Scoping study

Financing Renewable Energy Projects in Ukrainian Municipalities

March 2024

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A scoping study "Financing Renewable Energy Projects in Ukrainian Municipalities" was conducted in November 2023 – January 2024 in order to analyze effectiveness of current support schemes available for municipalities to finance small scale renewable projects and to provide recommendations of optimal structure of financial support to municipalities that could address current challenges and boost development of small RES in municipal sector. In addition to this, the work provides technical analysis of different types of renewables projects that can be implemented in municipalities as well as recommendations for their prioritization and selection.

This study has been conducted by independent team of authors under general supervision of NGO "Ecoclub" and supported by the European Climate Foundation. Responsibility for the information and views set out in this study lies with the authors. The European Climate Foundation cannot be held responsible for any use which may be made of the information contained or expressed therein.

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Executive Summary

The aggressive full-scale invasion initiated by the Russian Federation in Ukraine in 2022 and the subsequent attacks on Ukraine's energy infrastructure have caused substantial damage to the country's electricity sector. Ukrainian municipalities need to recover energy and utilities infrastructure to provide electricity, water, heat, and other vital services to the population. Thus, they are looking for reliable and economically viable approaches to ensure energy security for these operations. This could be achieved through increased deployment of renewable energy sources installations at municipal infrastructure objects.

The Scoping Study focuses on solar power stations as they align with both economic and environmental objectives and offer a pragmatic and sustainable solution for local energy needs.

Municipalities can implement on-grid solar power stations or hybrid stations. On-grid solar power stations do not incorporate batteries and cannot operate with no external power supply (under condition of power outages). In contrast to on-grid stations, hybrid stations can operate in both grid-connected and autonomous modes. **On-grid solar power stations represent the most cost-effective option** in terms of installed capacity cost. They ensure the offset of a portion of the facility's consumption. The greatest economic benefit can be achieved under the condition that the solar power station's generation does not exceed the facility's own consumption at any given moment.

However, **if system reliability is the primary concern, preference should be given to hybrid stations** (which comprise storage). This type of stations offers operational flexibility in both grid-connected and autonomous modes, providing effective demand side management and reliability, especially valuable during outage conditions.

When selecting a facility for the installation of a solar power station, a municipality needs to take into account the pattern of energy consumption, available space for installation, and a need for hot water supply.The year-round electricity and hot water consumption of hospitals, kindergartens, and water supply systems facilitate effective load management, enabling use of generated electricity primarily for internal needs and active participation in load regulation of the electricity network. Conversely, schools and other facilities with extended periods of inactivity are not well-suited for such projects, unless there is a straightforward procedure in place for selling unused energy.

THE MOST EFFECTIVE OPTION IN TERMS OF PAYBACK PERIOD IS AS FOLLOWS:

- For on-grid solar power stations: The maximum power of the solar station should be close to the maximum daylight load power.
- For hybrid solar power stations: The maximum power of the solar station is selected to produce an equal amount of energy during the day as the daily consumption. The storage capacity should match the daily consumption, or half of it if most energy is used during the daytime.

On average, the payback period for a solar station without storage is around 4-7 years, while with storage it ranges from 8 to 16 years.

THE ANALYSIS SHOWS THAT THE FOLLOWING TYPES OF PROJECTS SHOULD BE PRIORITISED:

- installation of a self-consumption rooftop solar power plant in hospitals, equipped with a hybrid inverter with backup power capability;
- installation of solar power stations at water utility pumping stations and wastewater treatment facilities, equipped with hybrid inverters and backup capabilities (taking into account possible modernisation or replacement of pumping equipment);
- installation of solar power stations at sewage pumping stations with hybrid inverters and backup capabilities (taking into account possible modernisation or replacement of pumping equipment).

These projects can be implemented within a 6-12 month timeframe, including development and approval of project documentation.

To be able to implement renewable energy projects, municipalities need affordable financial mechanisms, support in the form of technical assistance and reservation from military service of personnel involved in the implementation of such types of projects.

State support schemes and programs for solar projects currently are almost non-functional. Municipalities have limited possibilities to attract loans from commercial banks due to high interest rates, ranging between 19.5% to 25% for loans in national currency. IFIs suspended part of their financial programmes due to full-scale war. Existing programmes either do not target directly municipal renewable energy projects or new applications are not currently being accepted from municipalities that were not selected during previous rounds of applications.

Direct financing of renewable projects in municipalities by IFIs and donors is considered the most attractive option in the current circumstances. It is also recommended to consider the possibility of combining different sources of financing, in particular, international loans with grants, or with municipalities' own funds.

It is possible to achieve a project payback for a municipality at the level of 5-6 years, provided that at least 30% of the grant is attracted (subject to loan rate at the level of up to 2%). The higher the rate, the larger the share of the grant shall be provided to achieve an acceptable payback.

Co-financing by a municipality allows to reduce costs of servicing the loan and as a result improves the payback period — therefore, if possible, it is better to consider at least 15% co-financing by the local self-governments.

Municipalities highlight the following aspects which are essential for a successful financial programme: loans should be provided in national currency under a fixed interest rest, swift administrative procedures, and technical assistance or grant component.

Introduction

The aggressive full-scale invasion by the Russian Federation to Ukraine in 2022 and the subsequent attacks on Ukraine's energy infrastructure have caused substantial damage to the country's electricity sector. According to a joint report by UNDP and the World Bank[1] the generating capacity of power plants has been drastically reduced by 61% as a result of the missile or drone attacks by the Russian Federation. Notably, the available capacity of Ukrainian power plants plummeted from 36 GW to 13.9 GW already in 2022.

To cope with the energy shortages, a substantial number of 669.4 thousand generators were imported into the country during 2022. While these generators have temporarily mitigated energy supply challenges, they come at the cost of increased reliance on petroleum products, posing adverse effects on both long-term energy security and climate change.

In these circumstances it is critical to ensure a sustainable recovery and enhanced energy security of municipalities in Ukraine. Ukrainian municipalities are required to rebuild and provide water, heat, electricity, transport, medical care, and other vital services to their population. Thus, they are looking for reliable and economically viable approaches to ensure energy security for these operations.

By incorporating renewable energy tech nologies, Ukrainian municipalities could increase a reliability of energy supply. Various renewable energy and energy efficiency projects, such as installing solar power stations for self-consumption, implementing weather regulation systems, modernising internal engineering systems, and establishing energy management and monitoring systems, offer compelling solutions for municipal sector infrastructure, with payback periods of up to 7 years. Nevertheless, there are barriers that challenge this pathway for Ukrainian municipalities willing to install renewable energy installations on their infrastructure objects. **The primary objective of this Scoping Study is to assist municipalities in identifying which projects to implement and to lay the groundwork for a comprehensive and effective mechanism to financially support renewable energy projects in Ukrainian municipalities.**

To achieve this objective, the following aspects were assessed within the Scoping Study:

1. **Technical and economic analysis of renewable projects.** This Chapter aims to assist in determining the most promising and impactful projects that align with needs and specific circumstances

1 https://www.undp.org/ukraine/publications/ukraine-energy-damage-assessment

of the affected municipalities in Ukraine based on recently developed feasibility studies and implemented projects.

2. **Overview of the current financial programmes.** The Scoping Study analyses the current financial programs and initiatives carried out by international financial institutions, donor and technical aid organisations, as well as the Ukrainian Government, in order to understand what the optimal approaches and which ones are did not work.

3. **Potential bottlenecks and risks for financing municipalities to implement renewable energy projects,** which are identified by means of surveying representatives of local authorities having relevant experience.

4. **Description of the key features of a proposed financial programme.** The Scoping Study provides key features and recommendations to build a coherent programme for supporting local self-governments in Ukraine in their aim for installing solar plants on municipal infrastructure objects.

Chapter 1

Technical and Economic Analysis of Renewable Projects

As of the beginning of 2022, the total installed capacity of renewable energy facilities, excluding those situated in temporarily occupied territories, stood at 9,656 MW, comprising:

- solar power plants owned by commercial entities (producers) – 6,381 MW;
- solar power stations owned by private households (consumers) – 1,205 MW;
- wind power plants – 1,673 MW;
- biomass power plants – 152 MW;
- biogas power plants – 124 MW;
- small hydropower plants – 121 MW[2].

At least 637 MW of renewable energy capacities are situated in temporarily occupied territories (Autonomous Republic of Crimea – 496 MW, occupied territories of Donetsk and Luhansk regions – 141 MW)[3]. The current level of installed capacity in Ukraine provides a solid foundation for the nation's renewable energy sector, offering a wealth of knowledge, tangible evidence from successful projects, and a pool of experienced professionals adept in the design and installation of renewable installations.

In this Scoping Study, our focus lies within solar power projects for municipalities, which offer a multitude of **advantages:**

- renewable energy projects enhance energy security by diversifying energy sources and reducing reliance on external suppliers;
- renewable energy projects contribute to environmental sustainability by diminishing use of fossil fuels, consequently mitigating CO_2 emissions and combating climate change;
- solar power stations entail lower upfront investments compared to other renewable energy projects, making them financially attractive for municipalities with constrained budgets;
- easy and fast implementation allows for rapid deployment addressing urgent energy needs;
- maintenance costs for solar power stations are insignificant, translating to cost savings over the long term;
- leveraging municipally owned building rooftops for installation eliminates the need for additional land plots and maximises proximity to consumption centres, optimising efficiency;

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2 The data indicates capacities which received feed-in tariff.

3 https://saee.gov.ua/sites/default/files/DraftNPDVE_2030_SAEE_21_09_2022.pdf

- utilising solar power stations for self-consumption eliminates a need for increased connecting capacity, presenting opportunities for substantial savings on connection costs;
- municipal projects play an exemplary role through demonstration of technology, building the capacity of contractors, and enhancing the market for equipment and services, which facilitates their future replication in residential sector.

Thus, prioritising solar power stations for municipal energy initiatives aligns with both economic and environmental objectives, offering a pragmatic and sustainable solution for local energy needs. Whitin this Chapter we outline types of solar power stations, facilities suitable for installation of solar power stations, factors which impact solar projects and additional measures which could significantly enhance overall efficiency and reduce carbon dioxide emissions on one hand, and, on the other hand, minimise project costs.

1.1 TYPES OF SOLAR POWER PROJECTS

There are the following key types of solar power stations: on-grid, off-grid and hybrid. The descriptions and analyses of these types of solar power stations, including their payback periods, as well as an evaluation of their respective benefits and drawbacks, are grounded in comprehensive feasibility studies conducted for real-life projects. These projects, as outlined in the table below, serve as tangible case studies, offering insights into the practical application and viability of solar energy solutions for municipalities (Tab. 1).

1.1.1 ON-GRID SOLAR POWER STATIONS

On-grid solar power stations comprise several key components: solar panels, an inverter, a meter, and connection to the power/utility grid. Surplus electricity generated by the solar system beyond immediate consumption requirements can be fed back into the electricity network. During periods of low/no solar generation, such as at night or when the solar power system is not operating optimally, electricity can be sourced from the power grid, ensuring continuous and reliable energy supply.

On-grid solar power stations do not incorporate batteries and cannot operate without external power supply (under condition of power outages). As a result, they **cannot be used as backup power sources** for municipal facilities. With considerable capacity and an absence of demand side management systems, they **may have a negative impact on the external power grid** due to stochastic generation.

Expanding time of the energy coverage provided by on-grid solar stations for municipal institutions or utilities can be achieved by boosting the capacity of these stations beyond the level of summer daytime demand. Nevertheless, this necessitates the incorporation of generation limiters in the power grid and the underutilisation of the generated energy, or sales of excessive volumes on organised electricity markets or through net-billing mechanism (Fig. 1).

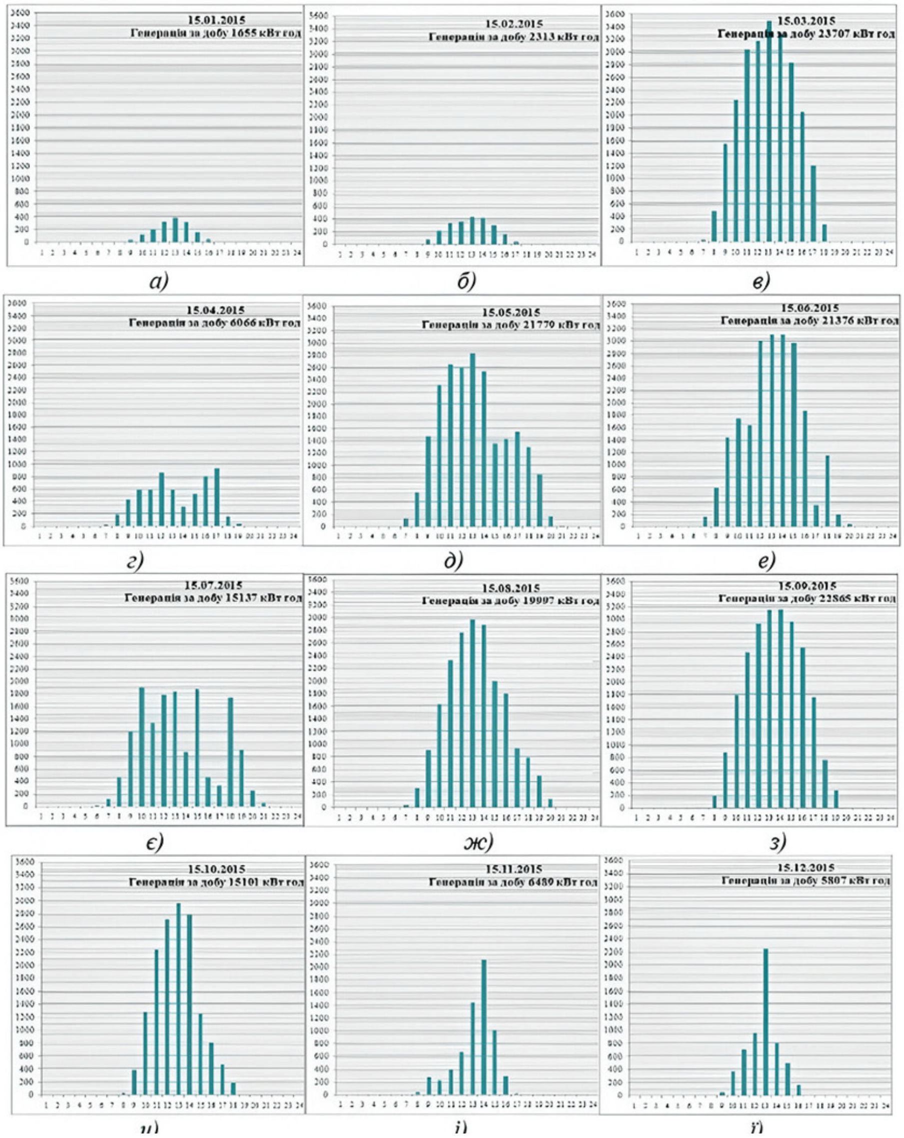
The estimated simple payback period for such stations as of 2023 ranges between 4 to 7 years. This period may vary depending on the region, impacting the level of insolation and electricity costs, as well as installation conditions such as shading, mounting structure costs, and a need for new power lines.

