ASSESSMENT OF THE POWER NEEDS OF UKRAINE'S WATER AND SANITATION SERVICE PROVIDERS

FINAL REPORT

APRIL 2023

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Cover photo credit: Ukrainian vodokanal pumping station (CDM Engineering Ukraine)

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ACRONYMS AND ABBREVIATIONS

AQ	Assessment Question
AVR	Automatic Reserve Activation
BOD	Biochemical Oxygen Demand
CDM	CDM Engineering Ukraine
CE	Communal Enterprise
DG	Diesel Generator
EOP	Emergency Operations Plan
EU	European Union
FC	Frequency Converter
GPS	Global Positioning System
HV	High voltage
ICRC	International Committee of the Red Cross
IDP	Internally Displaced Person
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
LMCE	Lviv Municipal Communal Enterprise
LV	Low voltage
MCE	Municipal Communal Enterprise
Minregion	Ministry of Communities, Territories, and Infrastructure Development
MW	Megawatt
MWh	Megawatt hour
NEURC	National Energy and Utilities Regulatory Commission
PJSC	Private Joint Stock Company
SOW	Scope of Work
UAH	Ukrainian Hryvnia
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USD	United States Dollar
V	Volt

WASH	Water, Sanitation, and Hygiene
WASHPaLS	Water, Sanitation, and Hygiene Partnerships and Learning for Sustainability
WPS	Water Pumping Station
WTP	Water Treatment Plant
WWPS	Wastewater Pumping Station
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

The United States Agency for International Development (USAID) commissioned the Water, Sanitation, and Hygiene Partnerships and Learning for Sustainability (WASHPaLS) #2 Activity to conduct a rapid assessment of power needs of water and sanitation service providers (vodokanals) in Ukraine. The assessment sought to fill the existing knowledge gap regarding impacts of power outages on vodokanals and corresponding needs for backup power generation. This cross-sectoral assessment will support USAID/Ukraine's rapid response to identify vodokanals' energy needs for continuity of operations in a shifting conflict environment. The assessment focused on emergency (immediate [Stage 1]), urgent (within 3 months [Stage 2]), and short-term (within 6–9 months, or longer [Stage 3]) vodokanal power needs. The assessment addressed two objectives:

> **Objective 1:** Provide specific and actionable data and findings to rapidly respond to energy demand and backup power needs (including fuel and related equipment) of select vodokanals in the short term, in the municipalities of Kyiv, Kharkiv, Kherson, Lviv, and Odesa. Within this objective, identify opportunities to optimize energy efficiency and resilience in the short term.

> **Objective 2:** Provide an overview of linkages and gaps between water and sanitation services and the energy sector—including aggregate demand, energy efficiency issues, and vulnerabilities/risks.

To address Objective 1, the team sent a questionnaire to the five vodokanals to collect initial data, including details on assets, technical and treatment processes, existing equipment and schematics, and equipment and supply needs. The team then conducted multi-day site visits to obtain key data and assess infrastructure conditions at each vodokanal. The team analyzed data to identify possible operational and energy efficiency improvements and prioritized needs. Needs were prioritized according to three stages based on the condition of existing facilities, the vodokanals' expressed priorities, and feasibility of procurement and installation. To address Objective 2, the team analyzed data from the National Energy and Utilities Regulatory Commission (NEURC) together with figures from the five vodokanals, covering national annual aggregate vodokanal power consumption and costs for 2020, 2021, and 2022.

Damage incurred, condition of facilities, interruptions to water supply and sanitation services, and corresponding needs varied across the vodokanals (see detailed vodokanal profiles in Annexes A-E). Vodokanals in eastern Ukraine experienced large decreases in population and associated demand and heavier damage to water, wastewater, and energy infrastructure, while Lvivvodokanal in the west sustained less direct infrastructure damage but experienced a large influx of internally displaced persons (IDPs). All vodokanals have outdated, Soviet-era equipment that often fails during power outages and surges, resulting in short-term service disruptions and continuous needs for repairs.

Vodokanals that have replaced older high-voltage equipment with low-voltage equipment have been able to meet their immediate backup power needs through donors and other humanitarian actors, though some backup power needs persist for vodokanals using more high-voltage equipment. For the purposes of this assessment, high voltage is defined as greater than 1 kilovolt (kV). Backup power needs for high-voltage equipment can be addressed in multiple ways, including custom high-voltage generators or low-voltage generators with step-up transformers, for example. While additional assessment is needed for the design and procurement of high-voltage generators, alternative options are detailed where relevant in Annexes A-E. Additional prioritized needs include cable products and electrical protection equipment, frequency converters, transformer replacement, and control stations (see equipment needs listed by vodokanal in Section 3 of Annexes A-E). Options to improve energy and operational efficiency in the short-term include replacing outdated electrical substations, equipment, and pumps, among other needs specific to each vodokanal. Prioritized needs and associated costs are presented in Table 1.

Inclusive of all five vodokanals, Stage 1 needs are estimated to cost approximately USD 3,560,000 – 3,890,000. Stage 2 needs are estimated to cost approximately USD 4,060,000 – 4,680,000, and Stage 3 needs are estimated to cost approximately USD 14,650,000 – 18,800,000. These estimates cover the cost of equipment alone and are based on current market estimates and availability. Certain equipment, such as generators, transformers, and custom electrical equipment may be subject to limited availability, long lead times for procurement, and cost fluctuation. Where possible, equipment should be grouped for delivery and commissioning to achieve economies of scale. Used and refurbished equipment may be more readily available and should be considered where lead times are unreasonable for new equipment, particularly for urgent needs under Stage 1.

TABLE 1: KEY SUMMARY INFORMATION BY VODOKANAL

	KYIV	KHARKIV	KHERSON	LVIV	ODESA
Backup power needs covered, water supply*	25%	15%	97%	80%	20%
Backup power needs covered, wastewater*	20%	10%	97%	10%	20%
Cost to cover Stage 1 needs (USD)*	170,000 - 190,000	400,000 - 440,000	290,000 - 310,000	2,000,000 - 2,200,000	700,000 - 750,000
Cost to cover Stage 2 needs (USD)*	1,200,000 - 1,400,000	1,150,000 - 1,300,000	160,000 - 180,000	1,000,000 - 1,200,000	550,000 - 600,000
Cost to cover Stage 3 needs (USD)*	6,000,000 - 8,000,000	6,500,000 - 8,500,000	200,000 - 250,000	1,500,000 - 1,600,000	N/A

*All figures are approximate and based on information available at the time of the assessment

1.0 ASSESSMENT PURPOSE AND APPROACH

1.1 ASSESSMENT PURPOSE AND INTENDED USE

Given the immense challenges facing Ukraine's water and sanitation sector prior to and following the Russian Federation's invasion on February 24, 2022, USAID commissioned the WASHPaLS #2 Activity to conduct a rapid assessment of power generation needs of water and sanitation service providers. The assessment goals were to: (1) prevent water shortages in urban centers by identifying key equipment and supply needs of water and sanitation service providers (referred to as "vodokanals" in Ukraine) in five focus municipalities; and (2) address the vodokanals' longer-term energy efficiency gaps.

The initial scope of work (SOW) for this assessment only included Kyiv, Kharkiv, and Kherson. Based on emergent needs, Lviv and Odesa were added. The five focus municipalities are shown in Figure 1.

Figure 1: Focus Municipalities for this Assessment: Kyiv, Kharkiv, Kherson, Lviv, and Odesa

The primary intended audience for the assessment and resultant report is USAID/Ukraine, who will use the evaluation findings and recommendations as part of their rapid response to help prevent water shortages in urban centers, ensure the resilience of vodokanals against power outages and limited power supply, and fill longer-term energy efficiency gaps of select vodokanals in Ukraine. The assessment team also will share findings with USAID implementing partners, humanitarian actors, and key Ukrainian government stakeholders. The assessment focuses on emergency (needed immediately), urgent (needed within 3 months), and short term (needed within 6–9 months, or longer) needs for continued operation of water and wastewater treatment facilities and key collection and distribution infrastructure.

1.2 RAPID ASSESSMENT DESIGN

1.2.1 ASSESSMENT QUESTIONS

The SOW for this assessment outlined two key objectives:

Objective 1: Provide specific and actionable data and findings to rapidly respond to energy demand and backup power needs (including fuel and related equipment) of select vodokanals in the short term. Within this objective, identify opportunities to optimize energy efficiency and resilience in the short term.

Objective 2: Provide an overview of linkages and gaps between water and sanitation services and the energy sector—including aggregate demand, energy efficiency issues, and vulnerabilities/risks.

Based on these objectives, the assessment team developed four assessment questions (AQs) to guide data collection and analysis:

> ***AQ1.*** What are the immediate onsite and backup power generation needs of Ukraine's water and sanitation service providers (vodokanals), and what equipment and supplies are needed to ensure these power generation needs are met? (SOW Objective 1)
>
> ***AQ2.*** How can the vodokanals in Kyiv, Kharkiv, Kherson, Lviv, and Odesa optimize energy efficiency, reduce demand, and increase energy resilience in the short term? (SOW Objective 1)
>
> ***AQ3.*** Since the Russian invasion, what key incidents to infrastructure in Kyiv, Kharkiv, Kherson, Lviv, and Odesa have resulted in water and sanitation service delivery interruptions, including but not limited to power failures, direct attacks on water and wastewater infrastructure, and emergency shutdowns? What was the resultant impact on service delivery and how were normal operations restored? (SOW Objective 1)
>
> ***AQ4.*** What is the annual aggregate energy (in megawatt hours [MWh]) and power (in megawatts [MW]) demand of Ukraine's water and sanitation sector and the annual cost of meeting current power needs? What energy efficiency improvements in existing water and wastewater infrastructure and facilities can improve continuity of operations in the short term? (SOW Objective 2)

Results pertaining to each AQ can be found in the following sections of and annexes to this report, as shown in Table 2.

TABLE 2: ASSESSMENT QUESTION AND RELEVANT REPORT SECTION

ASSESSMENT QUESTION	RELEVANT REPORT SECTION(S)	RELEVANT ANNEXES
AQ1	3.1–3.5	Annexes A-E, Sections 1 and 3
AQ2	3.1–3.5	Annexes A-E, Section 1
AQ3	3.1–3.5	Annexes A-E, Section 2
AQ4	2.3–2.4	Annexes A-E, Section 1

1.2.2 DATA COLLECTION AND ANALYSIS

The assessment team followed a three-phase process to answer the AQs: a desk review (Phase 1); primary data collection and compilation (Phase 2); and data analysis and reporting (Phase 3). WASHPaLS #2 implementer Tetra Tech subcontracted the local Ukrainian engineering firm CDM Engineering Ukraine (CDM) to conduct primary data collection, analysis, and reporting. Tetra Tech also hired a local investigative journalist as a Research Analyst to assist with desk review and primary data collection on key incidents impacting the focus vodokanals. Together, CDM, Tetra Tech, and the Research Analyst formed the assessment team.

Phase 1: Desk Review

To prepare for primary data collection, the assessment team undertook a detailed desk review of relevant documents, reports, news articles, and available datasets. The team compiled background information available online for each vodokanal and lists of incidents and damage to infrastructure impacting the five focus vodokanals. Based on available information, the assessment team outlined draft profiles for each of the focus municipalities and identified key gaps to be filled through site visits. The team compiled lists of primary contacts for each vodokanal in coordination with key actors in Ukraine's water and sanitation sector, including the United Nations Children's Fund (UNICEF)-led Water, Sanitation, and Hygiene (WASH) Cluster and the National Vodokanal Association.

Phase 2: Primary Data Collection and Compilation

Primary data collection and compilation focused on three data types: (1) records detailing water and wastewater facilities; (2) key informant interviews; and (3) photo and video footage of water and wastewater infrastructure, to the extent feasible. The team collected all three types of data through a combination of remote and on-site methods. The assessment team developed questionnaires with sections on the water and wastewater systems and key summary details about the vodokanals and shared them with the points of contact identified in Phase 1. These contacts filled out the information as completely as possible. The data provided in these questionnaires guided subsequent site visits to the five focus municipalities, which were conducted in February and March 2023. The full questionnaires are provided in Annex G, and details regarding the site visits to each vodokanal can be found in the profiles presented in Annexes A-E, Section 1. Information regarding key incidents impacting each vodokanal is provided in Annexes A-E, Section 2. The team used this data primarily to answer AQ1 and AQ2 and to provide additional detail for AQ3 and AQ4.

Through coordination with the National Energy and Utilities Regulatory Commission (NEURC), the assessment team also received and compiled information on national-level aggregate energy demand and cost from vodokanals serving more than 100,000 people. This data represents 52 vodokanals regulated by NEURC, which cover approximately 75% of water and sanitation services provided to the Ukrainian population. The team used this data primarily to answer AQ4.

Phase 3: Data Analysis and Reporting

Phase 3 included assessing the water and wastewater infrastructure's current conditions at each vodokanal's facilities and examining all data gathered during Phase 2. The team identified power requirements to fulfill Emergency Operations Plans (EOPs), where available, and the need for temporary repairs to existing infrastructure. Given on-site facility access challenges, the primary data sources for the recommendations in this report were on-site and follow-up phone interviews with vodokanal personnel and the data received from their representatives via the questionnaires. The team compiled detailed tables containing information on equipment and supplies needed to meet current power demands and to ensure the resilience of water and sanitation service delivery to power outages (presented in Annexes A-E, Section 3). The team also compiled summaries of the vodokanals' facilities and key challenges facing them into detailed profiles (presented in Annexes A-E, Section 1).

Priorities were identified according to a three-stage approach. Stage 1 (emergency/immediate) includes equipment that is needed as soon as possible. Stage 2 (urgent) includes equipment that is needed within the next 3 months. Stage 3 (short-term) includes equipment that is not needed for at least 6–9 months or cannot be procured in a short period of time. The prioritization of needs for each vodokanal took in to account each vodokanal's own priorities in line with their EOPs, feasibility of responding to needs given current costs and procurement timelines, and potential impact on energy and operational efficiency beyond the short-term.

The assessment team also determined the annual aggregate energy demand of Ukraine's water and sanitation sector (in MWh) and the cost of meeting these demands (in US dollars [USD]) from data provided by NEURC. The team compared this information with the power needs of the vodokanals included in this assessment to better understand the national water and sanitation sector's power consumption and how it compares to the vodokanals in Kyiv, Kharkiv, Kherson, Lviv, and Odesa.

1.3 LIMITATIONS

Given that Ukraine is currently under martial law, the data that vodokanals could provide to the assessment team was limited, as was the team's ability to visit all vodokanal facilities during the visits to the five municipalities. In particular, vodokanals were not always able to provide the exact number of consumers, copies of EOPs and strategic development plans, financial indicators, details on material and supply storage, global positioning system (GPS) coordinates of infrastructure assets and facilities, full names of assets and facilities, data regarding vodokanal employees (e.g., position titles and numbers of staff in key roles), water supply quantity and quality, and details regarding available equipment and backup power supplies. In addition, certain data provided by the vodokanals to the assessment team was for analysis use only and is not presented in this report. This includes technical documentation, lists of existing equipment with technical specifications, and water supply/sewerage network schematics. Many details about war-related incidents and the impact of these incidents on facilities were withheld by vodokanal management due to sensitivity.

The assessment team prepared this report based exclusively on information provided by NEURC, vodokanal management, and direct observation, complimented by and triangulated with data made available online and from other actors in the Ukrainian WASH sector, including UNICEF. During site visits, vodokanal management restricted the team's access to certain areas, facilities, and premises. Photography was often not allowed. Specific to national-level aggregate data, NEURC regulates approximately 52 vodokanals across Ukraine serving populations of more than 100,000 people per municipality. National-level aggregate data presented in this report is thus only reflective of these larger vodokanals; there is no central regulator or data source for the approximately 1,500 smaller municipality-owned vodokanals.

