and reduce heating costs.
- **Dronninglund (Denmark):** Dronninglund serves as a valuable example of how small towns may achieve energy independence, particularly in heating. Dronninglund operates a solar-powered district heating system equipped with 2,982 solar collector panels covering an area of 37,573 m^2. During summer months, the installed system

generates surplus energy stored in a large underground water pit thermal energy storage. This enables the town to not only meet 40-50% of its annual heating demand but also reduce CO_2 emissions by approximately 2 tons per household each year.

While sector coupling is essential for Ukraine, implementation can be technically challenging, as it would require the overall modernization of energy systems, adoption of European standards and alignment national legal and regulatory frameworks with EU legislation (e.g., Renewable Energy Directive (EU) 2023/2413, Energy Efficiency Directive (EU) 2023/1791, other legislation from the "Fit for 55" package and the Clean Energy for All Europeans package).

Implementing sector coupling in Ukraine also faces significant technical and infrastructural challenges. Much of the country's district heating network remains outdated and highly inefficient, with limited integration of modern technologies such as thermal storage systems or advanced SCADA platforms. Key enabling technologies for sector coupling - such as large-scale heat pumps, waste heat recovery systems, and smart control infrastructure - are minimally deployed across the country. This technological lag prevents the heating sector from effectively connecting with the electricity grid or industrial waste heat sources. Fundamental upgrades to core components (pipes, pumps, and control systems) are essential before meaningful sector coupling can occur. Moreover, digitalization across the sector remains low, with limited use of real-time data and automation that are critical for managing flexible, interconnected energy flows.

Another key barrier to advancing sector coupling in Ukraine is the lack of a clear regulatory framework for third-party energy input into district heating networks. Ukraine's DH sector is dominated by municipal utilities that often operate as natural monopolies in each city, with exclusive control over both heat production and infrastructure. As a result, there are no established procedures or incentives for independent producers - such as industrial facilities with waste heat, or private cogeneration units - to supply heat to city systems. This structural limitation hinders the integration of decentralized, low-carbon heat sources into the urban energy system.

In addition, urban planning and utility regulation also remain disconnected: new buildings often default to individual heating solutions, while city authorities have not prioritized integration with district heating networks or coordinated planning across the heating, electricity, and transport sectors. This fragmented approach makes it difficult to scale efficient, interconnected energy systems at the city level.

In some Ukrainian cities, there is a growing trend of consumers disconnecting from district heating systems in favor of individual heating solutions. While often driven by concerns over reliability or cost, this shift steadily undermines the customer base for district heating and weakens its economic foundation. As the scale of centralized systems shrinks, it becomes

increasingly difficult to justify or finance investments in modernization or integration with other energy sectors. This dynamic creates a vicious cycle where the lack of investment drives further disconnections, making long-term planning and sector coupling even more challenging.

Another major challenge for sector coupling in Ukraine is that most district heating companies are vertically integrated and focused only on heat. They don't typically operate across sectors, which makes it difficult to connect with electricity grids or industrial energy sources. Sector coupling requires more flexible business models, such as multi-utility companies that manage both heat and electricity, or agreements that allow private producers to supply heat into the system. With current lack of such models, district heating companies remain isolated from the broader shift toward integrated, low-carbon energy systems.

In Ukraine, sector coupling is often held back by limited awareness and technical know-how among key actors. Some plant managers, engineers, and city officials are still unfamiliar with technologies like waste heat recovery, large-scale heat pumps, or power-to-heat systems. A recent analysis pointed to both limited knowledge and a shortage of hands-on experience in integrating these solutions into district heating. This skills gap makes designing and implementing cross-sector projects challenging, even when technical potential exists. At the same time, public communication around successful examples from other countries has been minimal, so there's little shared understanding of what works or why it matters. Without greater visibility, training, and trust in these technologies, it's hard to shift mindsets or get decision-makers to prioritize sector coupling as a realistic and valuable step forward.