TABLE 1. ANALYSED PROJECTS

No	Location	Facility type	Type of solar system	Power, kW
1	Dubno, Rivne Oblast	**Hospital**	On-grid, roof-mounted	44.8
2	Rivne, Rivne Oblast	**Hospital**	On-grid, roof-mounted	30.0
3	Zhytomyr, Zhytomyr Oblast	**Hospital**	On-grid, roof-mounted	36.0
4	Zviahel, Zhytomyr Oblast	Water utility	On-grid, ground-mounted	150.0
5	Sumy, Symu Oblast	**Hospital**	On-grid, roof-mounted	60.0
6	Zviahel, Zhytomyr Oblast	Kindergarten with swimming pool	On-grid, ground-mounted	45.0
7	Kremenchuk, Poltava Oblast	**Hospital**	On-grid, roof-mounted	50.0
8	Zviahel, Zhytomyr Oblast	School	On-grid, roof-mounted	40.0
9	Nizhyn, Chernihiv Oblast (maternity)	Maternity hospital	Hybrid, roof-mounted	80.0+60.0 kWh battery
10	Chornomorsk, Odessa Oblast	Hospital	On-grid, roof-mounted	150.0
11	Khotyn, Chernivtsi Oblast	Hospital	On-grid, roof-mounted	150.0
12	Kodyma, Odessa Oblast	Hospital	On-grid, roof-mounted	90.0
13	Mykolaiv, Mykolaiv Oblast	Children hospital	On-grid, roof-mounted	40.0+40.0 kWh battery
14	Zviahel, Zhytomyr Oblast	**Hospital**	On-grid, roof-mounted	32.0

Solar power stations are not a reliable source of electricity during winter. Risks of blackouts could be only mitigated by using storage systems, which can charge from the grid or fuel generators. There are currently no effective technical solutions to use an on-grid solar station solely with a fuel generator without an external grid connection. Therefore, in our view, on-grid solar power stations are **not a viable option for critical infrastructure**.

FIGURE 1. AVERAGE SOLAR ENERGY GENERATION BY MONTH FOR THE TYPICAL 10KW STATION



1.1.2 OFF-GRID SOLAR POWER STATIONS

Off-grid solar power stations differ from the on-grid setup by relying on battery storage instead of a grid connection. These systems consist of components such as solar cells, inverters, and battery banks, with the option of a generator for backup power. Challenges with this type of station arise when demand exceeds solar or battery capacity. We believe it is unsuitable for municipal facilities due to its unreliability and economic infeasibility, as municipalities would need to invest significantly in storage instead of leveraging the benefits of the existing grid.

1.1.3 HYBRID SOLAR POWER STATIONS

Hybrid solar is the amalgamation of on-grid and off-grid solar power systems. In contrast to on-grid stations, hybrid stations can operate in both grid-connected and autonomous modes. This type of stations **can be integrated with storage installations and may provide effective demand side management.** The advantages of hybrid stations also include smooth integration with fuel generators and the **ability to utilise them with maximum efficiency during outage conditions**.

The simple payback period for such stations as of 2023 ranges from 6 to 12 years. The payback significantly depends on the quantity, and consequently, the price of battery storage. Therefore, to ensure the maximum efficiency of these stations, **it is recommended to use not only electrical but also thermal (for hot water supply systems) or hydraulic (for water supply systems) accumulators.** This allows for increasing the autonomy of the facility at a considerably lower cost. The payback period of such systems is also greatly reduced for facilities with significant interruptions in power supply that use diesel and petrol generators as backup power sources.

Considering the possibility of using these stations to balance load schedules (charging batteries during the day from solar energy and discharging at night with a low tariff, as well as returning energy during peak hours), the availability of a substantial battery resource is crucial. Currently, among the available technologies, LiFePo4 (lithium iron phosphate) batteries stand out, which, besides a significant number of charge-discharge cycles can deliver substantial power.

On-grid solar power stations represent the most cost-effective option in terms of installed capacity cost. It is important to note that on-grid solar power is predominantly implemented in the majority of analysed cases due to financial constraints, as they require fewer upfront investments. They ensure the offset of a portion of the facility's consumption. The greatest economic benefit can be achieved under the condition that the solar power station's generation does not exceed the facility's own consumption at any given moment. However, if system reliability is the primary concern, preference should be given to hybrid stations. This type of stations offers operational flexibility in both grid-connected and autonomous modes, providing effective demand side management and reliability, especially valuable during outage conditions.

1.2 FACILITIES TO INSTALL SOLAR POWER STATIONS

While shading and installation orientation serve as universal considerations across all solar installation scenarios, we advocate for a nuanced approach when considering the deployment of solar power stations for municipal facilities. As one the first steps we suggest analysing energy consumption patterns of municipal facilities. The year-round electricity and hot water consumption of hospitals, kindergartens, and water supply systems facilitate effective load management, enabling use of generated electricity primarily for internal needs and active participation in load regulation of the electricity network. Conversely, schools and other facilities with extended periods of inactivity are not well-suited for such projects, unless there is a straightforward procedure in place for selling unused energy. Below, specific considerations for the use of solar stations in key municipally owned facilities are outlined. Facilities like schools, which have minimal summer consumption, are excluded from the list due to significant challenges in terms of economic feasibility for installing such systems.

1.2.1 WATER UTILITIES

In water utilities, three primary categories of facilities can be distinguished, depending on the particularities of solar power station implementation:

Pumping Stations for Water Supply

Pumping stations for water supply exhibit nearly continuous energy consumption, with distinct peaks during early morning and evening periods. In this context, first lift stations and well pumps can operate not only on the grid but also on storage capacity. This enables the adjustment of electricity consumption schedules during periods of maximum solar generation.

Among the necessary accompanying measures, it is crucial to emphasise the mandatory installation of frequency regulators on pump units to reduce startup currents and decrease energy consumption. In some cases, there may be a need to replace pumps with less powerful ones, as pumps with excessive capacity are often encountered.

It is also noteworthy that not all pumping stations, especially those with 2-3 lifts, have sufficient space for installing solar panels.

Sewage Pumping Stations

The operation of sewage stations is typically characterized by intermittent activity, where pumps are activated for a short period after the reservoir is filled. This **operational mode is not conducive to solar installations**, and the solution should involve the installation of a lower-capacity and productivity pump with a frequency drive,

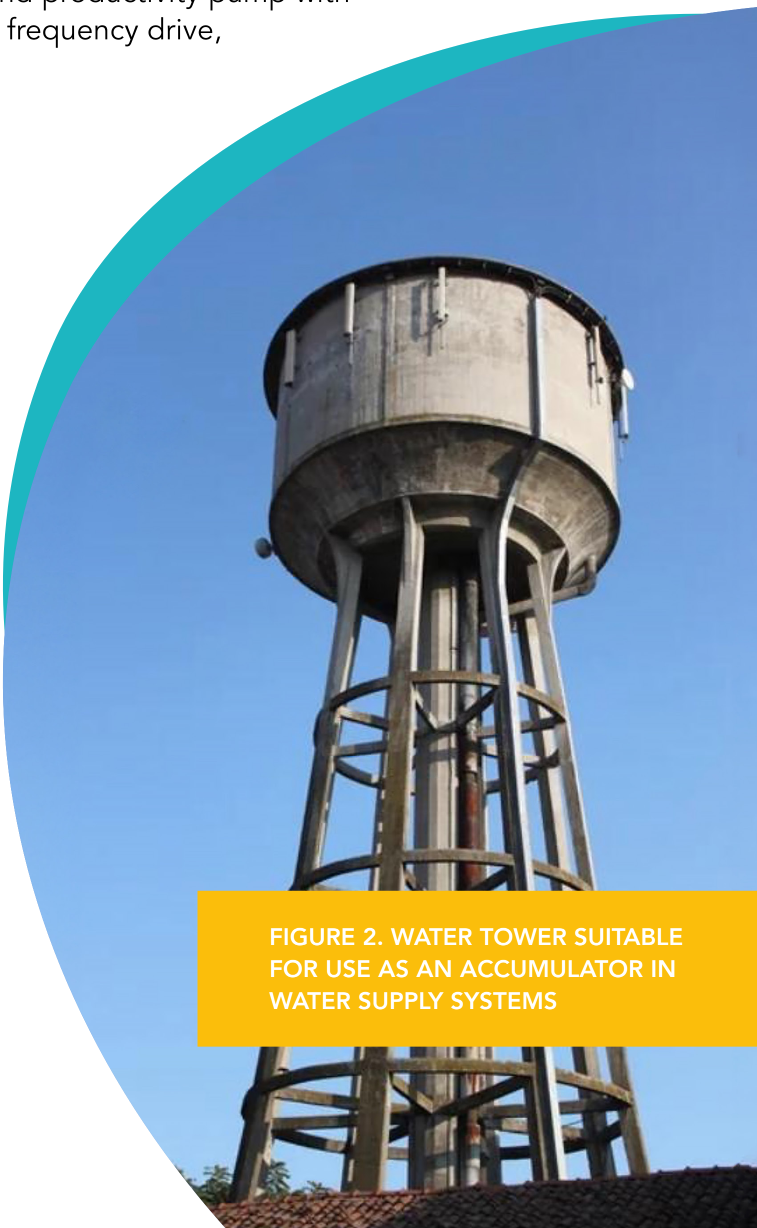


FIGURE 2. WATER TOWER SUITABLE FOR USE AS AN ACCUMULATOR IN WATER SUPPLY SYSTEMS

operating exclusively from the solar installation in a continuous mode.

These pumping stations are comparatively inconvenient for solar installation due to their placement in densely built-up areas and the insufficient space to install enough solar panels.

Wastewater Treatment Plants

Wastewater treatment plants feature a primary high-energy consumer — a compressor or an air blower used for wastewater aeration. Given that the power of these plants can surpass 100 kW, selecting a solar installation for full backup proves challenging. Nevertheless, **projects aiming for partial load coverage can be highly effective.** Additionally, if autonomy is required, the installation of frequency converters should be considered. A significant advantage of wastewater treatment plants as sites for implementing solar generation systems is the **availability of ample space for placing solar panels.**

In general, water utilities are the most optimal sites for implementing solar generation projects. However, it should be noted that to ensure the autonomy of such systems, it is not sufficient to only supply water (except in cases of water filling in tanker trucks); simultaneous wastewater discharge must be provided. Otherwise, the entire system will stop due to sewage system overflow. For such sites, the use of pumps with a drive that can be powered directly from solar installations may be promising. This minimises the number of conversions and eliminates the need for expensive batteries.

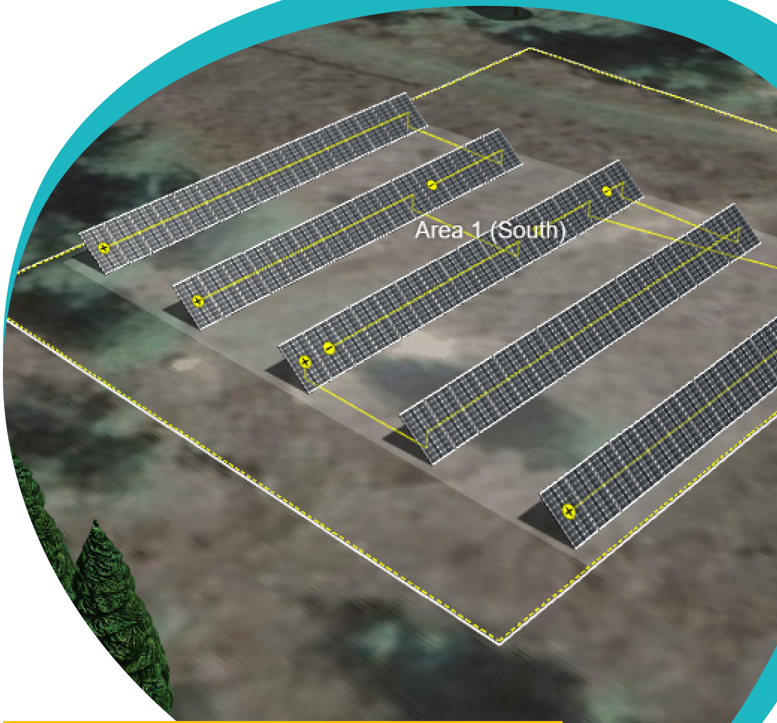


FIGURE 3. OPTION OF PLACING PANELS ON THE ROOFS OF STRUCTURES AND ON LAND PLOTS, TYPICAL FOR WATER MANAGEMENT FACILITIES AND BOILER HOUSES

1.2.2 HOSPITALS

Among municipally owned facilities, hospitals, especially inpatient facilities, are **primary candidates for the installation of solar power stations.** This is due to the **year-round demand for electricity and the substantial need for hot water supply**, currently mostly covered by capacitive electric water heaters, which can serve as both accumulators and regulators. Considering the layout of most hospitals, the optimal location for solar panels is on the roofs of the buildings.