While recommendations and results provided in this report, including cost and procurement data, are based on sound engineering design principles and professional judgment, they are drawn from currently available information and subject to change, given the complex and evolving conflict environment in Ukraine. Despite these limitations and challenges, Stage 1 and 2 needs were identified in close collaboration with the vodokanal management and in line with needs outlined in each vodokanal's EOP; these results are thus qualitatively and quantitatively accurate. Recommendations within Stage 3 are based on data gathered through site visits and follow-up discussions in addition to CDM's prior experience in Ukraine's water sector. While Stage 3 recommendations still represent improvements to vodokanals' facilities based on sound judgment and past experience, they should be further explored with vodokanal management prior to procurement and delivery of equipment. Accurate cost information was not able to be provided for all Stage 3 recommendations, as much of this equipment will need to be designed and special ordered.

2.0 WATER, WASTEWATER, AND ENERGY IN UKRAINE

2.1 THE WAR IN UKRAINE

On February 24, 2022, Russian Federation forces invaded Ukraine in a drastic escalation of ongoing conflict. Since the invasion, the war in Ukraine has resulted in increasing numbers of civilian deaths and displacements, and key infrastructure has suffered immense damage, often from direct attacks. Prior to the war, 70% of Ukrainians had access to centralized piped water supply and 50% to centralized wastewater collection and treatment, with significant disparities between urban and rural populations (World Bank 2023). Since the onset of the war, more than 500 water infrastructure facilities have been destroyed (UNICEF 2022). Physical damage to the water and sanitation sector in Ukraine is estimated at approximately USD 2.2 billion, just under half of which is due to damage inflicted between June 1, 2022, and February 24, 2023 (World Bank 2023). Kharkivska, Kyivska, and Khersonska oblasts are all among the worst affected.

In October 2022 the Russian Federation began targeting power infrastructure during attacks. Direct attacks on power generation and supply infrastructure had damaged an estimated 40% of Ukraine's energy system by capacity as of mid-2022 (Query 2022), and damage as of March 2023 is estimated to be five times greater than in mid-2022 (World Bank 2023). Damage to the power sector is estimated to be USD 6.5 billion (World Bank 2023). Key pre-war reform efforts in both the energy and water and sanitation sectors are stalled, as emergency measures are put in place to ensure provision of basic services (World Bank et al. 2022). Vodokanals in Ukraine have been forced to operate under emergency scenarios to ensure the treatment and distribution/conveyance of water and wastewater, often during complete power blackouts.

Reports of direct damage to water, wastewater, and energy infrastructure are widespread. However, the effects of damage to power generation and supply infrastructure on water treatment, wastewater treatment, and conveyance throughout existing networks are unclear at the national level. Damage and challenges vary from region to region, as well. Many cities in the eastern part of Ukraine have been occupied by Russian Federation forces and sustained significant damage and population loss as a result (e.g., Kherson). Meanwhile, cities in western Ukraine have experienced less direct damage to infrastructure but are faced with much higher demand due to the influx of internally displaced persons (IDPs) (e.g., Lviv). Vodokanals often operate Soviet-era infrastructure and historically have relied on spare part supplies from Russia and Belarus, which are no longer available due to the ongoing war. Overall, vodokanal personnel have responded quickly to outages despite immense safety risk, typically restoring water and wastewater service delivery within 24 hours. For a list of incidents and associated impacts due to the war in the five focus vodokanals, see Annexes A-E, Section 2.

2.2 WATER, WASTEWATER, AND ENERGY SECTOR CONTEXT

Approximately 80% of urban Ukrainians and 34% of rural Ukrainians had access to piped water supply prior to the war, though current figures are unknown (World Bank 2023). Access to flush toilets was 86% in urban areas and only 26% in rural areas; 75% of households in urban areas were connected to sewer systems compared to only 8% in rural areas. Deterioration of water supply and sanitation services and infrastructure prior to the Russian invasion resulted from inadequate capital investment and ignored maintenance needs of aging infrastructure. Prior to the war, approximately 40% of Ukraine's water supply network was in critical condition, and roughly 35% of drinking water treatment facilities needed rehabilitation or upgrades (Minregion 2020). National average water losses stood at approximately 36%, and low levels of water metering (about 60%) made and likely still make identification and reduction of water losses difficult, negatively affecting the efficiency of commercial enterprises managing the water supply systems.

The poor existing state of water infrastructure contributes to significant levels of energy consumption and high carbon emissions for daily operations. Ukraine is one of the most energy-intensive countries in the world, and the water and sanitation sector is no exception. Aging and oversized infrastructure, outdated energy-intensive processes, historically low tariffs for water and sanitation services and electricity, and ongoing lack of attention to maintenance needs contribute to these immense power needs (World Bank 2021).

Most of Ukraine's existing wastewater collection systems were built in the mid-twentieth century and, as is common in post-Soviet countries, most are oversized. These conditions, combined with lack of maintenance, affect the performance and efficiency of wastewater treatment plants (WWTPs). Wastewater in Ukraine often is improperly treated, resulting in widespread environmental impacts and increased greenhouse gas emissions. Tariff levels for water and wastewater services have historically been too low for cost recovery, even before the recent Russian invasion, coupled with very low investments in the sector at the national level (0.2% of gross domestic product on average, compared to 1% on average across Europe) (DESPRO 2020).

The Ministry of Communities and Territories Development (Minregion), responsible for water and sanitation in Ukraine until 2022, was subject to frequent staff turnover and minimal policy change in recent years (World Bank 2021). On December 2, 2022, Minregion merged with the Ministry of Infrastructure to create the Ministry of Communities, Territories, and Infrastructure Development (*The Kyiv Independent* 2022). As of May 2020, the Ministry of Energy is the entity responsible for Ukraine's power sector. NEURC is the sector regulator that reviews and approves water and wastewater tariffs, but as of 2018, the commission is only responsible for utilities serving over 100,000 people (approximately 52 vodokanals). For smaller vodokanals, municipal councils and local governments review and approve tariffs, making them subject to political interference, especially during election seasons. In addition, NEURC often is not considered a fully independent regulator due to political interference (World Bank 2021). Other key actors providing support to Ukraine's water and sanitation and power sectors include USAID, UNICEF, the Ukraine WASH Cluster, ICRC, the World Bank, and the National Vodokanal Association.

2.3 POWER CONSUMPTION IN THE WATER AND WASTEWATER SECTOR

Aggregate total annual energy consumption for all vodokanals that NEURC regulates for the previous three years is presented in Table 3.

TABLE 3: AGGREGATE AND AVERAGE POWER CONSUMPTION OF VODOKANALS IN 2020, 2021, AND 2022

	2020	2021	2022
Number of vodokanals reporting	52	52	41
Aggregate total annual energy consumption in Ukraine, MWh	118,789,949	126,340,756	89,658,726
Aggregate annual energy consumption by vodokanals regulated by NEURC, MWh	2,581,192	2,548,626	1,493,598
Average annual energy consumption per vodokanal regulated by NEURC, MWh	49,638	49,012	36,429

TABLE 3: AGGREGATE AND AVERAGE POWER CONSUMPTION OF VODOKANALS IN 2020, 2021, AND 2022			
	2020	**2021**	**2022**
Proportion of available energy consumed by vodokanals regulated by NEURC (%)	2.17	2.02	1.67

Average annual energy consumption per vodokanal ranged from approximately 36,400 to 49,600 MWh between 2020 and 2022. For reference, the average household in Ukraine used approximately 1.9 MWh in 2018, prior to the war (Zaporizhzhiaoblenerho 2018). Overall, approximately 2% of the nation's power consumption is from the water and wastewater sector (among those regulated by NEURC), a figure that decreased slightly each year from 2020 to 2022. For reference, water and wastewater services also account for approximately 2% of energy use in the United States (US EPA, 2023), and the EU water sector accounts for approximately 3.5% of total electricity consumption across the region (IEA 2016). Given temporary occupation of some cities by the Russian Federation, data was not available for all 52 NEURC-regulated vodokanals for 2022. On average, the vodokanals' annual energy consumption dropped by approximately 23% from 2020 to 2022. Power outages, gaps in reporting, and reduced water and wastewater service delivery likely influenced this decrease. Overall, the share of power at the national level consumed by Ukraine's vodokanals is low.

Operating costs for the vodokanals that NEURC regulates and the proportion of costs due to power needs for past three years are provided in Table 4.

TABLE 4: AGGREGATE AND AVERAGE VODOKANAL OPERATING COSTS AND PROPORTION OF COSTS DUE TO POWER NEEDS IN 2020, 2021, AND 2022			
	2020*	**2021***	**2022***
Number of vodokanals reporting	52	52	41
Overall operating cost of vodokanals, thousands Ukrainian hryvnia [UAH] (USD)	20,803,999 (747,807)	24,467,930 (899,556)	20,615,536 (563,882)
Cost of power needs for vodokanals, thousands UAH (USD)	4,957,157 (178,186)	6,427,178 (236,293)	5,592,920 (152,979)
Percentage of operating costs due to power needs of vodokanals	24%	26%	27%

* Costs calculated according to the USD/UAH exchange rate: 2020, 1 USD = 27.82 UAH; 2021, 1 USD = 27.20 UAH; 2022, 1 USD = 36.56 UAH.

On average, vodokanals regulated by NEURC spent 24%, 26%, and 27% of their total operating costs on electricity in 2020, 2021, and 2022, respectively. A slight increase in the proportion of operating costs due to power needs is observed in 2021 and 2022. According to the US EPA, energy costs typically make up 25-30% of a utility's operations and maintenance (O&M) costs (US EPA 2023). Overall, the cost for power supplied to vodokanals in Ukraine was nearly USD $153 million in 2022.

2.4 IMPROVING ENERGY EFFICIENCY IN THE WATER AND WASTEWATER SECTOR

The water supply and sanitation sector in Ukraine before the war faced issues similar to other post-Soviet countries. These include lack of adequate water and sanitation management at both the national and vodokanal levels regarding decision-making, roles and responsibilities between national and local-level personnel, tariff policy, capital investment planning, equipment operating well past design service life, and a lack of financing for modernization to align with Ukraine's pre–European Union (EU) accession goals. Eventually, Ukraine's water and sanitation sector will need to align with EU water sector requirements (BMUV, n.d.). These challenges have resulted in high water losses of 36% on average across Ukraine (National target social program "Drinking water of Ukraine" 2021) and pump stations and electrical substations and equipment that are outdated and energy intensive.

All five of the vodokanals the team assessed consistently identified energy efficiency problems related to their equipment. Pumping stations and electrical substations observed during the site visits all featured outdated equipment, often from the 1970s and 1980s, and often no longer commercially available. All vodokanal needs reflect this to varying degrees (see Annexes A-E, Sections 1 and 3). This situation worsened after the Russian Federation's invasion, when vodokanals were cut off from Russian and Belarusian spare part supply chains. A full block on trade between Ukraine and Belarus and Russia is in effect, meaning supplies are severely limited. The lack of spare parts exacerbates reliance on old equipment and increases risk of full equipment failure.

To improve energy efficiency among vodokanals in Ukraine, refurbishing and replacing outdated energy-intensive equipment and water supply/wastewater networks should be the first priority. These efforts should coincide with the development of regional and municipal master plans, feasibility studies, and technical and economic justifications required by Ukrainian law. Efforts should also be accompanied by the introduction of automation tools such as frequency control and variable drive tools supported by data collection, monitoring, and control systems such as SCADA, or the Supervisory Control and Data Acquisition system. Improvements made to existing facilities should account for the integration of renewable and alternative energy sources, as there is interest in these alternatives among the vodokanals assessed, most notably from Lvivvodokanal. Improvements should also align with EU guidelines and requirements to assist Ukraine's integration into the EU. Specific regions of Ukraine have seen significant population decline during the war and will require extensive reconstruction after the war. Master plans and studies should account for necessary modifications to network sizing and changing demands across these cities (e.g., Kherson) to minimize damage to assets and ensure accurate capital investment and tariff setting.

As a next step, interventions that can improve energy efficiency of Ukraine's vodokanals within the next three to five years include replacing outdated pumps and associated variable drives or frequency converter automation tools. While a large portion of vodokanals' existing equipment and infrastructure are outdated and in poor condition, replacing pumping equipment will provide the largest improvement in energy efficiency, as pumps are the single biggest consumer of power across all vodokanal facilities. At the same time, available tools for automation such as frequency control/variable drive equipment provide great potential for large-scale energy efficiency improvements.

3.0 VODOKANAL NEEDS IN FIVE KEY CITIES

Table 5 provides an overview of the water and wastewater facilities and networks in Kyiv, Kharkiv, Kherson, Lviv, and Odesa, and is followed by summaries of prioritized needs for each vodokanal. Kyivvodokanal, Kharkivvodokanal, and Lvivvodokanal also provide water to the district heating providers (teploenergos) to varying extents. See Annexes A-E, Section 1 for a more detailed overview of the vodokanals' facilities and prioritized needs and Section 3 for full lists of equipment needs along with details on vodokanals' abilities to carry out installations and required external support. See Section 2 of these annexes for a full list of incidents impacting vodokanals' power supply and operations.

Overall, damage incurred, facility condition, and corresponding needs varied greatly from one vodokanal to the next, as did the impact on continuous water supply, wastewater services, and associated impacts on the environment and public health. For example, while Kherson has seen a 55% reduction in water demand due to population decline, Lviv has seen a 54% increase due to the influx of IDPs. While Kherson's backup power supply requirements have largely been met by international donors such as UNICEF, Lviv still needs generators to support their wastewater pumping facilities. Kyiv and Kharkiv require creative solutions to provide backup power supplies for high-voltage pumping facilities—needs that are not shared among the others—but Kyivvodokanal and Kharkivvodokanal have different preferences regarding how backup power for high-voltage facilities should be provided. For the purposes of this assessment, high voltage is defined as greater than 1 kilovolt (kV).

Several challenges and requirements are common across vodokanals. Humanitarian groups or other donors have addressed most needs for low-voltage generators, though some wastewater facilities' needs persist. Outdated, energy-intensive facilities need improvements, including replacement of transformers, procurement of frequency converters and control stations, and supplies of protective and repair equipment. To improve energy security and operational efficiency, outdated electrical substations and equipment and outdated pumps require replacement (among other needs specific to each vodokanal).

Across all vodokanals assessed, long-term disruptions to the water supply and sanitation services due to power outages are rare. Short-term disruptions, however, are not only caused by a lack of power supply; disruptions are common due to outdated electrical substation equipment failures resulting from power fluctuations and surges following damage to the regional power distribution network. Vodokanal staff must manually repair this equipment, interrupting services until repairs are complete. Many generator needs expressed by vodokanals, in line with their EOPs, would be infeasible to address within a reasonable timeframe. The design, procurement, and installation of this type of generator requires 12 to 24 months to complete. Thus, alternative solutions are needed to address power needs and ensure continuity of services, including the replacement of electrical substations and associated high-voltage equipment. While these replacements may require similar implementation times as the high-voltage generators, they present a positive longer-term impact on vodokanal operational performance, improving energy efficiency and reducing need for constant manual repairs. High-voltage generators only offer an immediate solution with little added long-term value.

Inclusive of all five vodokanals, Stage 1 needs are estimated to cost approximately USD 3,560,000 – 3,890,000. Stage 2 needs are estimated to cost approximately USD 4,060,000 – 4,680,000, and Stage 3 needs are estimated to cost approximately USD 14,650,000 – 18,800,000. These estimates cover the cost of equipment alone. Certain equipment, such as generators, transformers, and custom electrical equipment may be subject to limited availability, long lead times for procurement, and cost fluctuation. Where possible, equipment should be grouped for delivery and commissioning to achieve economies of scale. Equipment such as transformers and any custom equipment may require long lead times for procurement. Used and refurbished equipment may be more readily available and should be considered where lead times are unreasonable for new equipment, particularly for urgent needs under Stage 1.