Needed Assistance (International):

- Ukrainian municipalities can leverage international cooperation and best practices from European cities, which serve as successful sector coupling models.
- Capacity building and municipal twinning programs can help Ukrainian communities to employ and upskill municipal energy managers and technical staff.
- Knowledge transfer can help Ukraine to develop standardized methodologies for integrated energy planning and optimizing heat supply systems through sector coupling.

5. Conclusions and Recommendations

Based on the results of surveys conducted in this study, it can be concluded that most communities desire alternative solutions to heat supply. At the same time, the level of ambition depends on the level of opportunities, which are greater in large cities. Many communities are aware of the importance and benefits of implementing a local energy management system with energy efficiency measures, and many have relevant successful experience. The primary obstacle in the development of such projects is the lack of funding, compounded by investor timidness as a result of the war.

One of the core issues of this funding obstacle is the lack of financially attractive models for project implementation. Even single-site projects, with one or more CGUs, in small towns require careful assessment and planning of operating costs for maintenance and service. Under the conditions of current tariff policy and regulation in the heat sector, distributed CGU projects are primarily aimed at ensuring energy supply to critical infrastructure, rather than a provision of heating services. They remain insufficiently economically attractive for permanent participation in the grid and provision of ancillary services.

There are significant obstacles to building resilient municipal heat supply in Ukraine, and overcoming them is essential for energy security, sustainable development, and European integration. Outdated infrastructure, fragmented regulation, lack of integrated planning and financial constraints hinder progress. To overcome these challenges, a strategic shift toward a decentralized, integrated, and resilient energy system is necessary.

At the national level, Ukraine must develop clear policies and standards to facilitate the modernization and integration of heat and power systems. Fully aligning national legislation with EU directives (e.g. the Renewable Energy Directive and the Energy Efficiency Directive) and implementing relevant policies at the local level will facilitate the introduction of innovative technologies and demonstrate Ukraine's commitment to integration into the EU energy market. Providing incentives for renewable energy and energy efficiency projects will be crucial to attracting the private sector investment necessary for this transition. At the same time, legislative changes aimed for European integration should also take into account conditions for recovery of local economies following the war.

The following key high-level recommendations suggest a roadmap for aligning with best practices from European cities and introducing coupling principles into infrastructure planning in Ukraine:

- To support the sustainable reform of Ukraine’s district heating sector, it is recommended to redirect all subsidies exclusively to targeted support for low-income households, while linking such assistance to incentives for energy efficiency and renewable energy investments. Tariff-setting should be transparent, fully cost-

reflective, and encourage energy loss reduction and modernization. Universal installation of radiator-based metering and controls is advised to enhance user satisfaction, with implementation costs included in tariffs. Legal and financial frameworks should enable district heating operators to profit from end-use efficiency improvements, breaking the current disincentive cycle tied to reduced heat demand. Also, a large-scale public information campaign is essential to increase awareness and foster public support for necessary reforms.

- Ukraine must transition from reliance on large, vulnerable centralized thermal power plants to a increasingly decentralized system that maximizes the use of solar and wind resources and includes municipal cogeneration units (CGUs), biogas and biomass boilers. By developing energy islands with localized generation and energy storage, Ukraine can enhance system reliability and security, and reduce dependence on centralized infrastructure.
- Sector coupling and the integration of renewable energy should become a priority for future infrastructure planning, with municipalities adopting energy-efficient technologies such as heat pumps, thermal storage, and Power-to-Heat (P2H) solutions. Expanding the use of flexible cogeneration powered by biomass and biomethane will further decrease reliance on fossil fuels, supporting both sustainability goals and long-term economic efficiency.
- Consistent regulatory and policy reforms are crucial to fostering investment and ensuring a clear framework for modernization of the heating sector. Ukraine must align its energy policies with EU directives, such as the Renewable Energy Directive and the Energy Efficiency Directive, to facilitate integration into the European market. Tariff structures should be reformed to make municipal heat projects financially viable, while municipal energy agencies should be established to coordinate planning, implementation, and oversight of heat supply modernization efforts.
- Securing adequate financial mechanisms and investment support is essential. Municipalities should have access to concessional loans, EU structural funds, and green bonds to support infrastructure upgrades. Public-private partnerships should be encouraged, along with tax incentives for heat pumps, flexible co-generation, and renewable energy technologies. The development of financially viable business models will ensure the long-term sustainability of municipal heat supply projects, making them attractive for investors.
- Finally, capacity building and knowledge transfer are key to ensuring the success of modernization efforts. Municipalities must establish energy management systems and train personnel to oversee energy efficiency measures and implement integrated infrastructure planning. Drawing on the expertise of European cities through knowledge-sharing platforms and targeted training programs will accelerate progress. Additionally, standardized methodologies for local energy planning should be developed to support the transition to integrated energy systems.