Among the constraints, it is important to note a poor condition of roofs (both flat and pitched) and a need for preliminary repair works. Additionally, large hospital complexes typically have multiple electrical inputs, requiring careful planning of connection points for solar installations to the power grid, and in some cases, the laying of additional electrical networks to maximise the use of generated energy.

Given the presence of critical consumers (equipment) in hospitals, the optimal solution would be the use of hybrid solar systems. Inclusion of storage systems would significantly enhance the reliability of power supply, especially when combined with backup diesel generators for blackout conditions. An additional advantage could be the use of group capacitive water heaters, which could be used to accumulate excess solar energy, especially when combined with heat pumps. The modern control systems facilitate efficient management without relying human factor.

1.2.3 KINDERGARTENS

Kindergartens, alongside hospitals, are sufficiently attractive for the deployment of solar generation. Their energy consumption pattern aligns with solar generation, except on weekends when consumption decreases practically to zero.

In such cases, systems with hybrid inverters and batteries could be optimal, allowing for the maximum utilisation of solar energy during the summer period, even on non-working days. Similarly to hospitals, use/installation of tank water heaters would be a significant advantage, especially when there is a need to utilise excess generation on weekends.

1.2.4 BOILER HOUSES AND HEAT SUB-STATIONS

Given that boiler houses operate year-round and provide hot water supply, solar installations can be **sufficiently effective for these facilities.** Solar energy can be used both for the own needs in electricity of a boiler house (mainly for powering pumping equipment) and for the generation of thermal energy (through direct heating or by using heat pumps).

As for the limitations, the availability of sufficient space on roofs and adjacent space for solar installations can be noted. Considering that more than 70% of consumers in district heating systems belong to the residential category, for whom natural gas is sold at regulated prices, the profitability of projects for hot water preparation is currently relatively low. However, this may change in the forthcoming years in case of abolishment of public service obligations.

FIGURE 4. EXAMPLE OF A ROOFTOP SOLAR INSTALLATION FOR A HOSPITAL

When selecting a facility for an installation of a solar power station, a municipality needs to consider the pattern of energy consumption, available space for installation, and the need for hot water supply. Technical and economic assessments carried out for different types of facilities suggest that solar systems for self-consumption can achieve optimal efficiency when energy consumption parameters are thoughtfully considered and adjusted for solar generation conditions.

1.3 FACTORS TO BE TAKEN INTO ACCOUNT BY MUNICIPALITIES

When determining the appropriate solar capacity to install, it is important to consider not only energy consumption patterns, available financing, and space, but also tariff conditions and operational constraints within the energy system. By doing so, municipalities can maximise the economic viability and sustainability of such projects.

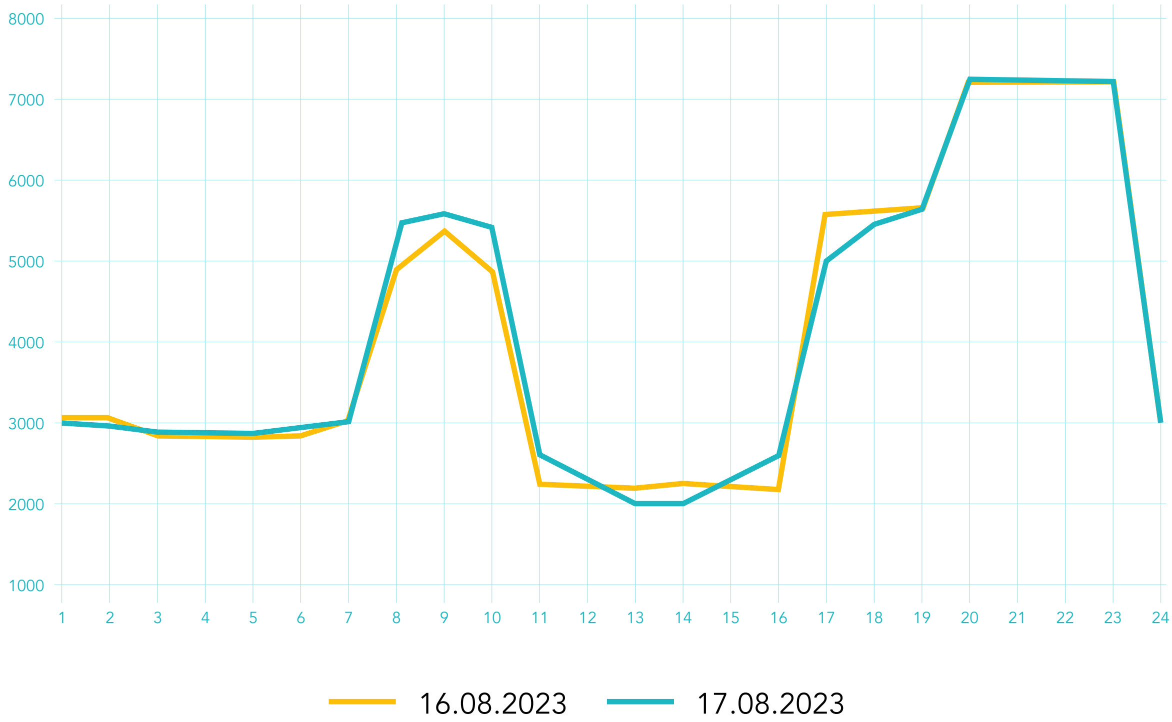
Tariff Conditions: Electricity prices for municipally owned organisations are approximated to market prices which results in favourable project profitability. Public facilities with installed capacities below 50 kW are considered small non-household consumers and can procure electricity at tariffs set by the National Energy and Utilities Regulatory Commission (NEURC), known as the universal service tariff. The universal service tariff varies in the range between 654 UAH/MWh to 3157 UAH/MWh for second voltage class (those connected to distribution systems with a voltage below 27.5 kV) with a median tariff of 2170 UAH/MWh[4]. The majority of public facilities are connected to systems below 27.5 kV. Please refer to Annex 1 of this Study for universal service tariffs of particular distribution system operators.

For facilities not falling within the category of small non-household consumers, municipalities procure electricity at commercial rates. It is important to note that there is a significant differentiation in the total cost of electricity across different regions, owing to variations in electricity distribution tariffs. This variation enhances the attractiveness of the project in certain regions. Distribution tariffs are established by NEURC for each distribution system operator.

On the other hand, in order to determine required installed capacity for solar stations it is advisable to take into account market prices of electricity during summer days at which electricity can be potentially sold. These prices are currently relatively low and vary between 3000 UAH/MWh to 7100 UAH/MWh. Figure 5 illustrates the electricity price on the market, suggesting that there will be no opportunity to sell energy produces by solar panels directly to the grid at the higher price.

4 Tariff range is given including VAT, while the tariffs established by NEURC and presented in the Annex 1 do not include VAT.

FIGURE 5. ELECTRICITY PRICES AT THE DAY AHEAD MARKET DURING THE SUMMER PERIOD



Furthermore, fluctuations in electricity market prices throughout the day are currently insufficient to justify the implementation of electricity storage as investment projects aimed at buying at low prices and selling for high prices, but rather for ensuring energy security. On average, the payback period for a solar station without storage is around 4 to 7 years, while with storage it ranges from 6 to 12 years.

Operation within energy system: The existing energy infrastructure enables maximisation of the advantages from renewable source generation during summer and ensures a possibility to back-up renewable energy installations by conventional energy sources during winter. At the same time, it should be noted that Ukraine has a restricted number of maneuverable generating capacities, predominantly comprised of hydro-electric power stations. Consequently, the automated control of non-critical loads emerges as one of the most effective approaches to balancing generation and consumption. This means that when installed capacities generate more than self-consumption of a municipally owned facility the excess electricity may be curtailed or in other words cannot be injected into the grid due to technical limitations.

1.4 TECHNICAL AND ECONOMIC INDICATORS OF PRIORITY PROJECTS

The table below summarises the priority types of projects for installing solar power stations, taking into account the cost of equipment and works, as well as energy resource prices as of 2023.

The data in the table is compiled based on an assessment of the technical and economic metrics of projects, focusing on social infrastructure facilities (primarily hospitals) and water supply utilities. The proposed measures are carefully chosen to facilitate implementation within a 6-12 month time-frame, inclusive of the development and approval of project documentation.

Furthermore, the analysis indicates the **potential for cutting carbon dioxide emissions by 10-20% compared to the baseline emissions** linked to electricity consumption from the national energy system. This reduction is accomplished through the direct substitution of electricity from the national energy system and by optimising daily consumption patterns, lowering electricity demand during peak hours and, consequently, diminishing the contribution of coal generation to the nation's energy mix.

Projects without full backup prove to be profitable within 4-7 years, signifying the potential for their funding, including through attracting loans. Simultaneously, the substantial increase of storage currently significantly extends the payback period.

TABLE 2. PROJECT EXAMPLES AND THEIR TECHNICAL AND ECONOMIC INDICATORS

Project Description	Power Capacity of the Station/ Battery Capacity	Investment Amount (Averaged), EUR	Simple Payback Period, years
Installation of a self-consumption rooftop solar power station in **hospitals**, equipped **with a hybrid inverter and battery storage**	90 kW 65 kWh	102,819	8
Installation of a self-consumption rooftop solar power station in **hospitals**, equipped **with an on-grid inverter without backup power capability**	90 kW 0 kWh	44,48	4,2
Installation of solar power stations at water utility pumping stations and treatment facilities, equipped **with an on-grid inverters without backup power capability**	70 kW 0 kWh	35,867	4,5
Installation of solar power stations at water utility **pumping stations and wastewater treatment facilities**, equipped **with hybrid inverters and backup capabilities** (taking into account possible modernisation or replacement of pumping equipment)	160 kW 450 kWh	510,628	16
Installation of solar power stations at **sewage pumping stations with hybrid inverters and backup capabilities** (taking into account possible modernisation or replacement of pumping equipment)	90 kW 25 kWh	120,274	9,4

However, prospectively, this extension will not only facilitate facility backup but also contribute to balancing the electricity grid. **Consequently, such systems can be deemed primary under grant financing, whereas projects without storage systems may secure funding through credit funds.**

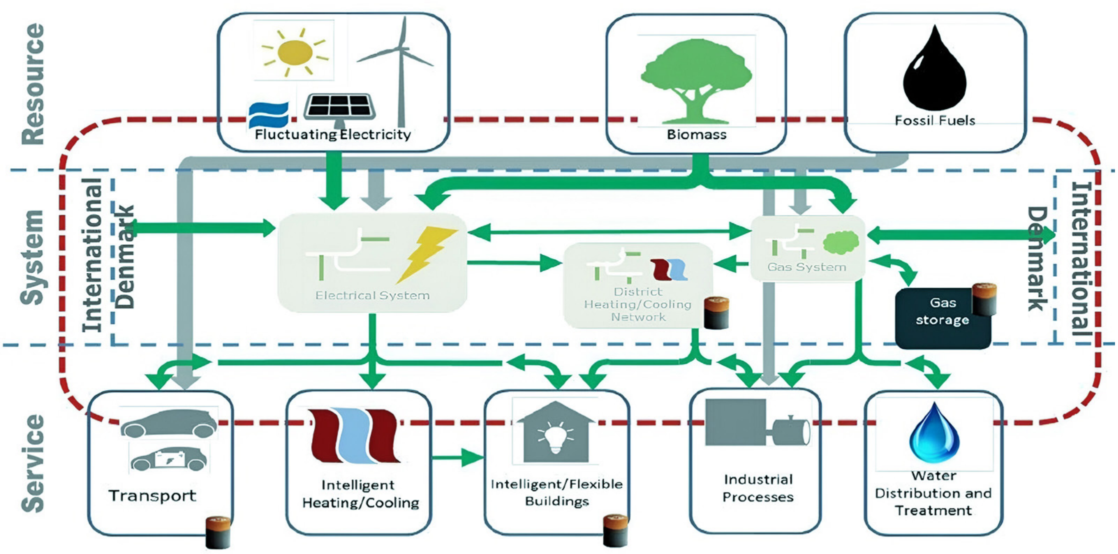
1.5 ADDITIONAL MEASURES FOR IMPROVING ENERGY CONSUMPTION EFFICIENCY

During the implementation of projects involving the installation of solar power stations, it is crucial to consider their impact on municipally owned facilities and the energy grid. This will significantly enhance overall efficiency and reduce carbon dioxide emissions on one hand, and, on the other hand, minimise project costs.

As solar power stations are effective primarily during the summer period, alternative energy supply sources must be planned to meet winter energy needs while efficiently complementing solar power stations. Below are the main types of projects that are strongly recommended to be implemented simultaneously with solar power stations or, at the very least, taken into account during the development of feasibility studies and implementing project works.

Given that municipalities own numerous facilities and distribution networks, municipal entities serve as a solid groundwork for establishing robust and effective local energy systems, as illustrated in Figure 6.

FIGURE 6. AN INTEGRATED ENERGY SUPPLY SYSTEM FOR THE CITY, COMBINING THE ADVANTAGES OF VARIOUS ENERGY SOURCES AND ALLOWING FOR THE OPTIMISATION OF GENERATION AND CONSUMPTION PARAMETERS



The proposed projects will be able to become integral parts of the future local energy systems using the benefits of the different energy sources and possibility to disturbed the energy between facilities.