TABLE 5: SUMMARY OF INFRASTRUCTURE AND FACILITIES AT THE FIVE FOCUS VODOKANALS INCLUDED IN THIS ASSESSMENT		KYIV	KHARKIV	KHERSON	LVIV	ODESA
WATER	Water Intakes	2	2	2	17	3
	Capacity of Water Intakes (cubic meters per day [m³/day])	1,680,000	574,000	Data not available.	452,000	820,000
	Source Types	Surface water; groundwater	Surface water; groundwater	Groundwater	Groundwater	Surface water
	Groundwater Wells	400 (160 in use)	14	146	197	Not applicable
	Max. Well Depth (meters [m])	360	800	Data not available.	250	Not applicable
	Surface Water Sources	Dnieper River; Desna River	Svirsky Donets River; Dnipro-Donbass Canal	Not applicable	Not applicable	Dniester River
	Length of Water Pipelines (kilometers [km])	4,200	2,741	929	655	1,853
	Water Pipe Max. Diameter (m)	Data not available.	1.6	Data not available.	1.4	1.6
	(Main) Water Pumping Stations	12	7	6	27	7
	(Local) Water Pumping Stations	30	14	63	23	56
	Treatment Plant Capacity (m³/day)	1,680,000	574,000	Data not available.	Data not available.	820,000
	Treated Water Storage Capacity (m³)	Data not available.	Data not available.	Data not available.	200,000	Data not available.
	Pre-War Demand (m³/day)	600,000	Data not available.	60,000	240,000	Data not available.
	Current Water Demand (m³/day)	Data not available.	Data not available.	20,000–27,000	370,000	350,000
	Change in Water Demand	Data not available.	Data not available.	-55%- -67%	54%	Data not available.
	Pre-War Supply (m³/day)	169,200	Data not available.	Data not available.	Data not available.	Data not available.
	Current Supply (m³/day)	145,200	381,850	Data not available.	Data not available.	350,000
	Change in Supply	-14%	Data not available.	Data not available.	Data not available.	Data not available.
	Water Provided to Teploenergos (m³)	33,200	25,744,700	0	127,400	2,485,889
WASTEWATER	Length of Sewerage Network (km)	3,000	1,684	297	605	932
	Main Collector Pipes	Data not available.	398	Data not available.	70	Data not available.
	Wastewater Pumping Stations	34	37	17	10	25
	Treatment Plant Capacity (m³/day)	1,800,000	1,050,0000	250,000	490,000	190,320
	Pre-War Total Wastewater Flow (m³/day)	1,000,000	Data not available.	60,000	280,000	Data not available.
	Current Total Wastewater Flow (m³/day)	Data not available.	303,610	35,000	300,000	190,320
	Change in Total Wastewater Flow	Data not available.	Data not available.	-42%	7%	Data not available.

3.1 KYIVVODOKANAL

Kyiv is the capital and the largest city in Ukraine with a pre-war population of approximately 2,952,300 people. Kyiv has been a key focus of the Russian Federation's attack on Ukraine, subject to frequent air raids and missile attacks. After the first several months of the full-scale invasion, Kyivvodokanal experienced a significant decrease in demand for water supply and sanitation services, though this did not affect the overall performance of the systems. Kyiv has not seen a large overall decrease in population to-date.

Missile attacks by the Russian Federation began targeting Ukrainian energy infrastructure in October 2022, leading to massive damage of critical infrastructure in the Kyiv region and significantly reducing the capacity of high-voltage power lines. These attacks have resulted in widespread emergency shutdowns in the power supply sector, including the power supply to vodokanals, with associated water and wastewater service interruptions. To keep water and wastewater services running, Kyivvodokanal developed an EOP to manage power outages to their facilities. UNICEF and USAID have provided Kyivvodokanal with generators for backup power supply, and the vodokanal is currently able to meet 20% and 25% of its emergency power needs for wastewater and water supply systems, respectively.

Kyivvodokanal currently needs both low-voltage and high-voltage backup power supplies and associated equipment to ensure implementation of the EOP. As a first priority (Stage 1), outdated electrical switching and protective equipment need to be replaced, as existing equipment continues to fail at critical times. Materials also are needed to support emergency repairs and alleviate supply chain issues. Stage 1 needs will cost approximately USD 170,000–190,000. As a second priority (Stage 2), low-voltage diesel generators, control stations, and frequency converters are needed to ensure minimum operation of water and sewage pumping stations. Kyivvodokanal also needs support to contract fuel delivery from third parties to operate diesel generators, as they do not want to increase local fuel storage at their facilities. Exact needs for fuel supply require further investigation. Stage 2 needs will cost approximately USD 1,200,000–1,400,000. Stage 3 needs include well reconstruction to improve the reliability and remote control of groundwater intakes and reduce fuel and electricity costs, pumping equipment replacement with control panels with frequency control at artesian wells, and backup power supply to high voltage pumping equipment. Multiple options are available for backup power supply to high-voltage equipment, including installation of low-voltage generators with step-up transformers, custom high-voltage generators, or low-voltage natural gas-piston cogeneration units with step-up transformers. Each option poses unique advantages and disadvantages. See Annex A, section A.1.5 for further detail. Stage 3 needs are estimated to cost at least USD 6,000,000–8,000,000. Procurement and installation of equipment may take one year or longer due to the intensive engineering design needs, specifications, and special-order requirements for high-voltage equipment.

3.2 KHARKIVVODOKANAL

Kharkiv is a city in northeastern Ukraine with a pre-war population of approximately 1,421,100 people. The proximity of Kharkiv to the border with Russian has resulted in the city being a frequent target of rocket attacks and artillery fire. Russia's attempts to occupy Kharkiv were unsuccessful but resulted in population loss and significant destruction. Systematic missile attacks by the Russian Federation on the Ukrainian energy system have resulted in massive damage to energy infrastructure in the Kharkiv region. The effects of these assaults include insufficient power supply for the city, periodic outrages, and total power blackouts. Kharkivvodokanal's water supply and sewage facilities, which use mostly high-voltage equipment, have no backup power lines and insufficient backup power sources, resulting in power outages to facilities and service disruptions.

The vodokanal's backup power supply needs have been partially covered through a combination of external assistance and the vodokanal's own resources, up to 10% and 15% of needs for wastewater and water supply systems, respectively. Kharkivvodokanal's most immediate needs (Stage 1) are cable products for emergency repairs after missile attacks. Stage 1 needs are estimated to cost approximately USD 400,000–440,000. As a second priority (Stage 2), the vodokanal needs low-voltage control stations with frequency converters, supply and installation of low-voltage diesel generators, and replacement of outdated, oil-filled, Soviet-era power transformers. Stage 2 needs are estimated to cost approximately USD 1,150,000–1,300,000. Additional identified needs (Stage 3) include backup power supply to high voltage pumping equipment and ultrasonic flow meters that would allow the vodokanal to accurately detect and control leaks and changes in water supply demand. Stage 3 needs are estimated to cost at least USD 6,500,000–8,500,000. Procurement and installation of equipment may take one year or longer due to the intensive engineering design needs, specifications, and special-order requirements for high-voltage equipment.

3.3 KHERSONVODOKANAL

Kherson is a city in southern Ukraine with a pre-war population of approximately 279,100 people. Russian Federation forces occupied Kherson from March to November 2022. During the occupation, scheduled maintenance of the city's water supply and sewage system was not possible, resulting in significant deterioration of the networks and facilities. Following Kherson's liberation, artillery and missile attacks from Russian Federation forces have become a daily occurrence. Khersonvodokanal's central administration building and control room were completely destroyed; computer equipment, servers, and archives were burned; and a sizeable portion of the vodokanal's operational data and records were lost. The occupation of Kherson and the ongoing attacks have resulted in large-scale migration out of the region and a corresponding reduction in water and wastewater service demand. Khersonvodokanal's facilities and infrastructure are periodically damaged and often lose power.

Khersonvodokanal's emergency and backup power supply needs have largely been met by humanitarian actors and donors. However, frequent power outages have caused old, Soviet-type electric power equipment to fail, requiring replacement of transformers and pumping equipment control stations (Stage 1). Stage 1 needs also include electrical switchgears and cable products. Stage 1 needs are estimated to cost approximately USD 290,000–310,000. The vodokanal's second priority needs (Stage 2) include replacement of low voltage switching and electrical protective devices (e.g., surge protectors, fuses, relays, and circuit breakers). Stage 2 needs are estimated to cost approximately USD 160,000–180,000. Stage 3 needs include additional power transformers, electrical cables, laboratory equipment, flow meters, and construction materials for facility repairs. Stage 3 needs are estimated to cost approximately USD 650,000–700,000. Equipment that can be assembled quickly and efficiently by the vodokanal's personnel must be prioritized, given challenges procuring professional installation services in the Kherson region.

3.4 LVIVVODOKANAL

Lviv is a city in western Ukraine with a pre-war population of approximately 717,300 people. Lvivvodokanal has seen less damage to water supply and wastewater infrastructure than other cities in Ukraine. Lviv's location in the west and proximity to Poland have resulted in a large influx of IDPs in the city and surrounding areas, placing additional burden on the water supply and wastewater infrastructure, the full consequences of which are not yet possible to evaluate. As in other cities across Ukraine, emergency shutdowns, including power outages to vodokanals, have interrupted water and wastewater services in Lviv. Lvivvodokanal developed an EOP to manage power outages and blackouts before the Russian Federation's invasion and started to procure equipment to cover backup power needs for water supply facilities. Backup power needs for water supply systems are currently 80% covered, though wastewater systems are only 10% covered.

Lvivvodokanal has requested vehicles to support repairs of critical infrastructure as a first priority (Stage 1). Nearly all cars and special machinery operated by Lvivvodokanal are old, in poor condition, and were manufactured in Russia (resulting in a lack of spare parts for their repairs). This poses risks to repair crews when responding to emergencies and could result in possible termination of the water supply or wastewater services when repairs are not possible. Stage 1 needs are estimated to cost approximately USD 2,000,000–2,200,000. As a second priority (Stage 2), backup power needs for wastewater facilities persist, including diesel generators and frequency convertors. Stage 2 needs are estimated to cost approximately USD 1,000,000–1,200,000. Due to wastewater pumping stations using outdated, energy-intensive equipment, Stage 3 needs include pumps with a direct start and frequency converters to reduce wear and tear on equipment and reduce power consumption. Stage 3 needs are estimated to cost approximately USD 1,500,000–1,600,000. Longer-term needs also include the reconstruction and modernization of outdated electrical substations that supply water pumping stations.

3.5 INFOXVODOKANAL (ODESA)

Odessa is a port city on the Black Sea in southwestern Ukraine with a pre-war population of approximately 1,010,000 people. Although the city is not near the front line, its location on the Black Sea has made Odesa a target for missile attacks from the sea. Fortunately, the missile attacks have not resulted in significant damage to the city's infrastructure or to Infoxvodokanal's facilities, and no major population shifts have been observed. Nonetheless, as in most other cities in Ukraine, shutdowns in the electrical supply systems following destruction of energy infrastructure and associated blackouts have caused interruptions in water and wastewater service delivery. Additionally, Infoxvodokanal's dependence on outdated electrical equipment results in inadequate functionality during emergency shutdowns. Power outages and subsequent impacts have been particularly pronounced for water intake infrastructure on the Dniester River. Odesa is supplied entirely by surface water.

Infoxvodokanal has developed an EOP to manage power outages at their facilities. About 20% of Infoxvodokanal's backup power needs have been addressed by other donors, but needs for both low-voltage and high-voltage equipment remain, particularly for surface water intake infrastructure. First priority needs (Stage 1) for Infoxvodokanal include the supply of low-voltage frequency converters, low-voltage switching and protective equipment, and cable products. This equipment and materials are needed for the connection of low-voltage diesel generators and for emergency repairs to increase the stability of Infoxvodokanal's electrical systems. Stage 1 needs are estimated to cost approximately USD 700,000–750,000. Second priority needs (Stage 2) include backup power supplies for both water supply and wastewater systems, as well as additional improvements to existing high-voltage equipment. This includes low-voltage diesel generators, power transformers (10/0.4 kV, 6/0.4 kV), and components of high-voltage cells necessary for emergency repairs. Stage 2 needs are estimated to cost approximately USD 550,000–600,000. Infoxvodokanal did not provide sufficient information to determine specific Stage 3 needs for short-term operational and energy efficiency improvements, but these needs are largely being addressed by other donors.

4.0 CONCLUSIONS

The ongoing war in Ukraine has exacerbated challenges in the water and wastewater sector, particularly due to inadequate and erratic power supply as Russian Federation attacks target key power infrastructure. While power consumption by Ukraine's vodokanals is relatively low overall, individual vodokanals face repair needs and short service disruptions due to outdated equipment that fails during power outages and surges. Recurring damage to power, water, and wastewater infrastructure and the outdated and deteriorating condition of existing facilities necessitates not only the provision of backup power supplies for vodokanals, but also improvements to their energy and operational efficiency.

Humanitarian organizations and donors have largely addressed low-voltage backup power supply needs, but those for high-voltage backup power persist. Equipment breakdowns and constant repair needs are exacerbated by supply chain issues, as most of the needed spare parts are sourced from now non-existent supply chains from Russia and Belarus. Replacement of outdated equipment and provision of spare parts for repairs is thus needed alongside provision of backup power supply.

Given that long-term service disruptions due to power outages are increasingly rare and that design and procurement timelines for addressing high-voltage generator needs are lengthy, the longer-term impact of high-voltage generator provision is limited. Where backup power supply to high-voltage equipment is still needed, creative solutions should be considered that balance cost and long-term impact. At the same time, vodokanals face frequent repairs and supply chain challenges, highlighting immediate needs for replacement of key equipment and upgrades to facilities' electrical systems. The highest-priority solutions vary from one vodokanal to the next but include the replacement of existing outdated substations and associated high-voltage equipment; provision of control stations, frequency convertors, and supplies and materials for repairs; replacement of existing pumps and associated frequency control/variable drives; and, in the longer term, implementing renewable energy sources at the facilities of vodokanals that express interest.

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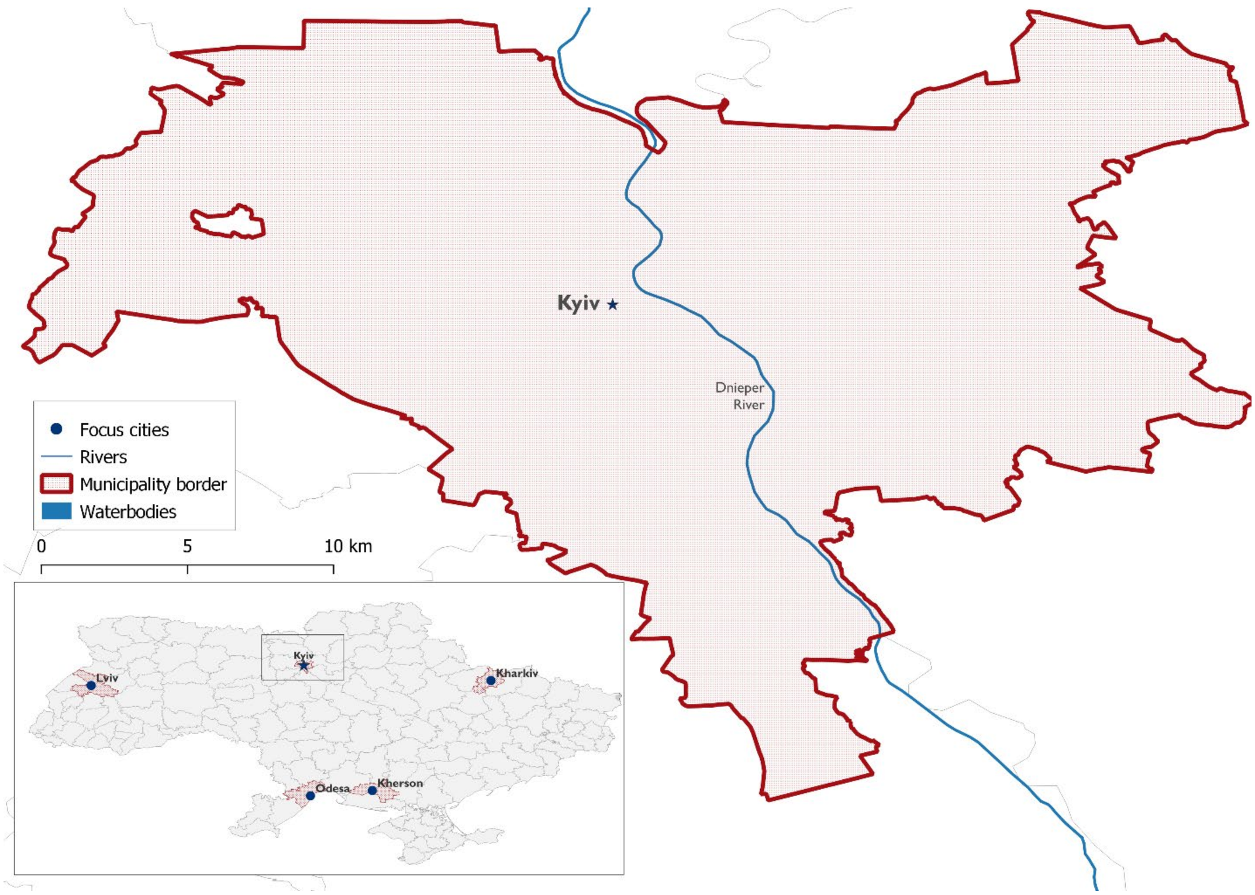
ANNEX A: KYIVVODOKANAL

KYIV
Private Joint-Stock Company (PJSC) Kyivvodokanal Pre-War Population: 2,952,301 Current Population: ~2,805,000 Net Population Change: ~5% Pre-War Employees (# of staff): 6,500 Current Employees (# of staff): Data not available. Net Employee Change: Data not available.