By adopting these high-level measures, Ukraine can modernize its municipal heating sector, enhance resilience, and accelerate integration into the European energy market. Likewise, these measures will ensure affordable and sustainable heat supply for its cities and communities.

Based on the results of on-the-ground surveys, we also provide a more narrow set of practical recommendations for Ukrainian cities, which can help overcome obstacles at the local level:

- Municipalities should develop their own capacity to implement projects by seeking technical and financial assistance from international partners, as well as learning from the experience of European cities.
- In the instances of new CHP plant or boiler house constructions, it is necessary to facilitate the modernization of existing heating networks in advance, with the installation of Individual Heating Points (IHPs) at all connected consumer facilities. Without which, inefficient use/distribution of heat and increased fuel consumption will continue.
- In case of difficulties in interacting with the local distribution system operator, it is necessary to file complaints with the Regulator regarding violations in terms of connecting facilities to the grid.
- Introducing energy management systems at the city level and in municipal enterprises, creating appropriate positions of energy managers, attracting specialist staff and continuously improving qualifications will be essential.

Modernising Ukraine's municipal energy infrastructure is critical to improving the country's energy security and decreasing demand for gas. This is an necessary to plan as it relates to Ukraine's accession to the EU. Ukrainian communities in their infrastructure planning must be guided by modern European practices, adopting sector coupling where possible. Integrated energy systems are at the heart of the EU's vision of a green and interconnected energy market, making their development a strategic priority for Ukraine.

Finally, as Ukraine seeks to join the EU, bringing its energy systems in line with European standards will demonstrate a readiness to integrate into the EU energy market. Sector coupling opens the door to setting and achieving ambitious decarbonization targets positioning Ukraine as a proactive and committed partner.

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Annex

Table 1. Results of surveys on the main risks and solutions for the heat supply in communities