1.5.1 OPTIMISING ENERGY CONSUMPTION MODES BY END CONSUMERS

To avoid a scenario where the demand for electricity significantly decreases after buildings' renovations and installed renewable stations are underutilised, it is recommended to consider and implement the following measures to enhance energy efficiency in public buildings prior to solar station installment:

- Implementation of an energy consumption monitoring system. It will facilitate proper analysis of energy consumption patterns and selection of optimal parameters for energy-generating equipment, as well as subsequent monitoring of energy use efficiency and verification of achieved savings;
- Modernisation of the lighting system by installing LED light sources;
- Allocating separate power lines to enable use of electricity from hybrid inverters with battery storage;
- Automation of the operation of tank water heaters to adjust their operation to solar generation;
- Installation of a weather-regulated heating system with the ability to reserve the automation system and circulation pumps using a hybrid solar power station;
- Installing the heat pumps for domestic hot water supply instead of the electricity heater.

1.5.2 ENERGY STORAGE SYSTEMS

In the conditions of continuous military attacks, a proximity of energy storage systems to an end consumer is an undeniable advantage for ensuring a reliable power supply. However, even in the post-war period, such an approach will help to minimise energy flows and losses in the networks.

In this context, it is essential to consider not only battery energy storage systems but also the possibility of accumulating thermal energy in accumulating storage tanks, which is particularly relevant for hot water supply systems. When recalculated to the cost per unit of capacity, such accumulating storage tank is 5-10 times cheaper than LiFePo4 batteries. Considering that electricity is often used for water heating (through direct heating or using heat pumps), this method of energy accumulation is quite promising. Moreover, it can work in conjunction with grid inverters using an appropriate control system.

Another promising direction is the use of pressure vessels in water supply systems based on elevated water towers or expansion tanks.

1.5.3 INSTALLATION OF COGENERATION UNITS AT HEAT GENERATION FACILITIES

Cogeneration units, whether using natural gas or solid fuel, can complement solar power stations, particularly for their potential use in providing both electricity and heat during the winter period.

Given the rapid startup of gas piston cogeneration units, they can function effectively during peak hours when electricity costs are highest, and solar generation is relatively low. In such cases, hybrid inverter storage systems will assist in maintaining the most optimal operation mode, akin to a hybrid automobile. This option is appropriate for district heating facilities and big electricity consumers, such as hospitals.

1.5.4 INSTALLATION OF HEAT PUMPS

Air-to-water and air-to-air heat pumps ideally complement solar power stations, especially when, in addition to heating water, they provide cooling for air conditioning systems. In this case, the energy demand schedules and solar generation practically align, offering the opportunity to utilise entirely renewable energy.

Another advantage of this combination is the release of electrical capacity, which is often a constraint when using heat pumps in existing buildings.

1.6 RECOMMENDATIONS FOR SOLAR PROJECTS PLANNING AND IMPLEMENTATION

Drawing from the experience gained in the implementation of pilot projects and the data prepared for feasibility studies, below are the key recommendations for the planning and execution of projects aimed at installing solar power stations for own consumption in public buildings and municipal facilities:

Recommendation 1: Conduct a thorough analysis of real energy needs. To achieve this, it is advisable to introduce an automated energy monitoring system that facilitates the collection of actual hourly or even minute-by-minute consumption data for in-depth analysis. By utilising this information, consumption patterns can be optimised, and a solar station with optimal parameters can be selected. Obtaining actual energy consumption data at least on an hourly basis is essential.

The most effective variant from the point of view of payback period are:

- **for the on-grid solar power stations:** the maximum capacity of the solar station needs to be near the maximum daylight load power;
- **for the hybrid solar power stations:** the maximum capacity of the solar station is chosen for possibility to produce equal amount of energy during day as daily consumption; the capacity of the storage need to be equal to a daily consumption or half of it in case if most of the energy is used during the daytime[5]. In this case for the summer days the solar station cover all needs during the daylight and additional energy will be saved in battery for using in the periods when the solar radiation is not enough.

5 For example, throughout the day, the consumption capacity is 10 kW. This equates to a total consumption of 24 * 10 = 240 kWh over the course of 24 hours. As the solar station operates for only 8 hours during daylight, it is necessary to calculate its capacity to cover the entire day's consumption. With a consumption of 240 kWh spread over 8 hours, the solar station requires a capacity of approximately 240/8 = 30 kW. During these 8 hours, the solar station generates 240 kWh of energy. Of this, 80 kWh is directly consumed by the load, while the remaining 160 kWh is used to charge the battery. Consequently, a battery with a capacity of 160 kWh is required. The energy stored in the battery during daylight hours will be utilised after sunset to meet the energy demand until the next sunrise.

Recommendation 2: Ideal facilities for project implementation include hospitals, water utility pumping stations, wastewater treatment facilities, boiler houses, and heat sub-stations, assuming a year-round hot water supply is in place. Especially in case of using electrical water heater with storage. Schools and universities that have a long summer vacation are not optimal facilities for installing solar power stations.

Recommendation 3: It is crucial to prioritise the completion of the feasibility study before commencing the development of project documentation. The feasibility study should, at a minimum, encompass an analysis of the following aspects:

- Availability of sufficient unshaded area for solar panel placement;
- Analysis of hourly and monthly electricity consumption needs;
- Analysis of critical consumers (equipment) requiring mandatory backup;
- Recommendations for optimising energy consumption;
- Analysis of concurrently implemented projects for their coordination.

Recommendation 4: Ensuring the effective operation of solar installations relies on qualified maintenance. Therefore, it is essential to either train in-house specialists or engage in a service maintenance contract.

Recommendation 5: Even if there are no immediate plans to use the station for backup power, it is advisable to install a hybrid inverter instead of an on-grid one (even without battery storage). This adjustment will not substantially increase the project budget but will offer greater flexibility and the potential for future station adjustments.

Recommendation 6: The energy price of the electricity in summer daytime is usually low. Due to this selling electricity to the grid is not effective for the most cases without special tariffs or supplying directly to own facilities. Therefore, it is preferable to prioritise a station for own consumption. This not only saves costs for electricity but also for its distribution.

Recommendation 7: Installing a cogeneration station for winter time is a viable option to ensure reliable energy supply.

Recommendation 8: When deciding to implement such projects, it is essential to conduct a thorough evaluation of the constraints associated with utilising renewable sources and their impact on the energy system, paying particular attention to following factors:

- Temporal Energy System Deficits: The energy system experiences deficits during early morning and evening hours, particularly in the winter period when solar generation is minimal.
- Market Dynamics: The cost of electricity on spot electricity markets during peak generation periods (summer daytime hours) is low, diminishing the profitability of projects aimed at selling electricity generated by solar stations.
- Security Considerations: In the aftermath of attacks on energy infrastructure, critical considerations extend beyond electricity generation to include its transportation from large power stations to end consumers. Therefore, the fundamental requirement is to position generation and storage sources as close as possible to consumers.

Chapter 2
Overview of the Current Financial Instruments and Programmes

This Chapter explores the diverse financing possibilities for priority renewable energy projects within municipalities, ranging from leveraging own funds to accessing grants from international institutions and securing loans from both domestic and international financial organisations. Additionally, alternative mechanisms such as energy performance contracts and potential state support mechanisms are examined. Municipalities can navigate the path toward more resilient energy systems by understanding these financing avenues.

2.1 POTENTIAL SOURCES OF PROJECTS FINANCING

2.1.1 OWN FUNDS OF MUNICIPALITIES

Installation of solar power stations is a sound investment in case of available own funds in municipalities, considering that the local budget is the main beneficiary of a priority project receiving improved energy supply reliability and electricity cost reduction. Also, such projects are easy to implement and further maintain.

However, in most cases, local budgets are limited and are allocated to critical repairs and ongoing maintenance of utilities rather than financing investment projects. Moreover, in the conditions of martial law, certain restrictions on the possibilities of municipal financing are established, as described in more detail in Chapter 3.

2.1.2 STATE SUPPORT

Presently, there are no functioning state support mechanisms offering financial assistance to local self-governments for the implementation of renewable energy projects.

RES Support Schemes

Concerning solar power stations, the feed-in tariff is available to installations below 1 MW. The net-billing mechanism is adopted policy, but not yet put into practice. Alongside these, the option to sell electricity under standard market conditions is available. However, this type of activities requires substantial capacity building for municipalities. Taking into consideration the purpose of the project to cover the own consumption these mechanisms are auxiliary because of low prices on the market.

The State Decarbonisation and Energy Efficiency Transformation Fund

In May 2023, amendments to the Budget Code of Ukraine established the State Decarbonisation and Energy Efficiency Transformation Fund as part of the special fund of the State Budget of Ukraine. The Decarbonisation Fund aims to finance measures and state-targeted programs in energy efficiency, renewable energy and alternative fuels. It will be replenished through CO_2 emissions tax, government borrowing, and other revenues. The 2024 State Budget allocates 759.2 million UAH for the Decarbonisation Fund. The details on what type of projects will be financed, how they will be selected and which shares of costs will be covered should be defined by a separate secondary legislation act, which as of January 2024 has not been approved. Nevertheless, there is a great potential to include compensation of interest rate or grant component as part of the support to be provided by the Decarbonisation Fund for solar projects at municipal infrastructure.

Distributed Generation Target Economic Programme:

The Law of Ukraine "On Amendments to Certain Laws of Ukraine Regarding the Restoration and 'Green' Transformation of the Energy System of Ukraine" envisions the introduction of a state-targeted economic program to support distributed generation. The Ministry of Energy of Ukraine has formulated a draft concept for this program. As per the concept, support could be provided for installing solar stations up to 500 kW, along with energy storage systems at critical infrastructure facilities, including water supply and sewage utilities, district heating utilities, medical facilities, and critical consumers in multi-apartment buildings. However, as of January 2024, the draft concept remains unapproved.

Energy Efficiency Fund

The State Institution "Energy Efficiency Fund" is at the forefront of driving the implementation of energy efficiency measures in Ukraine's multi-apartment buildings' sector. It also plays a crucial role in the restoration of multi-apartment buildings damaged due to full-scale aggressive war carried out by the Russian Federation.

According to the Law of Ukraine "On the Energy Efficiency Fund" activities of the Fund are focused on residential sector, however, there are no direct restriction to implement projects in public buildings. Currently, Energy Efficiency Fund does not cofinance projects at the municipal facilities.

State Support Programme “Affordable Loans 5-7-9%”

The “Affordable Loans 5-7-9%” Programme is implemented by the Government of Ukraine at the initiative of the President of Ukraine through the Entrepreneurship Development Fund. As part of the programme, the state compensates part of the interest rate on the loan through a network of partner banks, thus reducing the client's rate under the contract. While municipally owned enterprises are eligible to participate in the Programme, their involvement is currently limited. Firstly, they can receive interest rate compensation on loans for capital assets that were damaged due to Russian aggression; however, this provision does not extend to the construction of new renewable energy stations. Additionally, during the heating season 2023/2024, there was the possibility of receiving compensation for interest rates on loans for the recovery, repair, or substitution of cogeneration power plants; however, this provision is no longer in effect. Another option available is compensation for energy service companies, including municipally owned ones, that undertake energy efficiency measures or deploy renewable energy installations without receiving a feed-in tariff or feed-in premium. Under the Programme, loans of up to UAH 60 million (or up to 150 million for a group of affiliated companies) can be secured for a term of up to 10 years at an interest rate of 5-7-9%.

2.1.3 ENERGY PERFORMANCE CONTRACTS

This type of contract aids in implementing renewable energy measures without any costs from the facility owners but most of the savings (nearly 90%) are retained by the investor for the contract period (10-15 years). However, in case a municipality does not have own funds or the possibility to take a loan this can be a viable option. It should be noted, though, that in most cases investors would be willing to fund only on-grid stations without energy storage.

However, under conditions of war and significant investment risks, ESCOs exhibit limited interest in undertaking such projects. Moreover, ESCOs also face challenges in attracting finance for project implementation.

2.1.4 LOANS FROM UKRAINIAN BANKS

Several Ukrainian banks offer loans for the implementation of "green" projects, with the main conditions of certain banks present below (Tab. 3).

Interest rates of such loans mostly exceed the level of profitability of projects therefore loan attraction is not appropriate for projects with a payback of more than 3 years. Also, the mentioned programmes are mainly granted to private clients, while lending to municipalities is carried out under separate programmes, the terms of which are determined for each client individually. Overall, the possibilities of municipalities to attract funds from commercial banks is extremely limited, particularly in light of challenges arising from wartime conditions.

TABLE 3. MAIN LOAN CONDITIONS OF COMMERCIAL BANKS

Main conditions	Oschadbank	Ukrgasbank	Bank Lviv
Loan programme	Green energy	Eco energy	Energy Efficiency
Loan term, years	up to 6 years	up to 5 years	up to 4 years
Interest rate, %	19.5%	23,5%	25%
Commission, %	2.99%	4,5%	4%
Maximum loan amount, MUAH	1	1	0.5

Interest rates of such loans mostly exceed the level of profitability of projects therefore loan attraction is not appropriate for projects with a payback of more than 3 years. Also, the mentioned programmes are mainly granted to private clients, while lending to municipalities is carried out under separate programmes, the terms of which are determined for each client individually. Overall, the possibilities of municipalities to attract funds from commercial banks is extremely limited, particularly in light of challenges arising from wartime conditions.

2.1.5 FINANCING FROM INTERNATIONAL FINANCIAL ORGANISATIONS

Loans from International financial organisations (IFIs) are a priority source for financing investment projects in municipalities (in case the loan does not exceed the permitted amount of borrowing).