A.1 KYIVVODOKANAL PROFILE

Summary

- Missile attacks on critical infrastructure and stabilization shutdowns on electrical grids have caused multiple power outages at Kyivvodokanal. Donors and other agencies have provided equipment to support Kyivvodokanal. Up to 25 percent of backup power needs are covered for water supply systems, and up to 20 percent for wastewater systems.
- Kyivvodokanal utilizes both high-voltage (6 kilovolt [kV], 10 kV) and low-voltage (0.4 kV) equipment commissioned in the 1960s–1980s. The existing equipment is mostly outdated and requires constant maintenance. Most pumping equipment operates without variable drives or frequency converters. Existing electrical switchgear, electrical protection equipment, and cable products are outdated and require constant repair, reducing the reliability of the city's water supply and sewage services. Existing artesian well pumps are outdated, have no automated control, and need replacement. High-voltage equipment is currently not connected to backup power sources. There are short-term solutions for the remaining low-voltage backup power needs, but the high-voltage equipment requires additional assessment and design.
- Stage 1 needs are estimated to cost approximately USD 170,000–190,000. Stage 2 needs are estimated to cost approximately USD 1,200,000–1,400,000. Stage 3 needs are estimated to cost at least USD 6,000,000–8,000,000.

Site Visit Overview

Three CDM Engineering Ukraine engineers visited Kyivvodokanal on February 28, March 2, and March 15, 2023. During the site visits, multiple meetings with Kyivvodokanal management took place and the team toured several water pumping stations, wastewater pumping stations, and artesian wells.

General Overview

The Private Joint Stock Company (PJSC) Kyivvodokanal (Kyivvodokanal) was established in 1871 to provide water supply and sanitation services to the city of Kyiv. Kyivvodokanal partially covers water needs for Kyivteploenergo, the city's district heating service provider.

A.1.1 OVERVIEW OF NETWORK AND FACILITIES

Water System Overview

TABLE A.1: WATER SYSTEM OVERVIEW – KYIVVODOKANAL			
CATEGORY		DATA	NOTES
WATER	Water Intakes	2	2 surface water intakes
	Capacity of Water Intakes (m³/day)	1,680,000	
	Source Types	Groundwater; surface water	
	Groundwater Wells	400	Only 160 are in use.
	Max. Well Depth (meters [m])	360	
	Surface Water Bodies	2	Dnieper River and Desna River
	Length of Water Pipelines (kilometers [km])	4,200	
	Water Pipe Max. Diameter (m)		Data not available.
	(Main) Water Pumping Stations	12	
	(Local) Water Pumping Stations	30	
	Treatment Plant Capacity (cubic meters per day [m³/day])	1,680,000	

TABLE A.1: WATER SYSTEM OVERVIEW – KYIVVODOKANAL			
CATEGORY		DATA	NOTES
	Treated Water Storage Capacity (m³)		Data not available.
	Pre-War Demand (m³/day)	600,000	
	Current Water Demand (m³/day)		Data not available.
	Change in Water Demand		Data not available.
	Pre-War Supply (m³/day)	169,200	Amount supplied in 2020.
	Current Supply (m³/day)	145,200	Amount supplied in 2022.
	Change in Supply	-14%	
	Water Provided to Teploenergos (m3)	33,200	Amount provided for 2022.

The city's water supply consists of both surface water and groundwater sources. Two surface water intakes are on the banks of the Dnieper River, and 400 artesian wells are located throughout the city for groundwater supply. Of the artesian wells, approximately 40 percent (160) are in operation. Sodium hypochlorite is added for disinfection at the groundwater intakes. The design capacity of the Desnianska station is 1,080,000 m³/day, the Dnipro station is 600,000 m³/day, and the total combined capacity of the water treatment facilities is 1,680,000 m³/day.

The water pumping stations (WPSs) of the first lift are equipped with vertical centrifugal pumps installed in the 1930s, with a pumping capacity of 5,200 m³/h per pumping unit. After going to the water treatment plants (WTPs), water undergoes a two-stage treatment process and travels to the second lift station, which operates four pumps with a capacity of 4,700 m³/h each and two pumps with a capacity of 3,000 m³/h each. The city also has pumping stations of the third and fourth lifts, which operate as booster stations. There are 42 total WPSs: 30 local and 12 main pumping stations. The total length of the city's water supply networks is 4,200 km. In 2020, Kyivvodokanal supplied 169,200 m³ of water to the city; in 2021, 168,800 m³; and in 2022, 145,200 m³.

Kyivvodokanal supplies treated water to boiler houses in heating networks at the district and quarter level, where additional chemical treatment (sodium cationization) makes the water safe for domestic hot water (centralized domestic hot water supply system) in the central heating stations. In 2020, Kyivvodokanal supplied 45,800 m³ of water to Kyivteploenergo; in 2021, 44,900 m³; and in 2022, 33,200 m³.

Wastewater System Overview

TABLE A.2: WASTEWATER SYSTEM OVERVIEW – KYIVVODOKANAL			
CATEGORY		DATA	NOTES
WASTEWATER	Length of Sewerage Network (km)	3,000	
	Main Collector Pipes		Data not available.
	Wastewater Pumping Stations	34	
	Treatment Plant Capacity (m³/day)	1,800,000	
	Pre-War Total Wastewater Flow (m³/day)	1,000,000	
	Current Total Wastewater Flow (m³/day)		Data not available.
	Change in Total Wastewater Flow		Data not available.

The city's sewerage system consists of approximately 3,000 km of sewerage networks and 34 wastewater pumping stations (WWPSs). The sewer collector delivers the wastewater to the Bortnicheskaya aeration station and wastewater treatment plant (WWTP), where mechanical and biological treatment takes place. Far less detail was provided to the assessment team on Kyivvodokanal's wastewater facilities than for other cities assessed.

A.1.2 POWER NEEDS AND SUPPLY

Kyivvodokanal utilizes both high-voltage (6 kV, 10 kV) and low-voltage (0.4 kV) equipment. The existing electrical equipment was commissioned in the 1960s, 1970s, and 1980s, and despite significant wear and tear, has not been reconstructed or replaced. This equipment requires constant maintenance, resulting in high operating costs to maintain performance, as there are no spare parts available. Kyivvodokanal has both energy efficiency policies and resource efficiency usage plans but has no assigned personnel responsible for energy management. According to standards from the International Organization for Standardization, Kyivvodokanal has not implemented a certified energy management system.

Total annual energy consumption of Kyivvodokanal for the last three years is below in Table A.3.

TABLE A.3: ANNUAL ENERGY CONSUMPTION OF KYIVVODOKANAL FOR 2020–2022

	2020	2021	2022
Total annual energy consumption of Kyivvodokanal, thousands of kWh	298,281	301,356	241,932

Energy consumption dropped in 2022 due to population reductions (especially from February to April 2022) and due to scheduled stabilization outages, where districts of the city with no direct damage following an incident still had their power supply shut down to stabilize the grid.

Though they have reconstructed the electrical equipment in some facilities, the scale of these improvements is too small to make a measurable impact on Kyivvodokanal's overall energy efficiency. For example, new energy-efficient, low-voltage pumping equipment with modern control stations with cascade control and frequency regulation has been installed in some WWPSs. However, most of the electrical equipment (especially high-voltage WPSs of first and second lifts) has not been reconstructed. These upgrades are clearly not enough to ensure that the operation remains stable, particularly under conditions of constant shutdowns and emergency changeovers.

Annual energy effectiveness indicators for Kyivvodokanal for the last three years (2020–2022) are in Table A.4, calculated as the total power consumed by each system per m³ of water or wastewater produced.

TABLE A.4: ANNUAL ENERGY EFFECTIVENESS INDICATORS OF KYIVVODOKANAL FOR 2020–2022

	2020	2021	2022
Annual energy effectiveness of water supply system, kWh/m³	0.633	0.639	0.673
Annual energy effectiveness of wastewater systems, kWh/m³	0.561	0.566	0.548

A.1.3 KEY CHALLENGES DUE TO THE WAR IN UKRAINE

Ongoing missile attacks by the Russian Federation on the Ukrainian energy system have led to massive damage of critical infrastructure in the Kyiv region and significantly reduced the capacity of high-voltage power lines. The Kyiv region also has the highest rates of electricity consumption in the country. This has led to a power generation deficit of 30–50 percent, and, consequently, **emergency and stabilization shutdowns, main and backup power supply losses at Kyivvodokanal's facilities, and failure of Soviet-era equipment** due to constant emergency switching. For a full list of incidents and impacts, see section A.2.

During the blackouts on October 31 and November 23, 2022, 80 percent of Kyivvodokanal's facilities were de-energized for more than 24 hours, including the WWTP and WTPs. The vodokanal was able to power some equipment (e.g., 0.4 kV low-voltage equipment) with mobile diesel generators. Bypass collectors released a portion of wastewater, avoiding destruction of the gravity feed collectors due to the weight of accumulated wastewater—and averting an environmental and humanitarian catastrophe.

Emergency and stabilization shutdowns also affected overall facility operation. These interruptions in the power supply to facilities (especially WWPSs, WPSs, and groundwater well pumps) disrupted treatment processes and reduced service life of already worn and outdated equipment. This forced Kyivvodokanal's personnel to conduct constant operational switches and emergency repairs.

Due to active conflict in the Kyiv region from February to March 2022, Kyiv's population significantly decreased, forcing Kyivvodokanal to operate at its lowest possible supply limit of 300,000 m^3/day. Operations personnel were preparing to discharge some of the treated water in the event of a further drop in water consumption. During this period, there was a lack of frequency control on the pumping units, preventing accurate flow regulation of water supply and wastewater systems.

Kyivvodokanal has developed an Emergency Operations Plan (EOP) to ensure the minimum necessary provision of water and wastewater services under power blackout scenarios (the EOP was described to the assessment team, though the vodokanal staff were unable to share copies of these plans). However, the plans include some engineering challenges. WPSs of first and second lifts **include high voltage pumping equipment (6 kV and 10 kV), which is much more difficult to supply with emergency power** (see Section A.1.4). In addition, all components in the water treatment and supply chain must receive backup power supply together, as no individual component can be without power for treatment to be successful. Thus, according to the Kyivvodokanal's emergency plans, diesel/gas generators must be available for all components at the same time.

Since the majority of WWPSs have low-voltage pumping equipment (0.4 kV), connecting them to the backup power supply is less difficult. The United Nations Children's Fund (UNICEF) has partially covered the existing need for backup power to this equipment: UNICEF supplied low-voltage (0.4 kV) diesel generators to Kyivvodokanal and installed them at some well pump sites and WWPSs. USAID has also provided generators. However, high-voltage equipment is still in need of backup power supply. A full list of Kyivvodokanal's facilities in need of backup power supply is included in Annex A.3.

A.1.4 PRIORITIZED NEEDS TO ENSURE CONTINUOUS SERVICE DELIVERY

A detailed list of needs with divisions by the priority stages is provided in Annex A.3. The stages are as follows:

- Stage 1 (emergency/immediate): Equipment needed as soon as possible
- Stage 2 (urgent): Equipment needed within the next three months
- Stage 3 (short-term): Equipment is not needed for at least 6–9 months (or longer), or cannot be procured in a short period of time

Stage 1: To increase the resilience of Kyivvodokanal facilities and systems, the supply of low voltage switching and protective equipment with cable products for emergency repairs are needed. The cost of addressing Stage 1 needs is approximately USD 170,000–190,000 (only approximate cost of equipment/materials, excluding any additional costs for delivery).

Stage 2: To increase the resilience of Kyivvodokanal facilities and systems, provide backup power supply for wastewater systems, and increase energy efficiency, the following Stage 2 priorities have been identified:

- Supply and installation of low-voltage control stations with frequency converters
- Supply and installation of low-voltage diesel generators
- Reconstruction of groundwater intakes (artesian wells)

The estimated cost to cover Stage 2 needs is approximately USD 1,200,000–1,400,000 (low-voltage diesel generators and control stations with frequency converters are estimated to cost approximately USD 550,000–600,000).

Stage 3: To cover efficiency improvements, the longer-term needs for Stage 3 are in section A.1.5.

Control stations and frequency converters

Before supplying low-voltage emergency power supply equipment, control stations need to be installed with frequency regulation of induction motors of pumping equipment. This will reduce the incoming currents several fold, increase the service life of pumping equipment and diesel generators (reducing the consumption of diesel fuel), reduce electric power consumption at facilities where pumping equipment operates in variable modes (not at nominal parameters), and reduce the number of hydraulic shocks and emergency repairs of pipelines and valves.

Kyivvodokanal's technical personnel can install low-voltage control stations (0.4 kV) with support from the manufacturer, including commissioning the equipment and training operating personnel. Prior to ordering the control stations, a questionnaire should be filled out with the manufacturer outlining key specifications. Information for the questionnaire would include number of pumps; capacity and type of motors; rated and starting currents of the pumps; operation algorithm, including operating/standby modes; lengths of power and control cables; distances to the installation sites of measuring sensors; sensor measurement ranges; and additional design documentation depending on site specifications. Additional requirements for installation of control stations may require more design documentation depending on site specifications. Results of this questionnaire can be the basis for any tender procedure, as they represent the customer's technical requirements.

Diesel generators

Facilities and equipment outlined in Kyivvodokanal's EOPs require low-voltage diesel generators (0.4 kV). The power requirements for generators listed in Annex A.3 assume that they will operate in tandem and that frequency converters will be provided and installed. Details on generators and frequency converters needed are provided in Annex A.3.

Switching equipment, protective equipment, and cable products

Existing electrical switchgears, electrical protection equipment, and cable products are outdated and constantly require repair, reducing the reliability of the city's water supply and sewage. Constant emergency switching further reduces the workability of the equipment. Backup power supplies will not increase the resilience of Kyivvodokanal's water and wastewater systems unless they replace old switching and protective equipment. The current equipment is not reliable and repeatedly fails due to constant emergency and operational switching, often at critical times.

In addition, spare parts shortages exacerbate needs for repairs and maintenance. Replacement of low-voltage (0.4 kV) circuit breakers, switchgears, circuit breakers, and contactors will alleviate these issues. This equipment is available off-the-shelf and requires no additional design, and installation can be performed by Kyivvodokanal's technical personnel.

Reconstruction of groundwater intakes

Groundwater wells need control stations with frequency regulation installed at intake points, complete with protective and switching equipment, in addition to replacement of submersible low-voltage (0.4 kV) pumps. These needs can be covered by providing frequency-controlled control stations; modern energy-efficient, low-voltage submersible pumps; and sets of special submerged cables for connecting the pumps and control stations.

This equipment will allow a remote dispatcher to start groundwater well pumps to fill reservoirs when needed. In addition, replacing outdated equipment will significantly increase the reliability of the groundwater intakes and reduce electricity and fuel consumption. Prior to ordering the control stations, the manufacturer should complete a questionnaire including key specifications. Information for the questionnaire would include number of pumps; capacity and type of motors; rated and starting currents of the pumps; operation algorithm, including operating/standby modes; lengths of power and control cables; distances to the installation sites of measuring sensors, sensor measurement ranges; and additional design documentation depending on site specifications. Results of this questionnaire can be the basis for any tender procedure, as they represent the technical requirements of the customer.