Location (Population)	Damage to energy infrastructure	Key risks for the heat supply	Current challenges for communities	Support in action
Vinnytsia (369 739)	No reports of damage affecting the heat supply	There may be interruptions in heat supply (the main fuel is natural gas) due to the threat of constant Russian attacks on gas infrastructure throughout Ukraine	There is a lack of alternatives to natural gas for most heat consumers in the city. Fuel diversification is needed to reduce dependence on natural gas	- Provision of 4 CGUs under the USAID Energy Security Project - Installation of 1 CGU to ensure the operation of one of the city's boiler houses with the support of the International Organization for Migration (IOM) - Active participation in the project "Support of Energy Modernization" with the support of GIZ
Stryi (59 425)	Continuous attacks on Europe's largest gas storage facility near Stryi	High risk for natural gas consuming systems due to the threat of constant Russian attacks on the gas storage facility near the city of Stryi	-Regulatory risks associated with the connection of cogeneration plants under a simplified procedure -Economically unattractive heat tariffs for households: (1) lead to losses for the utility company that provides heat to consumers, (2) hinder the development of biomass heat production projects, despite the availability of sufficient local resources (primarily forest waste)	-Provision of two CGUs under the USAID Energy Security Project
Chortkiv (28 279)	No reports of damage affecting heat supply	There may be interruptions in heat supply (the main fuel is natural gas) due to the threat of constant Russian attacks on gas infrastructure throughout Ukraine.	With the loss of an external heat supplier, there is a risk of the timely and high-quality planning and commissioning of heating networks. - Lack of qualified personnel to implement projects and maintain the heating infrastructure. - Lack of experience in deploying heat supply systems at the city level. - Limited capacity of the network for the installation of CGU. Additional investments are required to modernize existing networks, including the substations.	There is no information available
Dolyna (20 417)	No reports of damage affecting the heat supply	There may be interruptions in heat supply (the main fuel is natural gas) due to the threat of constant Russian attacks on gas infrastructure throughout Ukraine	Lack of alternatives to natural gas for most heat consumers in the city. Fuel diversification is needed to reduce dependence on natural gas.	There is no information available
Ukrainka (16 081)	Attacks on the Trypilska TPP in 2024	High risk of heat supply to consumers due to complete dependence on the thermal power plant, which was severely damaged by shelling. Lack of alternative heating systems in the city	- The search for proper support for alternative heat supply projects in the city is ongoing - Dense urban development complicates the deployment of energy island projects based on CGUs. - Tariff barriers for potential alternative heat. - Lack of qualified personnel.	Declarative intentions of support from German partners
Dobrotvir (6 339)	Repeated attacks on Dobrotvirska TPP in 2024	High dependence of heat consumers in the community on TPPs with significant damage caused by shelling. This risk is mitigated by the introduction of alternative heating systems before the start of the next heating season	-Timing of alternative heat supply implementation. - Tariff barriers for alternative heat. - Lack of qualified personnel in wartime. - Heat losses in an open heating system	- Several CGUs from USAID and the Netherlands are planned to be installed - Alternative heating solutions are being implemented at the expense of the reserve fund of the Cabinet of Ministers of Ukraine

Table 2. Distribution of powers between the regulatory authorities in the heat supply sector of Ukraine.

Powers	Regulator (NEURC)	Local Governments
Establishment of licensing conditions (terms and conditions of certain types of activities)	The regulator develops and approves licensing conditions and the procedure for monitoring compliance with them in the heat supply sector.[2] Licensing conditions for conducting business activities in the field of heat supply: • for the production of thermal energy;[3] • for the transportation of heat energy through main and local (distribution) heating networks;[2] • for the supply of heat energy.[2] Separately, the Regulator develops and approves licensing conditions for conducting business activities in centralized water supply and centralized sewerage. [4]	Ukrainian legislation does not provide for this.
Licensing (issuing licenses for certain types of business activities)	The regulator licenses activities: • heat energy production (*except for heat energy production at facilities using non-traditional or renewable energy sources*), its transportation by main and local (distribution) heating networks, supply of heat energy in volumes exceeding the level established by the terms and conditions of business (license conditions); • on centralized water supply and sewerage in volumes exceeding the level established by the terms and conditions of economic activity (license conditions)[1], namely, if the centralized water supply and/or centralized wastewater disposal systems of business entities are located in one or more settlements within the territory of one or more regions (including the city of Kyiv), the	Regional and Kyiv city state administrations carry out licensing of business activities: 1) heat energy production (except for heat energy production at thermal power plants, thermal power plants, nuclear power plants, cogeneration plants): • at production facilities located in the relevant region of Ukraine and the city of Kyiv; • at plants using alternative energy sources; 2) on the transportation of heat energy by main and local (distribution) heating networks of business entities if the heating networks of business entities are located in the territory of the relevant region of Ukraine and the territory of the city of Kyiv;

[2] According to Article 6 of the Law of Ukraine "On State Regulation of Public Utilities"

[3] NEURC Resolution No. 308 of 22 March 2017, as amended by NEURC Resolution Resolution No. 1791 of 22.10.2024