Most of the international loans were being granted on soft loan terms with an interest rate of 5-7% for 7 or more years with the possibility of providing additional grants for projects aimed at reducing CO_2 emissions.

When the full-scale invasion began, Ukraine was deprived of access to new credits since most of the IFIs had to halt the disbursement of credit funds to municipal projects. Hopefully, these programmes will be renewed after the war ends. However, in the short term, it is unlikely that municipalities will be able to attract significant loan amounts.

At the same time, some IFIs continue to provide financing for critically important projects, some of them are presented below:

NEFCO Green Recovery Programme for Ukraine

The programme is providing financial support (grant funding from various governmental contributors/donors) and technical assistance to municipalities in Ukraine to address both direct and indirect consequences of the war. Financial support is currently being used for:

- short-term repair and restore needs of critical infrastructure and public service buildings;
- renovating and building utilities and facilities serving internally displaced persons (IDPs);
- capacity building and Local Green Recovery plans to ensure Ukraine is built back greener and better.

In all construction projects, green components shall be considered for installation, such as heat pumps or solar energy systems.

According to data on the Nefco website, within the scope of the programme, which was launched in 2022, there are currently 40 projects under implementation, with work actively ongoing in various areas, and several new ones in the pipeline.

The selection of projects depends on the availability of donor funds and in accordance with the requirements of donors.

Within the framework of all projects, **technical and institutional support is provided** by Nefco, which is an important component for the successful implementation of projects – the importance of providing such support across funding programs will be discussed in more detail in Chapter 4.

EIB Emergency Credit Programme for Ukraine

The Programme is being implemented under the Financial Agreement between Ukraine and the European Investment Bank (EIB), credit resources totaling 200 million euro is secured. This funding should be funneled towards projects focused on rehabilitating social infrastructure in regions impacted by Russian military aggression and addressing the needs of settlements experiencing significant influxes of internally displaced persons, including housing initiatives.

Loan funds will be dispensed to communities in the form of subsidies from the state budget to local budgets. The allocated loan funds are designated for use from May 13, 2015, until October 31, 2022, with the possibility of extension by mutual agreement, contingent upon the ongoing application of the EU Guarantee to each disbursed tranche. While there is no publicly available extension agreement beyond October 31, 2022, the project selection process in the summer of 2023 suggests this timeline was extended.

Under this Programme, financing may be provided for the following purposes:

- urgent repair and energy efficiency measures for internally displaced persons' settlements infrastructure; reconstruction and restoration of water supply and drainage systems, including repairs to networks, intakes, pumping stations, and treatment facilities;
- reconstruction and restoration of electricity generation, transmission, and distribution systems;
- reconstruction and restoration of district heating systems;
- reconstruction of (local, regional, and national) roads and railways damaged as a result of the conflict, including affected bridges;
- repair and reconstruction of state or public buildings;
- urgent repair and energy efficiency measures in schools, medical centres, hospitals, social centres, post offices providing financial services, and other relevant buildings; and
- any other necessary quick recovery measures to restore living conditions and means of subsistence within the EIB rules to meet the criteria.

The Programme targets restoration of 286 social infrastructure objects. Municipalities were invited to submit project selection proposals by June 2, 2023. Consequently, municipalities that did not apply for participation in the programme currently do not have access to this opportunity.

EIB Ukraine Recovery Programme

The Programme is being implemented under the Financial Agreement between Ukraine and EIB on the aims to mobilise 340 million euro for financing initiatives focused on implementing projects to restore social infrastructure and housing and communal facilities in regions affected by the Russian military aggression (under effective control of the Government of Ukraine), and those facing significant strain due to an influx of internally displaced persons.

These loan funds will be distributed to communities in the form of subsidies from the state budget to local budgets, available from July 23, 2021, to December 31, 2026. The agreement allows funds to be directed towards various projects, including:

Under this financial agreement, funds may be allocated to projects including:

- restoration, modernisation, and construction of residential infrastructure; restoration or construction of heating systems; implementation of energy efficiency measures;
- restoration, reconstruction, and construction of water supply networks, rationalisation of water resource utilisation; repair and modernisation of water supply networks, pumping stations, and treatment facilities at regional and municipal levels;
- restoration and modernisation of production, transmission, and distribution of heat supply;
- restoration, modernisation, and construction of public buildings (hospitals, schools, cultural centres, postal services providing financial services, buildings of state administrative bodies);
  restoration and reconstruction of bridges and roads of local and regional significance, as well as other relevant infrastructure;
- restoration and reconstruction of urban transport infrastructure, pedestrian walkways, and replacement of destroyed urban transport vehicles.

Notably, the Programme does not explicitly include provisions for installing solar power stations.

Also, municipalities were invited to submit project selection proposals by June 25, 2023. Consequently, municipalities that did not apply for participation in the programme currently do not have access to this opportunity.

EIB Energy Efficiency of Public Buildings in Ukraine Programme

The Programme is being implemented under the Financial Agreement between Ukraine and EIB on the 300 million euro to be envisaged for allocation. The Programme focuses on improving the energy efficiency of approximately 1000 public buildings across Ukraine, including preschools, secondary schools, healthcare facilities, and various social, administrative, and cultural premises owned by the state or local authorities. The Programme specifically aims providing funds to small and medium-sized municipalities.

The funds will be disbursed as loans to each municipality as per the loan agreement concluded between the Ministry of Finance of Ukraine, the Ministry of Infrastructure, and the municipality. Denominated in euros, the loan carries an interest rate of EURIBOR (currently at 3.861%) plus 0.5-2% bank interest spread and an additional 0.25% from the Ministry of Finance. With a repayment term of up to 20 years, there is a grace period of 5 years during which municipalities only service the interest on the loan without repaying the principal. Furthermore, local budget expenses include the payment of value-added tax and the reimbursement of other necessary costs not covered by the loan. Municipalities are also supported in covering expenses related to project documentation preparation, energy audits, and an issuance of energy certificates. These loan funds are available from October 18, 2021, to October 18, 2025.

The loans will cover energy efficiency investments, structural refurbishment of the building necessary to extend its economic life and implement the energy efficiency investments, and limited non- energy efficiency related investments that can be implemented more economically during the refurbishment work. The energy efficiency components shall amount to more than 50% of the total investment costs:

Energy efficiency components are the following:

- thermal insulation of roof, basement and walls;
- efficient windows and doors;
- efficient lighting;
- waste heat recovery systems;
- renewable energy investments if part of a wider energy efficiency investment;
- efficient systems for space and water heating;
- efficient ventilation and air conditioning systems and controls;
- efficient building energy management systems;
- other components considered as energy efficient by EIB.

2.1.6 GRANTS OF INTERNATIONAL INSTITUTIONS

In the absence of IFI programmes specifically aimed at the development of renewable energy facilities by municipalities, these needs of municipalities are currently being addressed through separate initiatives by donors and civil society organisations. There are several international funds that provide grants for municipalities to implement pilot renewable energy projects. The primary aim is to showcase the advantages of renewable energy projects, paving the way for their broader deployment alongside other financial instruments. Grant programmes are provided by organisations such as UNDP, Oxfam, GIZ, and others.

2.2 EXAMPLES OF PROJECT FINANCING

Below is a list of some projects examples that align with the criteria for priority projects identified in this Scoping Study (Tab. 4).

The table above presents selected examples of solar energy projects implemented in 2022-2023. Although numerous similar projects exist, a closer examination reveals that the primary sources of funding are international donor assistance and sponsorship. Local budget funds fully very few projects; some are co-financed, combining donor assistance with local budget funds. The suggested options for co-financing renewable energy projects in municipalities are outlined in Chapter 4.

TABLE 4. EXAMPLES OF THE PROJECTS (IMPLEMENTED AND ON-GOING)

Project Name/Description	Total Cost	Source of Finance
Hospitals		
The "Ray of Hope" Project	In-kind support. 5.7 thousand solar panels to be supplied to hospitals, schools, and fire departments. The programme has not been implemented as of January 2024	Prospective project to be funded by the EU

Table 4 <

Project Name/Description	Total Cost	Source of Finance
Installation of solar station in a hospital, Zhytomyr	In-kind support. The donated equipment is valued at over UAH 920,000 (~EUR 21,700), with an additional expenditure of over UAH 320,000 (~EUR 7,560) allocated for installation work and project documentation	The Czech company SOLSOL s.r.o. and the non-governmental organization NESEHNUTI provided more than 120 solar panels and an inverter as a donation. The installation and project documentation were funded from the local budget
Installation of solar station in the hospital, Dubno	UAH 1,500,000 (~EUR 35,435)	The majority of the funds were attracted from abroad, while the remainder was allocated from the local budget
Installation of solar station in the hospital, Chernihiv	No information available	100 solar panels were installed with the support of the Embassy of Ukraine in Finland
Installation of solar stations in hospitals, Kyiv	EUR 500,000	The works will be financed from the grant funds of GIZ
Installation of solar stations in hospitals, Chernihiv	No information available	The Energy Act For Ukraine Foundation, a Ukrainian charitable organisation, collaborated with the Garnier brand for the project, and the solar panels were supplied by the Polish company Menlo Electric
Installation of solar stations in hospitals, Trostianets	UAH 2,700,000 (~EUR 63,786)	Grant provided by the Association for "Energy-Efficient Cities of Ukraine"
Installation of solar stations in hospitals, Zvyagel	UAH 850,000 (~EUR 20,080)	The funds for this project were collected during a charity marathon in the USA
The "Ray of Hope" Project	In-kind support. 5.7 thousand solar panels to be supplied to hospitals, schools, and fire departments. The programme has not been implemented as of January 2024	Prospective project to be funded by the EU
Educational Institutions		
Installation of a solar station in a lyceum, Ivano-Frankivsk	Approximately UAH 500,000 (~EUR 11,812)	Municipal budget, "Participatory Budgeting Project"
Installation of a solar station in a school, Irpin	No information available	The Energy Act For Ukraine, "100 Solar Schools" Project
Installation of a solar station in a school, Bozhedarivske amalgamated territorial community, Dniprovetrovsk region	UAH 200,000 (~EUR 4,725)	Local budget
Installation of a solar station in a school, Sumy	No information available	The UPSHIFT Green programme by the UN Children's Fund (UNICEF) and ING Bank

Table 4 <

Project Name/Description	Total Cost	Source of Finance
Municipal Organisations/Utilities		
Installation of a solar station in an Administrative Services Center, Lutsk	No information available	EGAP Programme "Energy-Independent ASCs": Project, funded by Switzerland. The EGAP Programme has been implemented by the East Europe Foundation in collaboration with the Ministry of Digital Transformation of Ukraine and the Innovabridge Foundation since 2015. The programme is involved in the digitisation of 44 pilot communities across six target regions: Volyn, Vinnytsia, Dnipropetrovsk, Luhansk, Odesa, and Chernihiv
Installation of a solar station of 1 MW at the territory of a water utility, Glyboke	No information available	This project was carried out with the backing of patrons. The solar power station installed now meets around 20% of the electricity requirements of the water utility
Installation of a solar station of 20 kW at a water utility, Mukachevo	UAH 450,000 (~EUR 10,630)	Water utility budget
Installation of a solar station of 20 kW at a water utility, Bobrynets	UAH 385,000 (~EUR 9095)	Local budget

The table above presents selected examples of solar energy projects implemented in 2022-2023. Although numerous similar projects exist, a closer examination reveals that the primary sources of funding are international donor assistance and sponsorship. Local budget funds fully very few projects; some are co-financed, combining donor assistance with local budget funds. The suggested options for co-financing renewable energy projects in municipalities are outlined in Chapter 4.

2.3 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the analysis of potential sources of financing, it can be concluded that there is a pressing need to develop additional financial instruments aimed at fostering increased use of renewable energy sources in municipal facilities.

Currently, state support programmes are almost non-functional, commercial banks offer loans at high interest rates, IFIs suspended or repurposed part of their financial programmes due to full-scale aggressive war. Therefore, the following options can be considered for the development of financial capabilities:

Development of the financial potential of state funds, in particular the Energy Efficiency Fund

In the process of energy modernisation, the Energy Efficiency Fund could function both as a technical expert for implementing energy-efficient measures and as an administrator through which grants can be extended to the end consumer, in this case, the municipality. This implies that the Energy Efficiency Fund can oversee the accuracy of project implementation, aligning with donor requirements and within defined project costs. For project execution, the Energy Efficiency Fund can engage partner banks through which grants will be disbursed and which can provide financing.

Advantages of this Option: Experience in collaborating with funds from international donors offering grants for implementing energy efficiency measures in Ukraine. The Fund provides a functional mechanism, along with qualified personnel capable of scrutinizing document packages and project cost estimates at the outset and conducting project verification before grant disbursement. The presence of partner banks that can offer financing. A refined procedure for advancing measures for projects with approved project cost estimates, streamlining the project implementation process.

Disadvantages of this Option: Given that the Energy Efficiency Fund is a state institution, the ultimate decision on working with the Energy Efficiency Fund and grant policies must be coordinated with the Government of Ukraine, potentially prolonging the process of project implementation. Simultaneously, if an agreement on co-financing similar projects is reached at the donor level, alongside funds from donors and the Government of Ukraine, adjustments will need to be made to the state budget of Ukraine to allocate funds to the capital of the Energy Efficiency Fund.

Therefore, this option cannot be considered optimal in the existing circumstances.

Compensation of interest rate and loan guarantees

The proposed option consists of the possibility of compensating the difference between market interest rates (20-25% per annum) and the available interest rates (up to 5% per annum) due to international financial support. Also, considering that municipal financing during wartime poses additional risks to banks, the above option can be combined with the option of offering guarantees for loans.