A.1.5 ENERGY AND OPERATIONAL EFFICIENCY

A number of Kyivvodokanal's emergency needs are difficult to address in the short term due to significant engineering and design requirements and extensive procurement timelines. Reconstruction of high-voltage equipment is needed at the WPSs of the first, second, and third lifts as well as at WWPSs in two districts of the city. Reconstruction of high-voltage equipment (6 kV, 10 kV) requires intensive design, special orders, and specialized contractors for installation.

The following work is needed to improve energy efficiency, provide high-voltage backup power supply, and improve operations in line with Kyivvodokanal's EOP. All works detailed below have long design/implementation timelines (6–9 months, or longer):

- Installation of high-voltage control stations with frequency control/direct soft start
- Installation of backup power supply sources for high voltage pumping equipment

The cost of covering Stage 3 needs is approximately USD 6,000,000–8,000,000, and procurement and installation of equipment may take a year or longer due to the need for extensive design and special orders. An alternative option for backup and emergency power supply to high-voltage pumping equipment is a cascade of low-voltage diesel generators with step-up transformers. To develop this solution, additional engineering design will be required, including but not limited to a topographical survey and further design/cost estimation. See Table A.5 or additional detail.

High-voltage control stations with frequency control/direct soft start

The existing high-voltage motors in the WPSs with first and second and lifts are synchronous and thus have high starting torques. High incoming currents are required to bring the rotor into sync with the stator, which can be five to seven times higher than the nominal values. This coefficient depends on the design of the pumps. Where pump units are directly connected to backup power sources (without soft start/frequency control), the capacity of the generators must be increased accordingly. Installing frequency-controlled/direct soft start control stations solves this problem, reducing the prime power needed of a diesel generator, extending the service lives of the pumps, and reducing the negative impact of high currents on electrical equipment and backup power generators.

A soft starter system is sufficient at the first lift WPSs since the pumps operate in the nominal mode without changing the operating point. However, frequency converters should be installed at second and third lift WPSs, where the throttling is carried out, which will provide additional electricity savings.

High-voltage control stations are large, and installing them in existing WPS and WWPS buildings will be difficult. Construction of lightweight structures, including a reinforced concrete foundation, metal frame, mineral wool, and profiled sheets, is recommended at the outer wall of the building where the high-voltage control station will be installed. These solutions require detailed design and a third-party review as required by law (Government of Ukraine, 1999). A company with relevant expertise and required permits should install and commission of this equipment.

Backup power supply for high voltage pumping equipment

Backup power supply for high voltage pumping equipment presents significant challenges that can be addressed in several ways (see Table A.5):

TABLE A.5: BACKUP POWER SUPPLY OPTIONS FOR HIGH-VOLTAGE PUMPING EQUIPMENT

	Option 1	Option 2	Option 3
Brief description	Installation of **low-voltage** (0.4 kV class) container-type diesel generators with step-up transformers to achieve the required voltage of 0.4/6 kV and 0.4/10 kV. Equipment for outdoors installation.	Installation of **high-voltage** (6 kV, 10 kV) container type diesel generators with direct connection to the switchgear of the pump station.	Installation of low-voltage (0.4 kV) **natural gas-piston cogeneration units** with step-up transformers to achieve the required voltage of 0.4/6 kV and 0.4/10 kV.
Advantages	Shorter procurement/delivery and installation times. Possibility of cascading by installing several low-voltage generators of lower power.	Less capital investment, smaller size of the diesel generator	Lower operating costs for fuel. Longer maintenance intervals, more functional hours (up to 100,000 engine hours). Ability to generate heat and electricity for own needs under both emergency and normal operations.
Disadvantages	Higher capital investment required, larger dimensions of the diesel generator. Shorter service life (up to 20,000 engine hours).	The delivery time of one diesel generator can be 8–12 months. Higher maintenance requirements for installation and commissioning of the diesel generator. Shorter service life (up to 20,000 engine hours).	Need to build a medium-pressure gas pipeline. Development of the design, approvals, and construction can take 12–24 months. Requires approval from the Environmental Inspectorate, which also increases implementation timeline.

The most feasible option for providing backup and emergency power supply to high-voltage pumping equipment is a cascade of low-voltage diesel generators with step-up transformers. Due to the pumping stations being in areas with large numbers of active utility infrastructure, siting prior to installation requires a topographical survey and other examinations, in addition to specific design and cost estimations. As there are safety concerns, the vodokanal should not install emergency power supply equipment without frequency control equipment or a soft starter.

One promising intervention to improve energy efficiency and sustainability is the installation of natural gas-piston cogeneration units at large WPSs (first, second, and third lifts). This will significantly reduce operating, costs, and maintenance costs, as this type of equipment allow for much longer time periods between required service checks and a calculated working life of up to 100,000 motor hours. This option is a long-term solution, as it requires laying a gas pipeline, developing design and estimate documentation, and obtaining design approval and permitting from the environmental services. This process can take 12–24 months.

An additional challenge facing Kyivvodokanal, as with other vodokanals in Ukraine, is outdated electrical equipment in electrical substations and electrical control rooms. The existing high-voltage complex switchgears in electrical substations and control rooms have exhausted their service lives five to six times over. This equipment does not provide the necessary reliability and safety in conditions of constant emergency and stabilization shutdowns. Additional assessment must happen to evaluate equipment replacement needs.

Projects specific to the introduction of alternative energy sources, such as solar panels, wind turbines, heat pumps, and biogas, can be considered following the replacement and modernization of outdated electrical equipment.

A.2 KYIVVODOKANAL INCIDENTS AND IMPACTS

SUMMARY

Kyivvodokanal experienced a total of 55 hours of service disruptions due to power outages caused by Russian missile attacks between October and December 2022. According to Kyivvodokanal, facilities and buildings sustained minor damage during these attacks—only damage to windows was reported. The longest service disruptions took place from October to December 2022. Due to a missile attack on October 31, 2022, all water and wastewater facilities were disconnected from power supply. On November 23, 2022, another missile attack disconnected all wastewater facilities and 80 percent of water facilities from their power supply. Kyivvodokanal reported no additional service disruptions due to power outages since January 2023. Only two attacks were reported in January, compared to four in December, so this is likely due to decreasing frequency and severity of attacks. Additionally, the installation of new power generators supplied by the United States Agency for International Development minimized service disruptions (Vodokanal.kiev.ua 2023).

INCIDENT 1: OCTOBER 31, 2022

On the morning of October 31, a Russian missile attack aimed at Ukrainian energy infrastructure hit at least 10 power plants. Kyivvodokanal reported that all water pumping station (WPSs) were nonfunctional due to power outages caused by the missile attack. All wastewater facilities, excluding the treatment plant, were nonfunctional. The vodokanal partially resumed services by the end of the day. Over the course of the day, a missile attack caused the disconnection of 80 percent of consumers from both water and wastewater services (Vodokanal.kiev.ua 2022g). The vodokanal completely restored services on November 1. Overall, it took Kyivvodokanal 23 hours to completely resume operations. No major damages at Kyivvodokanal's sites were reported. Kyivvodokanal stated that existing generators were only supplying enough power to support radio communication and the work of dispatchers, but not to resume services. Water and wastewater services resumed only when the vodokanal reconnected facilities to the electricity supply.

INCIDENT 2: NOVEMBER 23, 2022

On November 23, a Russian missile attack caused a partial blackout in 11 Ukrainian oblasts, including the city of Kyiv (Slovoidilo.ua 2022a). Kyivvodokanal stated that the power outage completely disconnected the treatment plant and drainage pumping stations from the electricity supply. The attack also disconnected 80 percent of the city's WPSs. Kyivvodokanal could not specify what kinds of facilities remained operational and whether they used power generators to remain active. The restoration of water supply and sewerage services took place after electricity supply was restored. On November 24, Kyivvodokanal stated that water services had resumed in three districts (Desnianskyi, Dniprovskyi, and Darnytskyi) on the left bank of the city (Vodokanal.kiev.ua 2022f). The vodokanal reconnected all consumers to the water supply and wastewater services within 27 hours (Vodokanal.kiev.ua 2022d).

INCIDENT 3: DECEMBER 16, 2022

On December 16, 2022, Kyivvodokanal stated that a missile attack had resulted in the disconnection of all water supply facilities from their power supplies (Vodokanal.kiev.ua 2022c). All wastewater facilities remained operational. The vodokanal had restored water supply services to all consumers within 27 hours. In response to an information request, Kyivvodokanal mentioned that services resumed after restoration of the electricity supply from the network. Kyivvodokanal reported no damage to its facilities during the missile attack or emergency power outage. Kyivvodokanal did not have enough generator capacity to maintain service delivery during the power outage.

INCIDENT 4: DECEMBER 20, 2022

On December 20, 2022, all of Kyivvodokanal's WPSs were disconnected from the power supply after an emergency power outage due to the damages caused by the missile attack on December 16 (Vodokanal.kiev.ua 2022a). According to the general director of electricity supplier Yasno, Kyiv did not have enough power supply to keep public services running due to a missile attack on December 16, 2022 (Kravchenko 2022b). He said that 1.1 million inhabitants and all water supply facilities had been disconnected from the electricity supply. He also stated that power capacity was 50 percent lower than required to keep public services running. The electricity supply was restored to WPSs by the local power supply company within one hour. Electricity supply was restored to consumers within four hours (Vodokanal.kiev.ua 2022e).

INCIDENT 5: DECEMBER 29, 2022

On December 29, 2022, after a Russian missile attack on Ukrainian energy infrastructure, Kyivvodokanal warned the public about possible disruption of services (Vodokanal.kiev.ua 2022b). However, all Kyivvodokanal's facilities remained operational. Kyiv's mayor specified that only some consumers might experience water supply outages (Zharikova 2022b). The vodokanal provided no additional information on this incident.

A.3 KYIVVODOKANAL EQUIPMENT LIST

Kyivvodokanal has developed an EOP to ensure water and wastewater service delivery during power outages and blackouts. To carry out these plans, Kyivvodokanal needs both low-voltage and high-voltage equipment. Equipment needs are divided into three stages depending on the level of need (from the most urgent to the least):

- Stage 1: Equipment is needed immediately; Stage 1 needs will cost approximately USD 170,000–190,000.
- Stage 2: Urgent, equipment is needed within 3 months; Stage 2 needs will cost approximately USD 1,200,000–1,400,000.
- Stage 3: Equipment is not needed for at least 6–9 months or cannot be procured in a short period of time. Stage 3 needs are estimated to cost at least USD 6,000,000–8,000,000.

The point of contact from Kyivvodokanal for communication regarding equipment procurement and delivery is provided in the table below. All equipment and materials should be delivered to the following address: [information available upon request]. While vodokanal staff were not able to provide GPS coordinates for facilities, the names of facilities where equipment awaits installation are listed in the tables below and should be referenced when discussing delivery and installation with the vodokanal's point of contact. Costs provided in each row in the subsequent tables are total costs, not per unit costs.

POSITION	NAME	CONTACT PHONE	EMAIL
Chief Power Engineer	Available upon request	Available upon request	Available upon request

A.3.1 GENERATOR NEEDS

Stage 2: Urgent, equipment is needed within 3 months.

Justification: The vodokanal needs generators to power low-voltage wastewater system equipment in case of power outages, in line with the EOP.

TABLE A.6: LOW-VOLTAGE GENERATOR NEEDS FOR KYIVVODOKANAL'S WASTEWATER FACILITIES (ADDITIONAL INSTALLATION OF FREQUENCY CONVERTERS IS REQUIRED)

NO.	LOCATION	TYPE OF GENERATOR	SPECIFICATIONS	QTY	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
1	Wastewater Pumping Station (WWPS)-5, -6, -7, -8, -9, -10, -11, -12, -13	Diesel Generator (DG)	Fuel type: Diesel Prime Power: 70 Kilowatt (kW) Voltage: 400 Volt (V) Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging	7	130,000	• For chosen power of DG additional installation of frequency converter (FC) required; • Installation of DG on the site can be done by vodokanal personnel • Additional installation of Automatic Reserve Activation (AVR) in the electrical room is required (can be designed and developed by special orders); • Testing and commissioning from manufacturer representatives after installation is required • Contracts for follow up maintenance from manufacturer and fuel/oil supply is required.
2	WWPS-14	DG	Fuel type: Diesel Prime Power: 130 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging.	1	25,000	
3	WWPS-15	DG	Fuel type: Diesel Prime Power: 300 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary; Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging.	1	55,000	
4	WWPS-16, -17	DG	Fuel type: Diesel;	2	56,000	

TABLE A.6: LOW-VOLTAGE GENERATOR NEEDS FOR KYIVVODOKANAL'S WASTEWATER FACILITIES (ADDITIONAL INSTALLATION OF FREQUENCY CONVERTERS IS REQUIRED)						
NO.	**LOCATION**	**TYPE OF GENERATOR**	**SPECIFICATIONS**	**QTY**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
			Prime Power: 160 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary; Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging.			
5	WWPS-18	DG	Fuel type: Diesel Prime Power: 550 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary; Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic	1	100,000	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

Stage 3: Equipment is not needed for at least 6–9 months, or longer, or cannot be procured in a short period of time.

Justification: Supply and installation of alternative power sources, like high-voltage generators, are required to ensure water supply system workability during city blackouts, or its parts, in line with the EOP, to keep the continuous operation of pumping stations at a minimum level.

TABLE A.7: HIGH-VOLTAGE GENERATOR NEEDS FOR KYIVVODOKANAL'S WATER FACILITIES (ADDITIONAL INSTALLATION OF FREQUENCY CONVERTERS IS REQUIRED)							
NO	**LOCATION**	**TYPE OF GENERA-TOR**	**SPECIFICATIONS**		**QTY**	***INDICATIVE PRICE, USD**	**NOTES/ ADDITIONAL REQUIREMENTS**
			HIGH VOLTAGE GENERATOR	**ALTERNATIVE OPTION**			
1	WPS of the 1st lift 1	DG	Prime Power: 2000 kW Voltage: 6 kV	Low voltage Generator Prime Power: 2000 kW Step up transformer 0.4/6 kV	1	Requires additional design work for estimation.	This solution requires the development of design documentation. It is necessary to fill out a checklist with all the required parameters to order the equipment.
2	WPS of the 2nd lift 1 and Drinking Water	Diesel or Natural Gas	Prime Power: 1800 kW Voltage: 10 kV	Low voltage Generator Prime Power: 1800 kW Step up transformer 0.4/10 kV	2	Requires additional design work for estimation.	

NO	LOCATION	TYPE OF GENERA-TOR	SPECIFICATIONS		QTY	*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			HIGH VOLTAGE GENERATOR	ALTERNATIVE OPTION			
	Purification Technology		**OR** Prime Power: 3520 kW Voltage: 10 kV		1	Requires additional design work for estimation.	
3	WPS of the 2nd lift 2	Diesel or Natural Gas	Prime Power: 2600 kW Voltage: 6 kV	Low voltage Generator Prime Power: 2600 kW Step up transformer 0.4/6 kV	1	Requires additional design work for estimation.	
4	WPS of the 3rd lift 1	Diesel or Natural Gas	Prime Power: 1800 kW Voltage: 10 kV	Low voltage Generator Prime Power: 1800 kW Step up transformer 0.4/10 kV	1	Requires additional design work for estimation.	
5	WPS of the 3rd lift 2	Diesel or Natural Gas	Prime Power: 800 kW Voltage: 10 kV	Low voltage Generator Prime Power: 800 kW Step up transformer 0.4/10 kV	1	Requires additional design work for estimation.	
6	WPS of the 3rd lift 3	Diesel or Natural Gas	Prime Power: 1800 kW Voltage: 10 kV	Low voltage Generator Prime Power: 1800 kW Step up transformer 0.4/10 kV	1	Requires additional design work for estimation.	
7	WPS of the 3rd lift 4	Diesel or Natural Gas	Prime Power: 1300 kW Voltage: 10 kV	Low voltage Generator Prime Power: 1300 kW Step up transformer 0.4/10 kV	1	Requires additional design work for estimation.	