[4] NEURC Resolution No. 307 of 22.03.2017 as amended by Resolution No. 1791 of 22.10.2024

	total population of which is more than one hundred thousand people and the volume of services sold is, respectively: for centralized water supply - more than three hundred thousand cubic meters per year; for centralized wastewater disposal - more than two hundred thousand cubic meters per year.[4] Entities that have obtained licenses for these types of activities are licensees of the NEURC.	3) for the supply of heat energy to business entities if the business entity carries out (plans to carry out) the supply of heat energy in the territory of the relevant region of Ukraine (territory of the city of Kyiv);[2] 4) for centralized water supply and/or centralized sewerage (wastewater disposal and/or treatment) for business entities that do not fall under the NEURC's regulation criteria Entities that have obtained licenses for these types of activities are licensees of the respective authority.
Formation and setting of tariffs	The regulator develops and approves rules and procedures in accordance with which it sets tariffs for the NEURC licensees, namely, taking into account the requirements: • Methods for the formation, calculation, and setting of tariffs for electricity and/or heat produced at TPPs and CHPs;[5] • The procedure for setting tariffs for heat energy, its production, transportation, and supply;[6] • The procedure for setting tariffs for heat supply services;[7] • Procedure for the formation of investment programs of licensees for the production of electricity and heat at thermal power plants and cogeneration units;[8] • Procedure for the development, approval, coordination, approval, and implementation of investment programs of business entities in the field of heat supply, licensing of	The executive bodies of city, settlement, and village councils set tariffs for local self-government licensees in accordance with the rules and procedure established by MinRegion, namely, in accordance with the following: • The procedure for review by local governments of calculations of tariffs for heat energy, its production, transportation and supply, as well as calculations of tariffs for utilities submitted for their establishment.[10] The powers to set tariffs and approve investment programs for local government licensees are vested in the executive bodies of city, village, and settlement councils in accordance with Article

[5] NEURC Resolution No. 991 dated 01.08.2017

[6] NEURC Resolution No. 1174 of 25.06.2019 as amended by Resolution No. 2814 of 30.12.2020

[7] NEURC Resolution No. 416 dated 18.02.2020

[8] NEURC Resolution dated 15.10.2015 No. 2585 as amended by Resolution No. 953 dated 07.06.2019

[10] Order of MinRegion dated 12.09.2018 No. 239 as amended by the Orders of the Ministry of Development of Communities, Territories and Infrastructure No. 558 dated 30.06.2023, No. 512 dated 05.06.2024

	which is carried out by the National Commission for State Regulation of Energy and Public Utilities.[9] The NEURC is empowered by law to set tariffs and approve investment programmes for the NEURC's licensees, in particular, in accordance with Article 16 of the Law of Ukraine "On Heat Supply", as well as the Laws of Ukraine "On the NEURC" and "On State Regulation of Public Utilities".	28 of the Law of Ukraine "On Local Self-Government", as well as in accordance with Article 13 of the Law of Ukraine "On Heat Supply" and Article 4 of the Law of Ukraine "On Housing and Communal Services".
Control of licensees	The regulator carries out state regulation, monitoring, and control of the NEURC licensees' activities, including general control over compliance with license conditions; reviews cases of violation of license conditions and makes decisions within its powers.[11]	The local authorities that carry out licensing, i.e. regional state administrations and the Kyiv City Administration, ensure control over compliance by such local authority licensees with the established prices and tariffs, within the powers granted by law,[12] and the relevant licensing conditions.[13]

[9] NEURC Resolution No. 1059 dated 31.08.2017 as amended by Resolution No. 140 dated 24.0

[11] According to Article 2 of the Law of Ukraine "On the NEURC", Article 16 of the Law of Ukraine "On Heat Supply"

[12] According to Article 28 of the Law of Ukraine "On Local Self-Government"

[13] According to Article 16-1 of the Law of Ukraine "On Heat Supply"