In simpler terms, such a guarantee can lead to more banks being willing to lend to municipalities and result in improved lending terms. For instance, a reduction in the interest rate by 1-3% and/or a simplified approach to collateral, which will be provided for the loan, may ensure higher attraction of municipalities. Some banks may also offer loans under guarantees either without collateral or against the collateral of the equipment installed as part of the programme, such as solar panels.

This financing scheme has proven successful for banks lending to legal entities and entrepreneurs for business development. A prevalent option for providing guarantees is lending under State guarantees as part of the "Affordable Loans 5-7-9%" Programme by the Entrepreneurship Development Fund.

Similar initiatives have been executed in Ukraine, where the European Investment Bank (EIB) entered agreements with selected banks to facilitate lending under EIB guarantees. For instance, a project was executed with Raiffeisen Bank Aval to support the financing of small and medium-sized enterprises. Another comparable project was undertaken with the support of the European Bank for Reconstruction and Development (EBRD) through an agreement with PrivatBank, Ukraine's largest bank, to provide guarantees for the financing of Ukrainian businesses.

Advantages of this Option: Ukrainian banks possess experience in lending under the guarantees of the State and international financial institutions such as EIB and EBRD. Banks that have been involved in implementing such programmes have a wide branch network and qualified specialists, making it straightforward for them to execute similar projects in the municipal sector. Moreover, in this case, the possibility of lending in the national currency can be provided, which significantly reduces currency risks for municipalities.

Disadvantages of this Option: considering the reduction of budget revenues of cities as a result of changes in the budget legislation, there is a risk of non-compliance with credit obligations to banks, resulting in fewer banks willing to participate in this programme. The complexity of financing municipalities also lies in the challenge of obtaining municipal property as collateral, and without collateral, banks are unlikely to agree to finance municipalities, especially in the conditions of martial law.

The specified risks can be reduced due to state support – in the case of signing agreements between European donors and the Government of Ukraine regarding the implementation of renewable energy projects through state banks of Ukraine (PrivatBank, Oschadbank, Ukrgazbank, UkrEximBank).

Nevertheless, the implementation of this mechanism might take a substantial amount of time, especially if one of the donor requirements involves co-financing from the state for a portion of the project cost. Presently, the Ukrainian state budget is experiencing a significant deficit, and priorities are primarily given to programmes where the state's financial involvement is minimal.

Therefore, this options also cannot be considered optimal in the existing circumstances.

Resumption of IFI's programmes

Direct financing of renewable projects by IFIs and donors is considered the most attractive option in the current circumstances. It is also recommended to consider the possibility of combining different sources of financing, in particular, international loans with grants, or with municipalities' own funds. This will make it possible to implement more complex and expensive projects, increasing their profitability for municipalities. Proposals for potential project financing models are presented in Chapter 4.

Chapter 3

Potential Bottlenecks and Risks for Financing Municipalities to Implement Renewable Energy Projects

As part of the preparation for the Scoping Study, a series of in-depth interviews was undertaken, engaging key representatives from local governments in various cities. The interviewees comprised deputy mayors, heads of energy management units, ecology units, and the head of a district heating utility. Through these discussions, several prominent risks and barriers were brought to light by the participants, summarised below.

3.1 FINANCIAL RISKS AND BARRIERS

3.1.1 MUNICIPAL FINANCING

The main restrictions for financing projects from the local budget are presented below.

Regulations on Local Borrowings and Guarantees

Volume and terms of local borrowings and the provision of local guarantees shall be agreed upon by the Ministry of Finance. In 2023, the Ministry greenlit only nine applications for local borrowings and ten applications for local guarantees[6]. Local self-governments are subject to several constraints when seeking financing, notably that the aggregate local debt and guaranteed debt must not exceed 200% of the average annual revenue of the local budget's general fund over the preceding three fiscal years, excluding personal income tax and intergovernmental transfers. Moreover, expenditures on servicing local debt within the local budget cannot surpass 10% of the general fund's outlays. Approval from the Ministry of Finance is also mandatory for any alterations to significant terms of borrowing contracts, including type, amount, currency, duration,

6 https://mof.gov.ua/uk/miscevij-borg-ta-miscevij-garantovanij-borg

interest rates, and repayment terms. Notably, there are instances where changes aimed at accelerating debt repayment are not endorsed by the Ministry. When designing a financial programme for municipalities, it is important to consider that municipalities require flexibility to repay debts ahead of schedule, particularly in instances where loans are denominated in foreign currency and/or subject to floating interest rates.

Decreased Municipal Budgets

In 2023, tax revenues accounted for 67% of total revenues to local budgets, amounting to 434.5 billion UAH, with 44% of these revenues attributed to the personal income tax[7]. By comparison, in 2022, personal income tax contributed to 70% of tax revenues[8]. Amendments to the Budget Code of Ukraine, effective from November 2023, redirected personal income tax from military personnel's salaries, previously allocated to local budgets, to the state budget. The Ministry of Finance of Ukraine estimated a reduction in revenues to local self-government bodies of 93.7 billion UAH for 2024[9]. These Amendments not only substantially reduced revenues of the local budgets, but also prescribed financing directions for surplus funds from local budgets during the period of martial law. The list of permissible types of expenditures does not explicitly include renewable energy projects on municipal infrastructure.

Constraints to Municipal Payments

Municipal expenditures are managed through the State Treasury Service. Cabinet of Ministers of Ukraine by the Resolution No. 590 of June 9, 2021 adopts the Procedure for Performing Functions by the State Treasury Service in a Special Regime during Martial Law[10]. This Procedure delineates the process for handling payments from municipalities via the Treasury, including the sequence of payment execution by the Treasury taking into account the resources available in the single treasury account.

Notably, the list of permissible expenditures encompasses the "acquisition and installation of backup power sources." However, the absence of a clear definition for "backup power source" could pose challenges, particularly if solar power stations are not recognised as such. Furthermore, payments are restricted to goods delivered, work performed, and services rendered, precluding advance payments for pending transactions. Moreover, the State Treasury Service has the authority to decide on channeling budgetary funds only to separate non-budgetary accounts (managed by Treasury) of suppliers, works contractors, and service providers. In this case the received funding can be solely utilised for tax and duty payments to all levels of budgets, and for contributions to mandatory state social insurance. This limits the possibilities for municipalities to collaborate on working according the energy service contracts.

7 https://openbudget.gov.ua/?month=12&year=2023&budgetType=LOCAL
8 https://decentralization.ua/news/16105
9 https://zakon.rada.gov.ua/laws/show/590-2021-п#Text
10 https://zakon.rada.gov.ua/laws/show/590-2021-п#Text

However, **there is the possibility to finance the goods, works and services purchased during the implementation of international programmes supported by the European Union, foreign governments, foreign finance and donor institutions and international financial organisations, including on the terms of co-financing**. Thus, municipal funds as a source of project financing are better considered in the form of co-financing within international projects. Surveyed municipalities confirmed, that currently there are no problems with blocking funding under international projects, though this risks should be still taken into account.

3.1.2 ATTRACTED FINANCING

High Interest Rates of Ukrainian Commercial Banks

The commercial interest rates at the level of 20-25% significantly exceed the NBU Key Policy Rate (15%[11]) and the average annual inflation index. The majority of respondents noted that existing commercial rates make it impossible to attract loans from commercial banks for municipal investment projects. According to the interviewed representatives of municipalities, they find a loan in national currency below the level of inflation the most appealing (up to 12%).

Exchange Rate Risk

In conditions of high political and economic instability, obtaining loans in foreign currency poses a significant risk for municipalities. The interviewed representatives of municipalities indicate that maximum interest rate in euro ranges between 3.5% to 4% (Fig. 7).

Risks Associated with Fluctuating Interest Rates

Moreover, linking the interest rate on the loan to the fluctuating interest rates is

FIGURE 7. DYNAMICS OF UAH/EUR EXCHANGE RATE[12]

11 https://bank.gov.ua/en/monetary/archive-rish
12 https://bank.gov.ua/en/markets/exchangerate-chart

considered suboptimal from the municipalities' perspective, as predicting its changes is challenging, affecting in increasing expenditure volumes throughout the loan term. Ukrainian municipalities have experience in attracting finance under LIBOR rate which posed significant challenges in forecasting future payments (Fig. 8).

Taking into consideration experience with LIBOR rate which is widely known among municipalities, cities are currently cautious with attracting loans under EURIBOR rate which is suggested under EIB Energy Efficiency of Public Buildings in Ukraine Programme (Fig. 9).

Respondents highlighted that the inability to predict fluctuations in the exchange rate poses a significant risk for the implementation of renewable energy projects. They have previously had negative experiences with loans tied to the LIBOR rate, finding them to be costly with extended payback periods.

FIGURE 8. DYNAMICS OF LIBOR RATE[13]

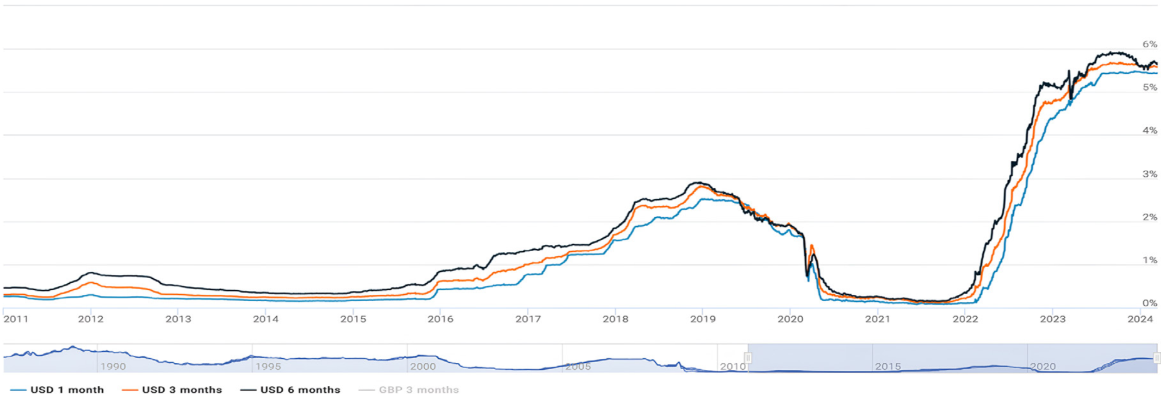
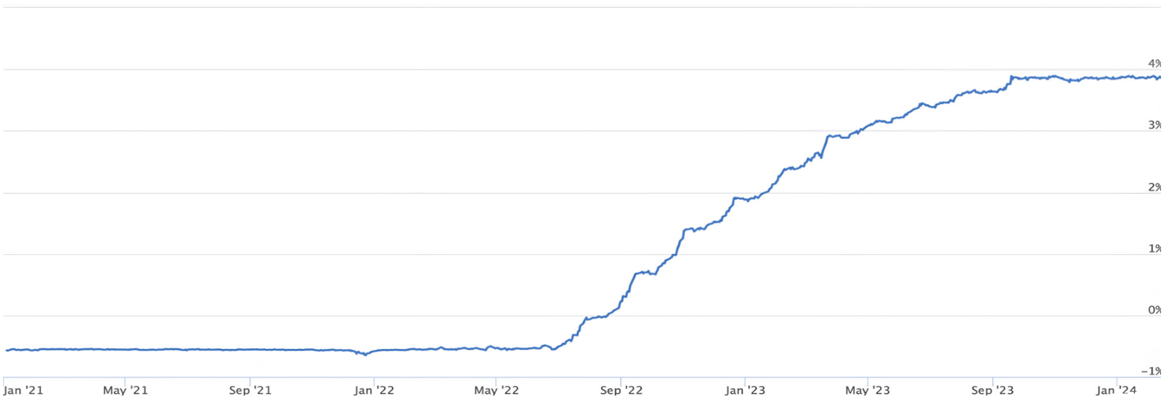


FIGURE 9. DYNAMICS OF EURIBOR RATE[14]



11 https://www.global-rates.com/en/interest-rates/libor/
12 https://www.euribor-rates.eu/en/euribor-charts/

The Complexity of Sovereign Loans Compared to Direct Loans

Most IFIs provide financing in the form of sovereign loans through governmental authorities. In this case, the Ministry of Finance acts as manager of funds and Ministry for Communities, Territories and Infrastructure Development of Ukraine (or another relevant ministry) – as the project administrator. As a result, the terms of approval of the main project stages and the terms of project implementation significantly increase.

Some cities that had experience in attracting loans from Nefco (under direct lending) and other IFIs through sovereign loans confirmed that in the second option projects may be delayed for 12-24 months. Sometimes they had to wait for the approval of relevant ministries for several months.

Moreover, as a result of such delays, cities suffered financial losses, as they were forced to pay commitment fee on the unused amount of the loan (while the project cannot start due to procedural issues) and to make changes to the cost estimates, as the cost of materials and equipment increased during this time. Cities are also required to pay a commission to the Ministry of Finance as a Fund Manager, which increases their project costs.

The Complexity of IFIs Procedures

It is worth noting that, according to conducted interviews, participants highlighted the complexity of some IFI procedures as a barrier to participation in financing programmes, EBRD procedures in particular. As a positive experience, participants noted cooperation with Nefco, the procedures of which are much more flexible and approval times are faster. Furthermore, it assigns appropriate consultants to assist the cities with all the procedures and the capacity-building of municipal staff.

3.2 TECHNICAL RISKS AND BARRIERS

The following technical risk are highlighted: defects of project implementation and the lack of monitoring of project results.

In most cases, cities do not monitor the results of the project, in particular, control over the achievement of the declared savings indicators, do not provide high-quality maintenance of the equipment, which reduces the effectiveness of the project. Also, most often, monitoring of the Defects Notification Period is not envisaged, which can also affect the results of the project.