TABLE A.7: HIGH-VOLTAGE GENERATOR NEEDS FOR KYIVVODOKANAL'S WATER FACILITIES (ADDITIONAL INSTALLATION OF FREQUENCY CONVERTERS IS REQUIRED)

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

A.3.2 CONTROL STATION NEEDS

Stage 2: Urgent, equipment is needed within 3 months.

Justification: The vodokanal needs control stations with FCs to be installed on low-voltage motors of wastewater pumping equipment (alongside installation of DGs of the chosen capacity from Table A.6). This will significantly improve the facilities' energy efficiency and increase the city wastewater system's reliability.

TABLE A.8: CONTROL STATION WITH FREQUENCY CONVERTERS FOR LOW-VOLTAGE MOTOR NEEDS FOR KYIVVODOKANAL'S WASTEWATER FACILITIES

NO.	LOCATION	QTY. OF FCS REQUIRED PER SITE	QTY. AND SPECIFICA-TIONS OF THE MOTORS	NAME OF FC FROM SCHNEIDER ELECTRIC	NAME OF FC FROM DANFOSS	NAME OF FC FROM SIEMENS UKRAINE	*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
1	WWPS-5, -6, -7, -8, -9, -10, -11, -12, -13	3	2 pcs x 30 kW (0,4 kV);	ATV610D30N4	FC-101P30KT4E20H2 + LCP	-	135,000	In addition will be required delivering to the site, spare

TABLE A.8: CONTROL STATION WITH FREQUENCY CONVERTERS FOR LOW-VOLTAGE MOTOR NEEDS FOR KYIVVODOKANAL'S WASTEWATER FACILITIES								
NO.	**LOCATION**	**QTY. OF FCS REQUIRED PER SITE**	**QTY. AND SPECIFICA-TIONS OF THE MOTORS**	**NAME OF FC FROM SCHNEIDER ELECTRIC**	**NAME OF FC FROM DANFOSS**	**NAME OF FC FROM SIEMENS UKRAINE**	***INDICATIVE PRICE, USD**	**NOTES/ ADDITIONAL REQUIREMENTS**
			1 pcs x 40 kW (0,4 kV);	ATV930D45N4	FC-101P45KT4E 20H2 + LCP	-	72,000	parts purchasing, installation works from manufacture, training of vodokanal personnel
2	WWPS-1	1	1 pcs x 7,5 kW (0,4 kV);	ATV320U75N4B	FC-051P7K5T4E 20H3B + LCP 11	-	4,500	
3	WWPS-2	1	1 pcs x 15 kW (0,4 kV);	ATV610D15N4	FC-051P15K5T4 E20H3B + LCP 11	-	5,500	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

Stage 3: Equipment is not needed for at least 6–9 months, or longer, or cannot be procured in a short period of time.

Justification: Installation of control stations with FCs on high-voltage motors of the water supply pumping equipment will ensure the installation of DGs of chosen capacity from Table A.6, significantly improve facilities' energy efficiency, and increase the reliability of the city's water supply system.

TABLE A.9: CONTROL STATION WITH FREQUENCY CONVERTERS FOR HIGH-VOLTAGE MOTORS NEEDS FOR KYIVVODOKANAL'S WATER SUPPLY FACILITIES						
NO.	**LOCATION**	**NAME**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ ADDITIONAL REQUIREMENTS**
1	WPS of the 1st lift 1	Pumping equipment control station	With Soft Start Motors: 860 kW, 6 kV - 2 pcs.	1	Requires additional design work for estimation.	Site delivery, spare parts purchasing, installation works from manufacture, and training of vodokanal personnel will be required
2	WPS of the 2nd lift 1 and Drinking Water Purification Technology	Pumping equipment control station	With frequency control Motor: 2000 kW, 10 kV - 1 pcs 1000 kW, 10 kV - 1 pcs 160 kW, 0,4 kV - 2 pcs 200 kW, 0,4 kV - 1 pcs	5	Requires additional design work for estimation.	
3	WPS of the 2nd elevation 2	Pumping equipment control station	With frequency control Motor: 2000 kW, 6 kV - 1 pcs 400 kW, 6 kV - 1 pcs	2	Requires additional design work for estimation.	
4	WPS of the 3rd elevation 3	Pumping equipment control station	With frequency control Motor: 1600 kW, 10 kV - 1 pcs	1	Requires additional design work for estimation.	
5	WPS of the 3rd elevation 4	Pumping equipment control station	With frequency control Motor: 800 kW, 10 kV - 1 pcs	1	Requires additional design work for estimation.	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

A.3.3 ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT, AND CABLE PRODUCT NEEDS

Stage 1: Equipment is needed immediately.

Justification: Existing electrical switchgear, electrical protection equipment, and cable products are outdated and require constant repair, reducing the reliability of the city's water supply and sewage services. Constant emergency switching further reduces equipment functionality, which often does not work in critical situations. Equipment and materials are needed for emergency repairs listed below.

TABLE A.10: ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT, AND CABLE PRODUCT NEEDS FOR KYIVVODOKANAL

NO.	NAME	SPECIFICATIONS	UNITS	QTY.	*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
1	Fuse (quick) BUSSMAN170M6813D	• Rated current (thermal) = 900A • Operating voltage=690V • DIN3 size • Characteristic AR • Type 170M6813D Rated current (thermal) = 900A	pcs.	3	1,000	Only purchasing of materials and delivery to the site is required
2	Circuit breaker 80A	80A, 3p, 25kA	pcs.	1	200	
3	Circuit breaker 100A	100A, 3p, 25kA	pcs.	1	220	
4	Circuit breaker 160A	160A, 3p, 35kA	pcs.	1	330	
5	Circuit breaker 250A	250A, 3p, 35kA	pcs.	1	600	
6	Circuit breaker 63A	63A, 3p, 400V	pcs.	1	120	
7	Circuit breaker 50A	50A, 3p, 400V	pcs.	2	70	
8	Circuit breaker 40A	40A, 3p, 400V	pcs.	7	180	
9	Circuit breaker 32A	32A, 3p, 400V	pcs.	23	590	
10	Circuit breaker 25A	25A, 3p, 400V	pcs.	34	730	
11	Circuit breaker 16A	16A, 3p, 400V	pcs.	34	650	
12	Circuit breaker 32A	32A, 1p, 230V	pcs.	3	30	
13	Circuit breaker 25A	25A, 1p, 230V	pcs.	18	70	
14	Circuit breaker 16A	16A, 1p, 230V	pcs.	18	110	
15	Box with a switch and safety fuses YARP-100	100A, ~3x400V	pcs.	2	220	
16	External triple waterproof socket with cover	TRIPLE, 16A, ~1x230V, IP54	pcs.	10	450	
17	Magnetic starter	PME-210, 25A	pcs.	4	100	
18	Soft start device	12A; 5.5kV; IP20, 50/60 Hz; 323 to 457 V	pcs.	5	1,000	
19	Cable KG-1x10.0 mm²	core - copper, number of conductors - 1, type - flexible	m	10	15	
20	Cable KG -1x16,0 mm²	core - copper, number of conductors - 1, type - flexible	m	100	275	

TABLE A.10: ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT, AND CABLE PRODUCT NEEDS FOR KYIVVODOKANAL						
NO.	**NAME**	**SPECIFICATIONS**	**UNITS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ ADDITIONAL REQUIREMENTS**
21	Cable KG -3x25+1x16 mm²	core - copper, number of conductors - 1, type - flexible	m	200	3,300	
22	Cable KG -4x25 mm²	core - copper, number of conductors - 4, type - flexible	m	200	1,200	
23	Cable KG -3x35+1x16 mm²	core - copper, number of conductors - 1, type - flexible	m	200	4,500	
24	Cable KG -4x35	core - copper, number of conductors - 4, type - flexible	m	600	15,000	
25	Cable KG -3x50+1x25 mm²	core - copper, number of conductors - 4, type - flexible	m	200	7,700	
26	Cable KG-4x50 mm²	core - copper, number of conductors - 4, type - flexible	m	300	11,500	
27	Cable KG -3x70+1x35 mm²	core - copper, number of conductors - 4, type - flexible	m	200	8,750	
28	Cable KG -1x70 mm²	core - copper, number of conductors - 1, type - flexible	m	300	4,000	
29	Cable KG-2x120 mm²	core - copper, number of conductors - 2, type - flexible	m	400	16,700	
30	Cable KG -1x150 mm²	core - copper, number of conductors - 1, type - flexible	m	300	7,500	
31	Cable KG -1x240 mm²	core - copper, number of conductors - 1, type - flexible	m	600	27,000	
32	VVG 4x4 mm^2 cable	core - copper, number of conductors - 4, type - flexible	m	100	250	
33	Cable VVG 4x10 mm2	core - copper, number of conductors - 4, type - flexible	m	100	670	
34	Cable VVGng 3x2.5 mm2	core - copper, number of conductors - 3, type – flexible, non-combustible	m	550	610	
35	Cable VVGng 4x25.0 mm2	core - copper, number of conductors - 4, type – flexible, non-combustible	m	50	660	
36	Cable VVGng 5x4.0 mm2	core - copper, number of conductors - 5, type – flexible, non-combustible	m	100	290	
37	Cable VVGng 3x2.5+1x1.5 mm2	core - copper, number of conductors - 5, type – flexible, non-combustible	m	100	90	
38	Wire APPV 2x2.5 mm2	core - aluminum, number of conductors - 2, type – flexible	m	800	230	
39	Cable AVVG 4x4.0 mm2	core - aluminum, number of conductors - 4, type – flexible	m	200	110	
40	Cable AVVG 4x6.0 mm2	core - aluminum, number of conductors - 4, type – flexible	m	400	300	
41	Cable AVVG 4x10.0 mm2	core - aluminum, number of conductors - 4, type – flexible	m	200	200	

TABLE A.10: ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT, AND CABLE PRODUCT NEEDS FOR KYIVVODOKANAL						
NO.	**NAME**	**SPECIFICATIONS**	**UNITS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ ADDITIONAL REQUIREMENTS**
42	Cable AVVG 3x16.0+1x10.0 mm2	core - aluminum, number of conductors - 4, type – flexible	m	100	150	
43	Control cable KKVG 10x2.5 mm2	core - copper, number of conductors - 10, type – flexible, control	m	50	170	
44	Repair clamps-couplings SN.10.60-67	PN16; Ø60-67mm/L=150mm	pcs.	40	1,700	
45	Repair clamps-couplings SN.10.113-123.200	PN16; Ø113-123mm/L=200mm	pcs.	120	7,520	
46	Repair clamps-couplings SN.10.167-177.300	PN16; Ø167-177mm/L=300mm	pcs.	40	4,320	
47	Repair clamps-couplings SN.10.219-229.300	PN16; Ø219-229mm/L=300mm	pcs.	40	5,040	
48	Repair clamps-couplings SN.10.273-283.300	PN16; Ø273-283mm/L=300mm	pcs.	40	5,550	
49	Repair clamps-couplings SN.10.320-330.400	PN16; Ø320-330mm/L=400mm	pcs.	40	8,270	
50	Repair clamps-couplings SN.20.420-440.400	PN16; Ø420-440mm/L=400mm	pcs.	40	17,030	
51	Copper tip DT-016	16 mm2	pcs.	130	140	
52	Copper tip DT-025	25 mm2	pcs.	130	160	
53	Copper tip DT-035	35 mm2	pcs.	260	420	
54	Copper tip DT-050	50 mm2	pcs.	130	290	
55	Copper tip DT-070	70 mm2	pcs.	130	300	
56	Copper tip DT-120	120 mm2	pcs.	130	850	
57	Copper tip DT-150	150 mm2	pcs.	65	460	
58	Copper tip DT-240	240 mm2	pcs.	65	720	
59	End coupling KNTP 10-70/120	150-240 mm2; 10 kV	pcs.	50	2,470	
60	End coupling KNTP 10-150/240	150-240 mm2; 10 kV	pcs.	60	3,770	
61	Connecting coupling STP-10	70/120 mm^2	pcs.	50	400	
62	Connecting coupling STP-10	150/240 mm^2	pcs.	50	1,200	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

A.3.4 GROUNDWATER INTAKE RECONSTRUCTION NEEDS

Stage 2: Urgent, equipment is needed within 3 months.

Justification: Existing well pumps are outdated and require replacement and have no automated control (staff respond to a central dispatcher and turn on the well pumps manually as needed, using bicycles and public transport to reach them). Installation of new modern pumps and control stations will significantly increase operational and energy efficiency and energy safety of the groundwater intake.

TABLE A.11: GROUNDWATER INTAKE RECONSTRUCTION NEEDS FOR KYIVVODOKANAL

NO.	NAME	SPECIFICATIONS	UNITS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
Needs specific to Automated Electrolysis Units						
1	Automated electrolysis unit EP-10-12	To obtain sodium hypochlorite 12 kg/day	set	4	72,000	Can be purchased by special orders after specifying the technical parameters with vodokanal representatives. Delivery to the site, testing, and commissioning and training need to be done with support of manufacturer representative.
2	Automated electrolysis unit EP-10-26	To obtain sodium hypochlorite 26 kg/day	set	7	30,000	
Needs specific to Pump Control Panels with Frequency Converter						
3	Pump Control Panels with Frequency Converter for 45 kW submersible pumps	~3x400V; 45 kW	set	10	120,000	Can be purchased by special orders after specifying the technical parameters with vodokanal representatives. Delivery to the site, testing, and commissioning and training need to be done with support of manufacturer representative.
4	Pump Control Panels with Frequency Converter for 37 kW submersible pumps	~3x400V; 37 kW	set	10	100,000	
5	Pump Control Panels with Frequency Converter for 30 kW submersible pumps	~3x400V; 30 kW	set	10	90,000	
Needs specific to Submersible pumps for artesian wells						
6	Submersible pumps for artesian wells with cable lines for connection included. 7.5kW	~3x400V 7.5 kW Flow rate: 10 m3/h Head: 180 m	set	1	2,000	Can be purchased by special orders after specifying the technical parameters with vodokanal representatives. Delivery to the site, testing, and commissioning and training need to be done with support of manufacturer representative.
7	Submersible pumps for artesian wells with cable lines for connection included. 5.5kW	~3x400V 5.5 kW Flow rate: 10 m3/h Head: 100 m	set	3	4,500	
8	Submersible pumps for artesian wells with cable lines for connection included. 5.5kW	~3x400V 5.5 kW Flow rate: 10 m3/h Head: 130 m	set	1	1,500	
9	Submersible pumps for artesian wells with cable lines for connection included. 15kW	~3x400V 15 kW Flow rate: 20 m3/h Head: 180 m	set	1	4,000	
10	Submersible pumps for artesian wells with cable lines for connection included. 9.2 kW	~3x400V 9.2 kW Flow rate: 20 m3/h Head: 100 m	set	1	3,000	
11	Submersible pumps for artesian wells with cable lines for connection included. 11 kW	~3x400V 11 kW Flow rate: 25 m3/h Head: 100 m	set	7	21,000	

TABLE A.11: GROUNDWATER INTAKE RECONSTRUCTION NEEDS FOR KYIVVODOKANAL						
NO.	NAME	SPECIFICATIONS	UNITS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
12	Submersible pumps for artesian wells with cable lines for connection included. 11 kW	~3x400V 11 kW Flow rate: 20 m3/h Head: 120 m	set	1	3,000	
13	Submersible pumps for artesian wells with cable lines for connection included. 13 kW	~3x400V 13 kW Flow rate: 30 m3/h Head: 100 m	set	10	35,000	
14	Submersible pumps for artesian wells with cable lines for connection included. 18.5 kW	~3x400V 18.5 kW Flow rate: 30 m3/h Head: 150 m	set	5	18,500	
15	Submersible pumps for artesian wells with cable lines for connection included. 22 kW	~3x400V 22 kW Flow rate: 30 m3/h Head: 180 m	set	4	16,000	
16	Submersible pumps for artesian wells with cable lines for connection included. 22 kW	~3x400V 22 kW Flow rate: 40 m3/h Head: 120 m	set	1	4,000	
17	Submersible pumps for artesian wells with cable lines for connection included. 22 kW	~3x400V 22 kW Flow rate: 40 m3/h Head: 130 m	set	3	12,000	
18	Submersible pumps for artesian wells with cable lines for connection included. 26 kW	~3x400V 26 kW Flow rate: 40 m3/h Head: 150 m	set	2	8,400	
19	Submersible pumps for artesian wells with cable lines for connection included. 22 kW	~3x400V 22 kW Flow rate: 45 m3/h Head: 100 m	set	2	8,000	
20	Submersible pumps for artesian wells with cable lines for connection included. 26 kW	~3x400V 26 kW Flow rate: 60 m3/h Head: 100 m	set	3	12,600	
21	Submersible pumps for artesian wells with cable lines for connection included. 26 kW	~3x400V 26 kW Flow rate: 65 m3/h Head: 100 m	set	1	4,200	
22	Submersible pumps for artesian wells with cable lines for connection included. 26 kW	~3x400V 26 kW Flow rate: 50 m3/h Head: 130 m	set	11	45,000	