3.3 REGULATORY RISKS AND BARRIERS

The interviews brought to light various regulatory obstacles hindering the progress of renewable energy and energy efficiency projects, with a notable emphasis on regulated tariffs. For instance, despite the rise in electricity prices, the tariffs for water utilities have remained static. This situation has left water utilities struggling to cover their expenses, making it even more challenging to attract loans for necessary investments.

Another regulatory hurdle that emerged relates to additional measures, specifically the installation of cogeneration units. Interviewees stressed the complexities of administrative procedures. Another challenging aspect is negotiating with distribution system operators for grid connections.

3.4 HUMAN RESOURCES

Lack of Experience and Limited Qualifications Among Municipal Staff

Most local authorities lack the necessary experience in renewable project preparation and implementation especially within the framework of international cooperation while attraction of qualified specialists is impossible due to a lack of finances.

At the same time, preparation of documentation for loan and grant applications demands expertise in compiling such materials, crafting economic justifications, etc. The absence of specialists with this kind of experience may lead to prolonged approval processes or the outright rejection of the project.

Moreover, it became evident from the interviews that municipalities require assistance in identifying potential projects. The interviewees emphasised that conducting standalone energy audits for specific buildings or facilities is insufficient. Instead, a comprehensive analysis of municipal infrastructure is deemed a preferred option. This thorough examination could be an integral part of the process of formulating local energy plans — an obligatory requirement for all local communities in Ukraine as stipulated by the Law of Ukraine "On Energy Efficiency." Additionally, assistance is needed in the preparation of heat supply schemes and feasibility studies. There is a clear need for support in crafting all these types of planning documents.

Therefore, cities also need technical support in the form of consultants and experts financed by IFIs.

Scarce Service Providers

The interviewees highlighted a notable challenge in involving international companies, as certain contractors are terminating contracts by citing force majeure due to the outbreak of war. This situation is hindering the advancement of the modernisation process, causing delays and disruptions. The imperative to find alternative contractors is apparent, but discussions reveal that this task is inherently challenging. Identifying and securing new contractors willing to undertake projects in the current circumstances proves to be asignificant obstacle, adding complexity to the already intricate landscape of project implementation.

War-related Conscription of Personnel

Ukraine currently has a significant shortage of workers due to conscription. In some cases, conscription was carried out directly on construction sites, which, of course, increases the risks of project implementation.

3.5 CONCLUSIONS AND RECOMMENDATIONS

Analysis of the above-mentioned risks and barriers lead to the following conclusions – to be able to implement renewable energy projects, municipalities need affordable financial mechanisms, support in the form of technical assistance and reservation of personnel involved in the implementation of international projects from military service during project timeframe.

Additionally, the following mitigation measures can be considered to minimise the above-mentioned risks and barriers.

TABLE 5. RISKS/BARRIERS MITIGATION MEASURES

Project Description	Simple Payback Period, years
Financial barriers	In light of significant exchange rate risks, it is recommended to discuss with banks or the Government of Ukraine the feasibility of exclusively **providing credit financing for local authorities in the national currency.** The retention of exchange rate risks can then be determined either at the level of international donors or at the state level. Fixed rate options may also be considered, without reference to EURIBOR/LIBOR. Also, in the current difficult financial conditions in Ukraine, it is important **to provide grant support for financing important environmental projects.**
Procedures complexity	It is proposed to consider the possibility of **direct financing of municipalities** in order to avoid additional complications with approvals from state authorities, speed up projects and build the potential of municipalities in cooperation with international organisations. Flexibility of IFIs and simplification of procedures are also the key component to successful project implementation.
Technical issues	Control over the quality of work, and monitoring during the defect notification period should be a requirement when providing financing. In addition, the requirement to monitor energy consumption after project implementation should also be mandatory. For this purpose, it is recommended to implement the automatised energy monitoring system under the project, in case of its absence.
Regulatory barriers	Completion of the reforms of energy markets in line with the EU acquis.
Human resources	This challenge could be mitigated through capacity building of Ukrainian employees. When forming a financial programme for municipalities, it is essential to consider the limited human resources of municipalities and explore the possibility of including supportive measures. These measures could involve **capacity-building initiatives and providing advisory support for preparing project documentation.** Typically, consultants funded by international projects, such as GIZ, IFC, UNDP, and others, offer such advisory support. Opening branches of international companies in Ukraine engaging local staff is also considered appropriate.
War-related conscription of personnel	In general, the normative acts of Ukraine provide for the possibility of reservation persons who are executors of international technical assistance projects. In practice, there are many difficulties with obtaining such a reservation. Therefore, support from the IFIs may be required.

Chapter 4

Description of the Key Features of a Proposed Financial Programme

4.1 PREREQUISITES FOR DETERMINING THE OPTIMAL FINANCIAL PROGRAMME

To determine the optimal financing model/programme, it is proposed to calculate various options of project financial structure on the example of a real municipal facility. It is suggested to base analysis on simple indicators of technical and economic feasibility, such as a simple payback period and internal rate of return (IRR). It should be considered that the majority of cities are interested in implementing projects with a payback period of up to 5 years (except for complex infrastructure projects of course) which is justified by:

- **political aspects:** in particular, the mayor's term of office (mayors are interested in getting results during their term and not to take loan/other obligations for a term that exceeds the term of office);
- **budgetary aspects:** there are no opportunities for long-term budget planning in Ukraine. Therefore, the planning of most projects and investments is carried out in the short and medium terms (especially now, in the conditions of war);
- **economical aspects:** unfortunately, one of the determining criteria for making a decision on project implementation is their economic feasibility. In contrast to Europe, where "green" projects are also justified by the ecological and social aspects, such non-monetary criteria are not decisive for Ukrainian municipalities (currently, only the increase in the reliability and uninterrupted power supply is mainly considered as non-monetary benefits). In this aspect, the support of donors, encouraging the implementation of ecologically important projects through grant support, is still relevant.

So, as the main limiting factors for determining the optimal financing programme, we have:

- limited available sources of project financing as summarised in Chapter 2;
- restrictions on the payback of 5-6 years.

Based on these limitations and calculations presented below, the most optimal model will be proposed, which, in our opinion, will be able to ensure the implementation of solar projects in Ukrainian municipalities.

4.2 MODEL PROJECT

As a model facility, the maternity hospital for which technical and economic justification for solar system installation was developed in 2023 was selected.

Brief Description of the Facility

- five-story building, 17 m high;
- about 300 people (medical and other personnel) work daily in the building servicing up to 600 people daily;
- monthly consumption is relatively uniform throughout the year: the highest consumption of electricity is observed in winter, and the lowest consumption – in summer;
- annual electricity consumption – 245,405 kWh;
- average monthly electricity consumption – 20,450 kWh;
- the daily schedule of consumption has a morning peak, which justifies the accumulator batteries' installation.

Proposed Technical Model

According to the results of the analysis, it was proposed to install a solar power plant with a capacity of 80 kW with the installation of an accumulator battery. The main components of such an installation are presented below:

- photo modules, 600 W – 134 panels;
- hybrid inverter, 15 kW – 6 pieces;
- accumulator battery, 5 kWh – 13 pieces;
- other required components and ad ditional materials.

The Structure of the Investment Cost of the System

In addition to the main system equipment, the investment cost included the costs of design, technical supervision, as well as project support, which is an important component of project implementation, as described in more detail in Chapter 3.

Energy Savings

The annual reduction in electricity consumption as a result of the operation of the solar installation is 88,000 kWh/year. With the current tariff at the level of UAH 6.2 UAH/kWh, the annual cost savings exceed 546,000 UAH.

TABLE 6. PROJECT INVESTMENT

Investment	Units of measurement	Value
Design	UAH	328 000
The cost of equipment and components	UAH	3 280 000
Construction works	UAH	492 000
Technical supervision and commissioning	UAH	164 000
Project support	UAH	328 000
Total	**UAH**	**4 592 000**

Project Payback

IRR of the Project is 3%, thus, attracting funds at a rate exceeding 3% will mean that the project will become economically unprofitable. In addition, the payback of such a project is more than 8 years (the discounted payback period even exceeds the project lifetime), which is also an issue considering the limiting factors described in section 4.1.

Therefore, we can conclude that there is a significant need to support the financing of such projects by international financial organisations. Possible options for increasing the profitability of such projects for municipalities at the expense of international support will be considered below.

FIGURE 10. CALCULATION OF THE PROJECT PAYBACK

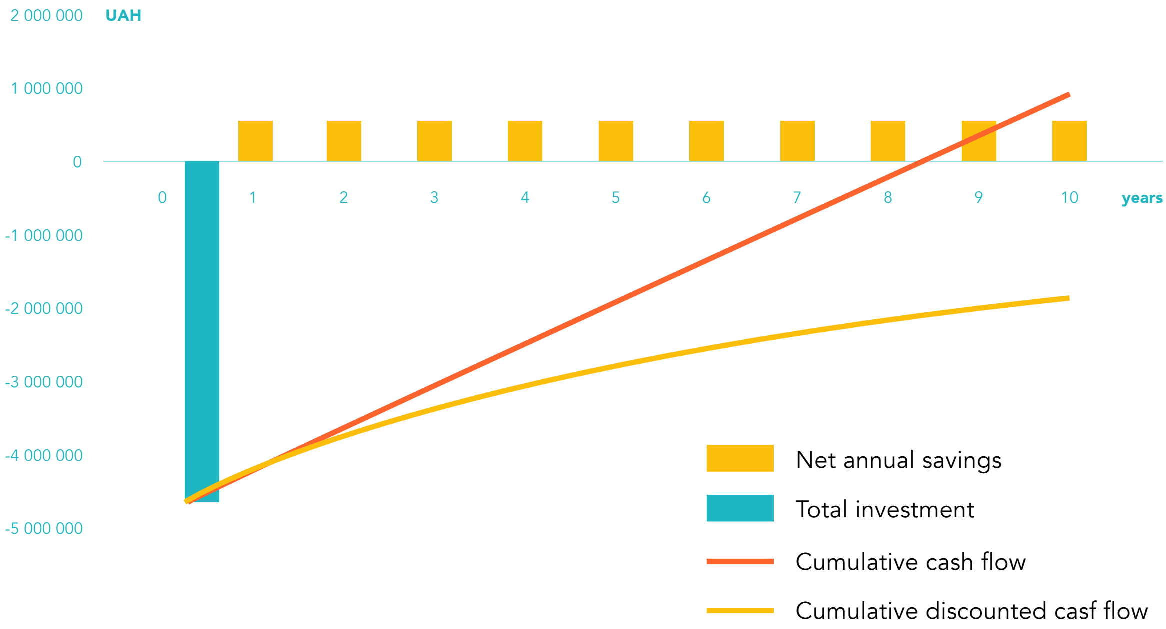


TABLE 7. PROJECT PROFITABILITY

Project Profitability	Units of measurement	Value
Simple payback period (PP)	years	8,4
IRR	%	3%
Discount rate (=NBU rate), %	%	15%
NPV	UAH	-1 853 759,84 ₴
DPP	years	23,7

4.3 MODELING OPTIONS OF FINANCIAL STRUCTURES

In the existing conditions of martial law, and limited financial resources in municipalities, of course, the most attractive for municipalities is **100% grant project financing.**

Alternatively, the option of attracting loan resources may also be considered, subject to the availability of a grant. In order to determine the optimal share of the grant, the calculations of profitability for various options were made (Tab. 8).

The profitability indicators were calculated based on:

- different shares of grant funding;
- subject to the possibility of city cofinancing, and in its absence;
- different interest rate options.

6.2 UAH/kWh, the annual cost savings exceed 546,000 UAH.

For all calculations, the loan term was assumed to be 5 years, and the front and fee rate – 0.5%. To simplify calculations, a single discount rate at the loan rate level was adopted.

In the calculation of the cash flow, the city's expenses for servicing the loan, the achieved project savings and its own contribution were taken into account. Thus, from the position of the city, it is possible to determine which financing options are most acceptable in terms of payback.

Calculation results are presented in Annex 3.

4.4 CONCLUSIONS AND RECOMMENDATIONS

Based on the calculations, the conclusion is that it is possible to achieve the payback of projects for a municipality at the level of 5-6 years, provided that at least 30% of the grant is attracted (subject to loan rate at the level of up to 2%). The higher the rate, the larger the share of the grant shall be provided to achieve an acceptable payback.

Co-financing by a municipality also allows to reduce the costs of servicing the loan and as a result improves the payback period – therefore, if possible, it is better to consider at least 15% co-financing by the local self-government is provided (Tab. 9).

TABLE 8. VARIABLES FOR OPTION CALCULATIONS

Source of funding	Variable options
Share of grant	0%, 20%, 30%, 40%
Share of co-funding from the municipality	0%, 15%
Loan interest rate (repayment period: 5 years; Front-end Fee: 0.5%)	2%, 5%, 8%

TABLE 9. RECOMMENDED SHARE OF THE GRANT FOR DIFFERENT LOAN RATE

Loan rates, %	Appropriate share of the grant, %
2%	30-50%
5%	40-50%
8%	50% and more

Conclusions

The deployment of renewable energy sources within the public facilities and utilities of Ukraine has proven to be highly effective, benefiting from the proximity of energy sources to end consumers and enhancing energy security. Considering these factors, installation of solar power plants in municipally owned facilities, such as water utilities, heat-generating stations, hospitals, and kindergartens, emerges as the most optimal solution, especially given limited financial resources.

The assessment shows that the following types of projects should be prioritised:

- installation of a self-consumption rooftop solar power plants in hospitals, equipped with a hybrid inverter with backup power capability;
- installation of solar power stations at water utility pumping stations and wastewater treatment facilities, equipped with hybrid inverters and backup capabilities (taking into account possible modernisation or replacement of pumping equipment);
- installation of solar power stations at sewage pumping stations with hybrid inverters and backup capabilities (taking into account possible modernisation or replacement of pumping equipment).

The analysis indicates the potential for cutting carbon dioxide emissions by 10-20% compared to the baseline emissions linked to electricity consumption from the national energy system.

The analysis of already implemented renewable energy projects in local communities shows that currently the primary sources of funding are international donor assistance and sponsorship. Local budget fully finance just a few projects; some are co-financed, combining donor assistance with local budget

The ongoing financial programmes of international financial organisations do not target specifically deploying renewable energy installations for municipal facilities. Municipalities highlight the following aspects which are essential for a successful financial programme: loans should be provided in national currency under a fixed interest rest, swift administrative procedures, and technical assistance or grant component.

Within this Scoping Study the following prerequisites for successful renewable project implementation were identified:

- a detailed analysis of the feasibility of the project and a comprehensive approach to its development should be provided, which should include the installation of the storage systems and the possibility of improving the reliability of the energy supply;
- financing of renewable projects by IFIs and donors is considered the most acceptable in the current circumstances. Also, in order for the projects to be economically justified for cities, it is worth considering the possibility of

attracting grants at the level of 30-50% and reducing loan rates at the level of up to 3-5%;

- it is also necessary to provide technical support to cities and train their project implementation units and other specialists to build their capacity to work with international organisations and within the framework of international rules and requirements;
- some IFIs procedures shall be simplified and expedited;
- and for projects to achieve the declared energy saving indicators, energy monitoring system must be introduced.

Some organisations are already working on similar principles, demonstrating the successful implementation of projects. For example, Nefco (before the full-scale aggressive war) provided direct loans to municipalities, combining loans with grants, assigned technical PIU support consultants, and ensured environmental and energy-saving monitoring of project results until the loan repayment. Currently, they continue to finance green projects providing 100% grant financing.

The EIB before the war had the most attractive financing conditions (the lowest rates), but this IFI worked through state institutions and had very complicated and lengthy procedures. As a result, only a small number of projects were initiated. The EBRD usually works with large cities and more complex projects. Under the existing circumstances, more flexible approaches should be used to stimulate renewable energy projects.

ANNEX 1

ELECTRICITY DISTRIBUTION TARIFFS EFFECTIVE FROM JANUARY 1, 2024[15]

Electricity Distribution Tariffs applicable from January 1, 2024, through December 31, 2024, inclusive

No	Distribution system operator	Electricity distribution	
		1st voltage class, UAH/MWh (excluding VAT)	2st voltage class, UAH/MWh (excluding VAT)
1	VINNITSIAOBLENERGO JSC	344,82	2028,18
2	VOLYNYOBLENERGO PRJSC	256,27	1722,53
3	DTEK DNIPROVSKI ELECTROMEREZHI JSC	226,41	1328,03
4	DTEK DONETSKI ELECTROMEREZHI JSC	394,34	1808,60
5	ZAKARPATTYAOBLENERGO PRJSC	474,95	2152,21
6	ZAPORIZZHYAOBLENERGO PJSC	177,78	1333,19
7	DTEK KYIV ELECTRICAL NETWORKS PJSC	194,35	767,97
8	DTEK KYIV REGIONAL ELECTRIC NETWORKS PJSC	402,65	1601,47
9	LVIVOBLENERGO PRJSC	311,75	1631,03
10	MYKOLAIVOBLENERGO JSC	460,44	1995,58
11	DTEK ODESK[illegible] ELECTROMEREZHI PRJSC	304,92	1872,98
12	POLTAVAOBLENERGO JSC	250,87	1748,69
13	PRIKARPATTYAOBLENERGO JSC	330,44	2131,79
14	SUMYOBLENERGO JSC	316,88	2243,43
15	TERNOPILOBLENERGO JSC	400,33	2126,05
16	KHARKIVOBLENERGO JSC	438,67	1818,79
17	KHMELNYTSKOBLENERGO JSC	423,93	2019,05
18	CHERKASYOBLENERGO PRJSC	242,03	1709,11
19	CHERNIGIVOBLENERGO JSC	435,25	2147,25
20	DTEK HIGH VOLTAGE NETWORKS LLC	102,57	2630,87
21	PEEM "CEK" PRJSC	201,57	1387,91
22	LUHANS'KE ENERHETYCHNE OB'YEDNANNYA LLC	556,28	2140,52
23	DPEM "ATOMSERVIS" PRJSC	91,36	1411,45
24	REGIONAL ELECTRIC NETWORKS SOE	181,01	545,02
25	DTEK PEM-ENERGY COAL PRJSC	61,91	619,19
26	"NAFTOGAZ TEPLO" LLC (Noviy Rozdil)	316,01	1844,35
	"NAFTOGAZ TEPLO" LLC (Novoyavorivsk)	286,48	1476,01
27	JSC "UKRZALIZNYTSYA"	388,59	1730,19

15 https://www.nerc.gov.ua/sferi-diyalnosti/elektroenergiya/promislovist/tarifi-na-elektroenergiyu-dlya-nepobutovih-spozhivachiv/tarifi-na-poslugi-z-rozpodilu-elektrichnoyi-energiyi/tarifi-na-poslugi-z-rozpodilu-elektrichnoyi-energiyi-shcho-diyut-z-01-sichnya-2024-roku

ANNEX 2 | ELECTRICITY DISTRIBUTION TARIFFS APPLICABLE FROM JANUARY 1, 2024, THROUGH MARCH 31, 2024, INCLUSIVE

No	Distribution system operator	Electricity distribution	
		1st voltage class, UAH/MWh (excl. VAT)	2nd voltage class, UAH/MWh (excl. VAT)
1	ZHYTOMYROBLENERGO JSC	327,86	1643,05
2	KIROVOGRADOBLENERGO PRJSC	397,24	1605,49
3	RIVNEOBLENERGO PRJSC	243,49	1344,41
4	KHERSONOBLENERGO JSC	491,28	1439,92
5	CHERNIVTSIOBLENERGO JSC	187,81	1462,19

THE TARIFFS FOR UNIVERSAL SERVICE PROVIDERS' SERVICES, WHICH ARE IN EFFECT FROM FEBRUARY 1, 2024[16]

No	Universal Service Providers	Tariffs for universal service providers' services, UAH/MWh (excl. VAT)
1	"ENERA VINNYTSYA" LLC	162,75
2	VOLYNYELEKTROZBUT LLC	138,74
3	DNIPROVSKI ENERGY SERVICES LLC	138,70
4	Donetsk Energy Services LLC	200,45
5	Zhytomyr Regional Power Supply Company LLC	167,16
6	ZAKARPATTYAENERGOZBUT LLC	147,11
7	ZAPORIZHYA ELECTROPOSTACHANYA LLC	119,32
8	KYIV ENERGY SERVICES LLC	117,82
9	KYIV REGIONAL ENERGY SUPPLY COMPANY LLC	80,33
10	Kirovohrad REGIONAL ENERGY SUPPLY COMPANY LLC	141,43
11	ENERA SHYD LLC	209,25
12	LVIVENERGOZBUT LLC	111,94
13	MYKOLAIVSKA ELECTROPOSTACHALNA KOMPANIA LLC	151,97
14	Odesa REGIONAL ENERGY SUPPLY COMPANY LLC	110,32
15	POLTAVAENERGOZBUT LLC	135,34
16	PRIKARPATENERGOTRADE LLC	169,98
17	RIVNE REGIONAL ENERGY SUPPLY COMPANY LLC	109,35
18	ENERA SUMY LLC	189,01
19	TERNOPIL ELEKTROPOSTACH LLC	133,00
20	KHARKIVENERGOZBUT LLC	155,58
21	KHERSON REGIONAL ENERGY SUPPLY COMPANY LLC	107,39
22	KHMELNYTSKENERGOZBUT LLC	147,00
23	CHERKASYENERGOSBUT LLC	150,84
24	Chernivtsi Regional Power Supply Company LLC	105,87
25	ENERA CHERNIGIV LLC	186,44

16 https://www.nerc.gov.ua/sferi-diyalnosti/elektroenergiya/promislovist/tarifi-na-elektroenergiyu-dlya-nepobutovih-spozhivachiv/tarifi-na-poslugi-postachalnikiv-universalnih-poslug/tarifi-na-poslugi-postachalnikiv-universalnih-poslug-shcho-diyut-z-01-lyutogo-2024-roku

ANNEX 3 | RESULTS OF CALCULATIONS OF PROJECT PROFITABILITY INDICATORS FOR VARIOUS FINANCING OPTIONS

TABLE 1: Project profitability in case of a loan rate of **2%**

Options	1	2	3	4	5	6	7	8	9	10
SHARE OF FUNDING SOURCES										
Grant, %	0%		20%		30%		40%		50%	
Own funds, %	0%	15%	0%	15%	0%	15%	0%	15%	0%	15%
Loan, %	100%	85%	80%	65%	70%	55%	60%	45%	50%	35%
AMOUNT OF FUNDING SOURCES										
Grant component, UAH	0	0	918 400	918 400	1 377 600	1 377 600	1 836 800	1 836 800	2 296 000	2 296 000
Own funds, UAH	0	688 800	0	688 800	0	688 800	0	688 800	0	688 800
Loan, UAH	4 592 000	3 903 200	3 673 600	2 984 800	3 214 400	2 525 600	2 755 200	2 066 400	2 296 000	1 607 200
Total, UAH	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**
LOAN SERVICING COSTS (INTEREST RATE: 2% AND FRONT AND FEE: 0.5%)										
Front and fee & Interest, UAH	-298 480	-253 708	-238 784	-194 012	-208 936	-164 164	-179 088	-134 316	-149 240	-104 468
PROFITABILITY INDICATORS										
PP, years	9,0	8,9	7,2	7,1	**6,3**	**6,2**	**5,4**	**5,3**	**0,3**	**3,5**
IRR, %	5%	4%	17%	13%	30%	19%	57%	27%	376%	36%
NPV, UAH	280 332	283 708	1 185 226	1 188 602	1 637 673	1 641 049	2 090 120	2 093 496	2 542 567	2 545 944
DPP, years	9,4	9,4	7,3	7,3	6,4	6,4	5,4	5,4	0,3	3,6

ANNEX 3 | RESULTS OF CALCULATIONS OF PROJECT PROFITABILITY INDICATORS FOR VARIOUS FINANCING OPTIONS

TABLE 2: Project profitability in case of a loan rate of **5%**

Options	1	2	3	4	5	6	7	8	9	10
SHARE OF FUNDING SOURCES										
Grant, %	0%		20%		30%		40%		50%	
Own funds, %	0%	15%	0%	15%	0%	15%	0%	15%	0%	15%
Loan, %	100%	85%	80%	65%	70%	55%	60%	45%	50%	35%
AMOUNT OF FUNDING SOURCES										
Grant component, UAH	0	0	918 400	918 400	1 377 600	1 377 600	1 836 800	1 836 800	2 296 000	2 296 000
Own funds, UAH	0	688 800	0	688 800	0	688 800	0	688 800	0	688 800
Loan, UAH	4 592 000	3 903 200	3 673 600	2 984 800	3 214 400	2 525 600	2 755 200	2 066 400	2 296 000	1 607 200
Total, UAH	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**
LOAN SERVICING COSTS (INTEREST RATE: 5% AND FRONT AND FEE: 0.5%)										
Front and fee & Interest, UAH	-711 760	-604 996	-569 408	-462 644	-498 232	-391 468	-427 056	-320 292	-355 880	-249 116
PROFITABILITY INDICATORS										
PP, years	9,7	9,5	7,8	7,6	6,8	6,6	**5,8**	**5,6**	**3,7**	**4,1**
IRR, %	1%	2%	12%	10%	21%	16%	37%	23%	94%	33%
NPV, UAH	-382 839	-379 559	496 201	499 481	935 721	939 001	1 375 241	1 378 521	1 814 761	1 818 041
DPP, years	11,2	11,2	8,5	8,5	7,2	7,2	6,0	6,0	3,9	4,6

ANNEX 3 | RESULTS OF CALCULATIONS OF PROJECT PROFITABILITY INDICATORS FOR VARIOUS FINANCING OPTIONS

TABLE 3: Project profitability in case of a loan rate of **8%**

Options	1	2	3	4	5	6	7	8	9	10
SHARE OF FUNDING SOURCES										
Grant, %	0%		20%		30%		40%		50%	
Own funds, %	0%	15%	0%	15%	0%	15%	0%	15%	0%	15%
Loan, %	100%	85%	80%	65%	70%	55%	60%	45%	50%	35%
AMOUNT OF FUNDING SOURCES										
Grant component, UAH	0	0	918 400	918 400	1 377 600	1 377 600	1 836 800	1 836 800	2 296 000	2 296 000
Own funds, UAH	0	688 800	0	688 800	0	688 800	0	688 800	0	688 800
Loan, UAH	4 592 000	3 903 200	3 673 600	2 984 800	3 214 400	2 525 600	2 755 200	2 066 400	2 296 000	1 607 200
Total, UAH	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**	**4 592 000**
LOAN SERVICING COSTS (INTEREST RATE: 8% AND FRONT AND FEE: 0.5%)										
Front and fee & Interest, UAH	-1 125 040	-956 284	-900 032	-731 276	-787 528	-618 772	-675 024	-506 268	-562 520	-393 764
PROFITABILITY INDICATORS										
PP, years	10,5	10,2	8,4	8,1	7,3	7,0	6,3	6,0	**5,2**	**4,8**
IRR, %	-2%	-1%	8%	8%	15%	13%	27%	20%	**55%**	**30%**
NPV, UAH	-883 277	-880 089	-28 655	-25 466	398 656	401 845	825 967	829 156	**1 253 278**	**1 256 467**
DPP, years	13,8	13,8	10,1	10,1	8,3	8,3	6,8	6,8	**5,4**	**5,4**