TABLE A.11: GROUNDWATER INTAKE RECONSTRUCTION NEEDS FOR KYIVVODOKANAL						
NO.	**NAME**	**SPECIFICATIONS**	**UNITS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
23	Submersible pumps for artesian wells with cable lines for connection included. 30 kW	~3x400V 30 kW Flow rate: 50 m3/h Head: 150 m	set	11	50,000	
24	Submersible pumps for artesian wells with cable lines for connection included. 45 kW	~3x400V 45 kW Flow rate: 50 m3/h Head: 200 m	set	1	4,700	
25	Submersible pumps for artesian wells with cable lines for connection included. 30 kW	~3x400V 30 kW Flow rate: 75 m3/h Head: 100 m	set	1	4,300	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

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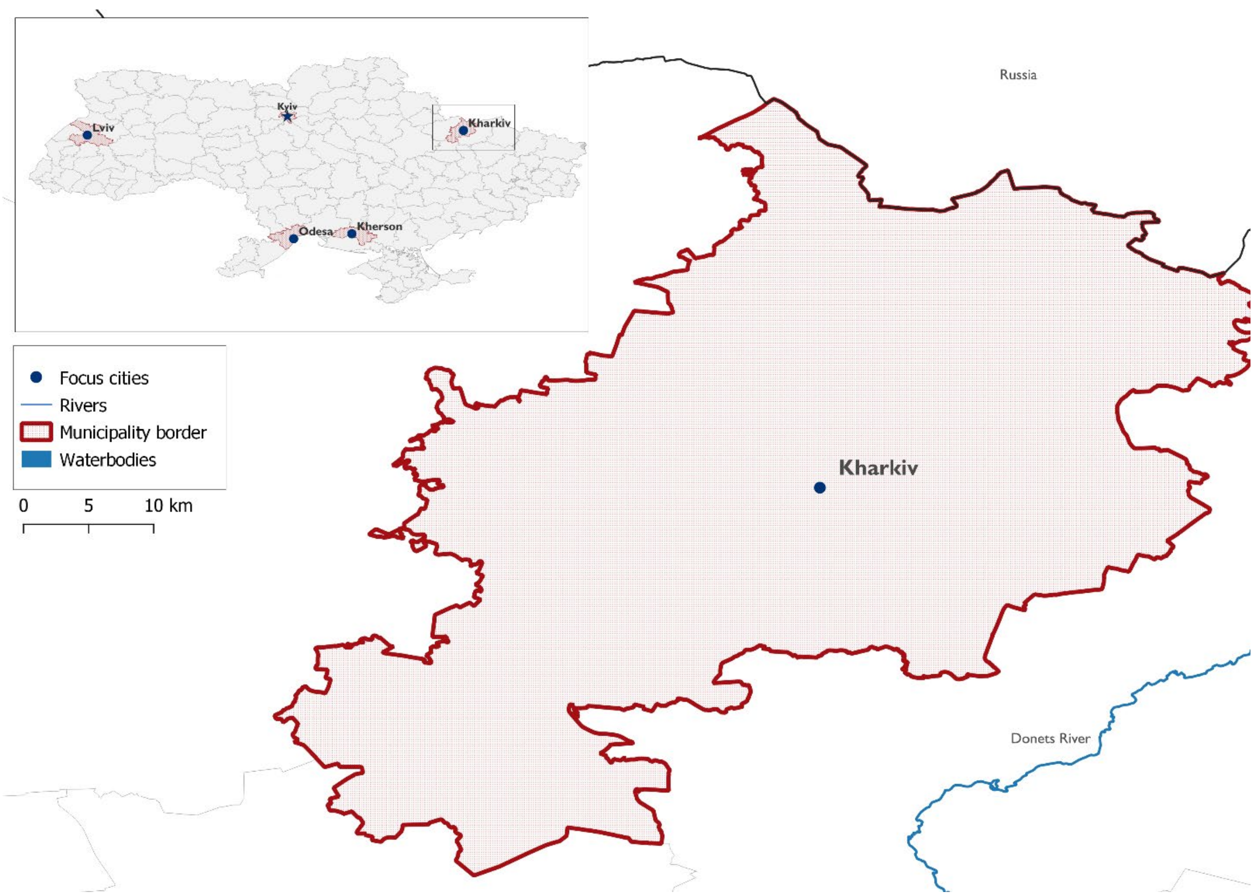
ANNEX B: KHARKIVVODOKANAL

KHARKIV
Communal Enterprise Kharkivvodokanal (Kharkivvodokanal) Pre-War Population (# of people): **1,421,125** Current Population (# of people): **~1,100,000** Net Population Change: **-23%** Pre-War Employees (# of staff): **5,835** Current Employees (# of staff): **4,964** Net Employee Change: **-15%**



B.1 KHARKIVVODOKANAL PROFILE

Summary

- Key challenges facing Kharkivvodokanal include direct destruction of water supply and wastewater infrastructure and power outages caused by missile attacks on critical power infrastructure. Kharkivvodokanal has received support from donors and other organizations. Currently, up to 15% of backup power needs are covered for water supply systems, and up to 10% for wastewater systems.
- The centralized water supply and wastewater systems of Kharkivvodokanal includes both high-voltage (6 kV and 10 kV) and low-voltage (0.4 kV) equipment. Most electric power equipment was installed between 1960 and 1990 and is outdated and in poor technical condition. Kharkivvodokanal uses mostly Soviet-type, oil-filled, step-down power transformers (10/0.4 and 6/0.4 kV) that require constant routine repairs. Kharkivvodokanal uses more high-voltage pumping equipment than most cities in Ukraine, which have begun switching to low-voltage equipment. Remaining low-voltage backup power needs can be addressed in the short-term, but additional assessment and design is needed for high-voltage equipment.
- Stage 1 needs will cost approximately USD 400,000–440,000. Stage 2 needs will cost approximately USD 1,150,000–1,300,000. Stage 3 needs are estimated to cost at least USD 6,500,000–8,500,000.

Site Visit Overview

Three CDM Engineering Ukraine engineers conducted Kharkivvodokanal's site visit on March 9–10, 2023. During the site visits, multiple meetings with Kharkivvodokanal management took place, as well as tours of water pumping and treatment facilities.

General Overview

The communal enterprise (CE) Kharkivvodokanal was established in 1881 to provide the city of Kharkiv and nearby areas with water supply and wastewater services. Kharkivvodokanal is owned by the territorial community of the city of Kharkiv. Kharkivvodokanal also supplies treated water for both central domestic heating and district heating purposes and is the only provider for Teploenergos, including Private Joint Stock Company HPP 5 and CE "Kharkivski teplovi merezi." In 2020, Kharkivvodokanal supplied 41,008,200 m^3 of water for district heating and hot water supply purposes; in 2021, 41,092,800 m^3; and in 2022, 25,744,700 m^3.

B.1.1 OVERVIEW OF NETWORK AND FACILITIES

Water System Overview

TABLE B.1: WATER SYSTEM OVERVIEW – KHARKIVVODOKANAL

	CATEGORY	DATA	NOTES
WATER	Water Intakes	2	Surface water intakes.
	Capacity of Water Intakes (m^3/day)	574,000	
	Source Types	Surface water; groundwater	
	Groundwater Wells	14	
	Max. Well Depth (m)	800	
	Surface Water Sources	2	Sivirskyi Donets River; Dnipro-Donbas Canal
	Length of Water Distribution Pipelines (km)	2,741	

TABLE B.1: WATER SYSTEM OVERVIEW – KHARKIVVODOKANAL		
CATEGORY	**DATA**	**NOTES**
Water Pipe Max. Diameter (m)	1.6	
(Main) Water Pumping Stations (WPSs)	7	
(Local) WPSs	14	
Treatment Plant Capacity (m^3/day)	574,000	
Treated Water Storage Capacity (m^3/day)		Data not available
Pre-War Demand (m^3/day)		Data not available
Current Water Demand (m^3/day)		Data not available
Change in Water Demand (m^3/day)		Data not available
Pre-War Supply (m^3/day)		Data not available
Current Supply (m^3/day)	381,850	Data from 2022
Change in Supply		Data not available
Water Provided to Teploenergos (m^3)	25,744,700	Data from 2022

Kharkiv receives water from a combination of surface and groundwater sources, located at significant distances from each other and from the city. Surface water sources including the Siverskyi Donets River, via the Pechenizhske reservoir, and the Krasnopavlivka reservoir on the Dnipro-Donbas Canal (total capacity of 574,000 m3/day). The city also receives groundwater from approximately 14 artesian wells. Water is treated at two water treatment plants (WTPs) (total capacity of 574,000 m3/day, one per surface water source).

The main source of water supply is the Pechenizhske reservoir with a capacity of 383 million m^3. Water from pumping stations of the first lift is supplied through water pipes with a diameter of 900–1,400 mm to the Kochetotsk water supply station. Treated drinking water is then supplied to the city of Kharkiv through five main water pipes, with diameters between 900 and 1,600 mm. The water intake from the Siverskyi Donets River consists of three blocks. Two intake units are equipped with horizontal pumps with a total capacity of 4,700 m^3/h.

The third water intake unit is equipped with vertical pumps with a total capacity of 6,500 m^3/h. Water is supplied from the intakes through six water pipelines with diameters ranging from 900 mm to 1,400 mm to the Donets WTP. Water treatment includes horizontal sedimentation tanks and quick filters. Treated water is supplied to the WPS of the third lift of the Rohan WTP through five lines of water pipes with a diameter of 1,400 mm. The WPS is equipped with pumping units with a capacity of 4,700 m^3/h each. Treated water is supplied to consumers through five water pipes, each with diameters ranging from 900 mm to 1,400 mm.

The water intake from the Dnipro-Donbas canal supplies water to the Dnipro WTP and the second lift WPS through two 1,400-mm water pipes. Water is supplied to the WPS of the third lift through two 1,400-mm water pipes. After the third lift, two 1,400-mm water pipes go to the switching chamber (the main line is connected by pipelines to ensure the redistribution of water between the main lines), from which water is supplied to the city by two 1,200-mm water pipes. The total capacity of the two WTPs is unknown.

Additionally, there are 14 artesian wells in another part of the city with a maximum depth of 800 m. Groundwater provides for approximately 10% of the city's supply, and the extent to which groundwater is treated is unknown.

There are 14 booster pumping stations in the city. The total length of the city's water supply network is 2,741 km, of which 801 km are main water pipelines. As of January 2023, 64% of the network (approximately 1,780 km, of which 509 km are main water pipelines) needs replacement due to poor condition and extensive leakage.

Wastewater System Overview

TABLE B.2: WASTEWATER SYSTEM OVERVIEW – KHARKIVVODOKANAL			
CATEGORY		DATA	NOTES
WASTEWATER	Length of Sewerage Network (km)	1,684	
	Main Collector Pipes	398	
	Wastewater Pumping Stations (WWPSs)	37	
	Treatment Plant Capacity (m^3/day)	1,050,000	2 separate plants: 1 with 750,000 m^3/day capacity, 1 with 300,000 m^3/day capacity.
	Pre-War Total Wastewater Flow (m^3/day)		Data not available.
	Current Total Wastewater Flow (m^3/day)	303,610	Data from 2022.
	Change in Total Wastewater Flow		Data not available.

The city's sewerage network consists of 1,684 km of networks and 37 WWPSs. The city's wastewater is collected through deep tunnel collectors. The length of the collectors is 67.8 km, the average depth is 20 m, and the maximum depth is 50 m. Wastewater is supplied to the main sewage pumping station located on wastewater treatment plant (WWTP) property. There are two WWTPs with a combined capacity of 1,050,000 m^3/day.

The total capacity of WWTP No. 1 is 0.75 million m^3/day. Treatment processes at the plant include mechanical and biological treatment and disinfection of treated wastewater. Currently, the complex's technological equipment has a total approximate depreciation of 60% for all facilities, and large amounts of equipment need to be replaced. The total capacity of WWTP No. 2 is 0.3 million m^3/day. WWTP No. 2 has an average depreciation of more than 65%.

B.1.2 POWER NEEDS AND SUPPLY

Most of Kharkivvodokanal's electric power equipment was installed between 1960 and 1990 and is now outdated and in bad technical condition, as it has never been replaced or rehabilitated. During continuous emergency shutdowns and forced operational switches, this equipment cannot provide the necessary energy security, often does not work in critical situations such as power outages, short circuits in electrical networks, and requires continuous maintenance.

The centralized water supply and wastewater systems of Kharkivvodokanal includes both high-voltage pumping equipment (6 kV and 10 kV) and low-voltage pumping equipment (0.4 kV). Kharkivvodokanal uses more high-voltage equipment than most cities in Ukraine, which have begun switching to low-voltage equipment. Thus, provision of generators for backup power supply to water supply and wastewater systems is difficult. Currently, only approximately 15% of backup power needs for water supply systems and up to 10% of backup power needs for wastewater system have been addressed by the UNICEF and the International Committee of the Red Cross (ICRC). To ensure that operations remain stable during constant shutdowns and power outages, installation of high- and low-voltage diesel generators and installation of control stations with frequency convertors are needed.

Kharkivvodokanal uses mostly Soviet-type, oil-filled, step-down power transformers (10/0.4 and 6/0.4 kV) from the 1960s and 1970s that require constant routine repairs. They have far exceeded their service lives and do not provide the necessary energy security.

Kharkivvodokanal's total annual energy consumption for 2020, 2021, and 2022, overall and separately for water supply, wastewater, and other internal production needs, is provided in Table B.3.

TABLE B.3: ANNUAL ENERGY CONSUMPTION OF KHARKIVVODOKANAL FOR 2020–2022

Year	2020	2021	2022
Total annual energy consumption for water supply (kWh)	217,691,457	209,882,295	168,746,886
Total annual energy consumption for wastewater services (kWh)	57,387,995	61,502,351	44,145,105
Total annual energy consumption for other internal needs (kWh)	476,767	335,877	192,568
Total annual energy consumption of Kharkivvodokanal (kWh)	275,556,219	271,720,523	213,074,559

Reduced energy consumption from 2020 to 2022 is due to population reduction following the Russian Federation's invasion and, as a result, less water consumption.

High-voltage pumping equipment with synchronous electric motors consumes a large portion of the vodokanal's power. These pumps are installed on WPSs of first, second, and third lifts, as well as on large booster pumping stations. Like most of the electrical equipment the team observed, these pumps were put into operation between the 1960s and 1980s and are now well past their service lives.

Frequency control systems have been installed at some WPSs and WWPSs, although they are mostly outdated, and a majority are not operable. Most pumping station motors do not have a soft start/frequency control system, which leads to high energy consumption and low energy efficiency.

Kharkivvodokanal's annual energy effectiveness indicators for 2020, 2021, and 2022 are provided in Table B.4, calculated as the total power consumed by each system per m^3 of water or wastewater produced.

TABLE B.4: ANNUAL ENERGY EFFECTIVENESS INDICATORS OF KHARKIVVODOKANAL FOR 2020–2022

Year	2020	2021	2022
Total annual energy effectiveness of water supply system, kWh/m^3	1.26	1.26	1.21
Annual energy effectiveness of wastewater system, kWh/m^3	0.34	0.36	0.4

B.1.3 KEY CHALLENGES DUE TO THE WAR IN UKRAINE

The proximity of Kharkiv to the Russian-Ukrainian border made the city a target for rocket attacks and artillery fire in the early days of the war. While Kharkiv was never occupied, significant destruction resulted that is still evident today. Ongoing missile attacks by the Russian Federation army on the Ukrainian energy system, which started in October 2022, resulted in massive damage to critical infrastructure in Ukraine as a whole and particularly in the Kharkiv region. This has resulted in a significant reduction in the capacity of high-voltage power lines. **Kharkivvodokanal's water supply and sewage facilities, which use mostly high-voltage equipment, have no backup power lines,** leading to continuous power outages and interruption of water supply and wastewater services. This has resulted in a power generation deficit, and, consequently, emergency and stabilization outages, where districts of the city with no direct damage following an incident still had their power supply shut down to stabilize the grid; loss of power supply (both main input and backup) to the facilities; and failure of old equipment due to constant emergency switching.

During a missile attack on the city in the summer of 2022, a water intake pump was severely damaged, part of the engine room destroyed, and the pumping unit damaged. The remaining part of the building was partially reconstructed and separated from the destruction, but the destroyed pump and much of the building are yet to be replaced. For additional details on incidents, see Section B.2.

Kharkivvodokanal's operations are complicated by emergency and stabilization shutdowns, including disruption of the technological processes and pumping equipment. Power outages and associated shutdowns also reduce the service life of already severely worn-out electrical equipment, forcing Kharkivvodokanal's personnel to carry out constant operational switches and emergency repairs.

Kharkivvodokanal has developed an Emergency Operations Plan (EOP) to ensure the minimum necessary water supply and sewerage in Kharkiv in case of a complete power outage. However, this plan includes some engineering challenges. **WPSs of first and second lifts use mostly high-voltage pumping equipment (6 kV and 10 kV), making it difficult to quickly restore emergency power supply.** Additionally, backup power sources need to be installed on all equipment included in this plan, including high-voltage equipment.

With the support of different funds and financial organizations, the need for backup power supply has been partially covered, but only up to 10% for both the water supply and wastewater systems. Low-voltage (0.4 kV) diesel generators and step-up transformers have been supplied and installed at the pumping stations and to address the WWPSs' backup power supply needs.

B.1.4 PRIORITIZED NEEDS TO ENSURE CONTINUOUS SERVICE DELIVERY

A detailed list of needs with divisions by the priority stages is provided in Annex B.3. The stages are as follows:

- Supply stage 1 (emergency): Equipment needed as soon as possible
- Supply stage 2: Equipment needed within the next three months
- Supply stage 3: Equipment is not needed for at least six to nine months (or longer) or cannot be procured in a short period of time

Stage 1: To increase the resilience of Kharkivvodokanal facilities and systems, the most urgent need is the supply of cable products for emergency repairs (Stage 1). Cable products may cost approximately USD 400,000–440,000, though this is an approximate cost for equipment/materials, excluding any additional costs for delivery.

Cables and cable connectors are needed to replace or restore low- and high-voltage networks and wiring that are currently outdated or damaged and do not meet modern safety requirements for electrical installations, reducing the reliability of the city's water supply and sewage. The supply of cable products is needed for the rapid rehabilitation of Kharkivvodokanal's multiple electrical networks, as well as for emergency works in case of damage incurred during future missile attacks.

Stage 2: To further increase the resilience of Kharkivvodokanal facilities and systems, second priority needs (Stage 2) include the supply and installation of low-voltage control stations with frequency converters, supply and installation of low-voltage diesel generators, and supply and installation of power transformers. The estimated cost of covering Stage 2 needs is USD 1,150,000–1,300,00, though this is an approximate cost for equipment/materials, excluding any additional costs.

Stage 3: Stage 3 needs cover efficiency improvements and are discussed in section B.1.5.

Low-voltage control stations with frequency converters

Before supplying low-voltage emergency power supply equipment, control stations need to be installed with frequency regulation of the pumping equipment's induction motors. Kharkivvodokanal technical personnel can install low-voltage control stations (0.4 kV) with support from the manufacturer (either in person or virtually), including commissioning the equipment and training operating personnel. Prior to ordering the control stations, a questionnaire should be filled out for the manufacturer with key specifications. The results of this questionnaire can be the basis for any tender procedure, as they represent the customer's technical requirements.

Low-voltage diesel generators

Low-voltage generators are required to power the water supply and wastewater systems' low-voltage equipment in line with the EOP. These will also allow vodokanal maintenance teams to power electrical equipment and tools during maintenance and repairs to the water supply and wastewater systems around the city and Kharkiv region. Kharkivvodokanal can carry out the installation and connection of low-voltage equipment.

Step-down power transformers (10/0.4 and 6/0.4 kV)

The replacement of these transformers will increase the energy security of the Kharkivvodokanal facilities. A more modern design without the use of liquid-based dielectrics will significantly reduce the fire hazard and lower maintenance and periodic servicing costs. The replacement of Soviet-era oil transformers will reduce the number of electric power equipment failures during frequent emergency switching and starting of pumping equipment—the effect of high incoming currents and sudden voltage increase. Before ordering this equipment, it is necessary to collect additional parameters to ensure correct operation in sync with existing equipment. These parameters may be included in considering tender procedures as the technical requirements of the tenderer.

B.1.5 ENERGY AND OPERATIONAL EFFICIENCY

Several Kharkivvodokanal emergency needs are difficult to address in the short term due to significant engineering and design requirements and extensive procurement timelines (a year or longer). This is particularly relevant for backup power supplies for high-voltage pumping equipment for water supply and wastewater systems. Providing high-voltage (class 10 kV and 6 kV) sources of emergency power supply that will cover some of the needed backup power supply requires multiple engineering and implementation steps going forward.

In line with Kharkivvodokanal's EOP, installation of backup power supply sources for high-voltage pumping equipment and the supply and installation of ultrasonic flow meters are needed. Given the lengthy procurement timelines and uncertainty regarding cost and availability, these needs are considered Stage 3. Procurement of ultrasonic flow meters will cost approximately USD 310,000–350,000. It is not possible to provide costs for high-voltage diesel generators without additional detailed engineering design and consultation with manufacturers.

Backup power supply for high-voltage pumping equipment

High-voltage generators are required to provide backup power to the water supply and wastewater systems' high-voltage equipment in line with Kharkivvodokanal's EOP. The vodokanal's management prefers not to replace their existing high-voltage equipment with low-voltage alternatives. The installation of high-voltage generators will require the installation of a control station with frequency converters on the high-voltage pumping equipment. Due to the lack of data from Kharkivvodokanal, it is not possible to provide further detail regarding these needs.

Ultrasonic flow meters for monitoring of water supply networks

The installation of new and replacement of old ultrasonic flow meters will allow for technological accounting of water supply zones in terms of volume. They will also allow for control of volumes and parameters of resources and understanding of volumes of consumption and create the basis for immediate reaction in case of increase in consumption volumes or identification of leakages.

B.2 KHARKIVVODOKANAL INCIDENTS AND IMPACTS

SUMMARY

Kharkivvodokanal experienced five water and wastewater service disruptions between October 2022 and January 2023. The vodokanal experienced power outages after missile attacks on October 10, October 31, November 23–25, December 16–17, and January 14. On January 10, consumers in Kyivskyi District of Kharkiv lost connection to water and wastewater services after a missile hit a section of water supply pipelines on Shevchenka Street. Kharkivvodokanal has experienced 61 instances of damage to water and wastewater networks (usually water pipelines) since February 24, 2022 (Vodokanal.kharkov.ua 2023a). In total, 1.5 km of water pipelines have been replaced. The Kyivskyi, Saltivskyi, and Industrialnyi Districts incurred the most damage.

INCIDENT 1: OCTOBER 10, 2022

Ukrenergo, an electricity transmission system operator in Ukraine, informed the public about power outages in most of Ukraine's oblasts, including Kharkiv oblast (Kostenko 2022). A Russian missile strike hit one energy facility in Kharkiv oblast (Fedorkova 2022). Associated power outages caused disruptions in water services in Kharkiv. Kharkivvodokanal did not specify whether wastewater services were also disrupted or how long the disruption lasted. Power supply of critical infrastructure, including water and wastewater facilities, was fully restored within a few hours of the missile strike.

INCIDENT 2: OCTOBER 31, 2022

After a Russian missile attack, the mayor of Kharkiv stated that there were "problems with water supply" due to a power outage (Slovoidilo.ua 2022c). Kharkivvodokanal did not specify whether the provision of wastewater services was affected. In some parts of Kharkiv, water supply disruptions lasted for more than 24 hours. In response to an information request, Kharkivvodokanal stated that service delivery resumed after electricity supply was restored. It also mentioned that diesel generators (DGs) were used but did not specify their capacity or what purpose the generators were used for.

INCIDENT 3: NOVEMBER 23, 2022

On November 23, 2022, a missile attack caused a power outage at Kharkivvodokanal. In response to an information request, Kharkivvodokanal stated that water supply services had been disrupted. It did not specify whether wastewater services were affected. On November 25, Kharkivvodokanal stated that water supply services had been completely restored, saying, "all water pumping stations of the Kharkivvodokanal work in the normal mode after resumption of the electricity supply from the network" (Vodokanal.kharkov.ua 2022a). Water and wastewater service disruption lasted for 36 hours.

INCIDENT 4: DECEMBER 16, 2022

On December 16, 2022, water supply service disruptions followed a Russian missile attack. Kharkivvodokanal did not specify how many facilities were disconnected from electricity supply or what Kharkiv districts were disconnected. The local press reported that Kharkiv residents experienced problems with the water supply (Ryazantseva 2022). Additional details were not available on associated impacts to wastewater infrastructure and services. On December 17, Kharkivvodokanal reported on its website that the provision of water services had resumed for all consumers, saying, "water supply of [our] consumers have been completely restored. All water pumping stations are working normally after resumption of a stable supply of electricity" (Vodokanal.kharkov.ua 2022b).

INCIDENT 5: JANUARY 10, 2023

On January 10, 2023, a Russian missile strike damaged two water supply pipelines (300 mm and 150 mm in diameter) located on Shevchenka Street in Kyivskyi District of Kharkiv. To prevent water leakage, the water supply through these pipelines was disconnected by the vodokanal and rerouted through other pipelines. A few private buildings and enterprises were disconnected by the vodokanal for several hours. On January 13, Kharkivvodokanal announced that it had replaced the damaged sections of the pipelines (Vodokanal.kharkov.ua 2023a).

INCIDENT 6: JANUARY 14, 2023

On January 14, 2023, a Russian missile attack caused a power outage in Kharkiv City and oblast (Tsvetkova 2023), resulting in disconnections for Kharkivvodokanal and private households. Kharkivvodokanal did not provide details on the extent of disruption; it only reported that consumers might have problems with water supply (Kharkov.comments.ua 2023). On January 15, Kharkivvodokanal stated that water supply services was restored for all consumers (Vodokanal.kharkov.ua 2023b). Service disruption lasted for approximately 15 hours.

B.3 KHARKIVVODOKANAL EQUIPMENT LIST

Kharkivvodokanal has developed EOP to ensure water and wastewater service delivery during power outages and blackouts. To carry out these plans, Kharkivvodokanal needs both low-voltage and high-voltage equipment. Equipment needs are divided into three stages depending on the level of need (from the most urgent to the least):

- Stage 1: equipment is needed immediately; Stage 1 needs will cost approximately USD 400,000–440,000.
- Stage 2: urgent, equipment is needed within three months; Stage 2 needs will cost approximately USD 1,150,000–1,300,000.
- Stage 3: equipment is not needed for at least six to nine months or longer or cannot be procured in a short period of time. Stage 3 needs will cost at least USD 6,500,000–8,500,000.

The point of contact from Khersonvodokanal for communication regarding equipment procurement and delivery is provided in the table below. All equipment and materials should be delivered to the following address: [information available upon request]. While vodokanals were not able to provide GPS coordinates for facilities, the names of facilities where equipment is to be installed are listed in the tables below and should be referenced when discussing delivery and installation with the vodokanal's point of contact. Costs provided in each row in the subsequent tables are total costs, not per unit costs.

POSITION	NAME	CONTACT PHONE	EMAIL
Director of the Department of Energy Policy	Available upon request	Available upon request	Available upon request

B.3.1 GENERATOR NEEDS

Stage 2: Urgent, equipment is needed within three months.

Justification: The vodokanal requires low-voltage generators to power low-voltage water supply and wastewater system equipment in line with the EOP and to power maintenance teams' electrical equipment and tools during work on water supply and wastewater systems around the city and region.

TABLE B.5: LOW-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL

NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
1	Complex for pumping and treatment water - "Donets" (vul. Kontorska)	Generator	Fuel type: Diesel; Prime Power: 6 kW; Voltage: 220 V; Phase(s): 1-phased; Generator type: portable; Type of transfer switch: manual	4	12,470	Only purchasing of equipment and delivery to the site is required. Installation works will be done by vodokanal personnel
2	Water Treatment Complex - "Donets" (vul. Miru)	Generator	Fuel type: Diesel; Prime Power: 30 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	1	14,317	
3	Complex "Kharkivvodopostachannya" (vul. Hutoryanska)	Generator	Fuel type: Diesel; Prime Power: 36,8 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	1	14,983	
4	Complex "Kharkivvodopostachannya"	Generator	Fuel type: Diesel; Prime Power: 6 kW; Voltage: 220 V; Phase(s): 1-phased; Generator type: portable; Type of transfer switch: manual	12	15,906	
5	Complex "Kharkivvodopostachannya" (vul. Kontorska)	Generator	Fuel type: Diesel; Prime Power: 15 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable;	1	11,339	

TABLE B.5: LOW-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			Type of transfer switch: manual			
6	WPS (vul. Svitla)	Generator	Fuel type: Diesel; Prime Power: 70 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	2	49,737	
7	WPS (vul. Kontorska)	Generator	Fuel type: Diesel; Prime Power: 6 kW; Voltage: 220 V; Phase(s): 1-phased; Generator type: portable; Type of transfer switch: manual	4	5,302	
8	Water Treatment Complex - "Dnipro" (vul. Osipenko)	Generator	Fuel type: Diesel; Prime Power: 10 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	2	8,204	
9	Water Treatment Complex - "Dnipro" (vul. Osipenko)	Generator	Fuel type: Diesel; Prime Power: 15 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	1	11,339	
10	Water Treatment Complex - "Dnipro" (vul. Osipenko)	Generator	Fuel type: Diesel; Prime Power: 25 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable;	1	11,764	

TABLE B.5: LOW-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			Type of transfer switch: manual			
11	Water Treatment Complex - "Dnipro" (vul. Korostelska)	Generator	Fuel type: Diesel; Prime Power: 6 kW; Voltage: 220 V; Phase(s): 1-phased; Generator type: portable; Type of transfer switch: manual	1	1,326	
12	Water Treatment Complex - "Dnipro" (vul. Miru)	Generator	Fuel type: Diesel; Prime Power: 6 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	2	5,717	
13	Complex "Kharkivvodovidvedennya" (vul. Kislovodska)	Generator	Fuel type: Diesel; Prime Power: 15 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	2	22,677	
14	Complex "Kharkivvodovidvedennya" (vul. Grekivska)	Generator	Fuel type: Diesel; Prime Power: 20 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	2	25,283	
15	Complex "Kharkivvodovidvedennya" (vul. Lgovska)	Generator	Fuel type: Diesel; Prime Power: 30 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable;	1	14,317	

TABLE B.5: LOW-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	**LOCATION**	**TYPE**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ ADDITIONAL REQUIREMENTS**
			Type of transfer switch: manual			
16	Complex "Kharkivvodovidvedennya" (vul. Akademichna)	Generator	Fuel type: Diesel; Prime Power: 60 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	1	20,685	
17	Complex "Kharkivvodovidvedennya" (vul. Moiseevska)	Generator	Fuel type: Diesel; Prime Power: 60 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	1	20,685	
18	Complex "Kharkivvodovidvedennya" (vul. Grekivska)	Generator	Fuel type: Diesel; Prime Power: 120 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	1	37,355	
19	Complex for pumping and cleaning wastewater (vul. Biologichna)	Generator	Fuel type: Diesel; Prime Power: 30 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	1	14,317	
20	Complex for pumping and cleaning wastewater (vul. Biologichna)	Generator	Fuel type: Diesel; Prime Power: 60 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable;	6	124,107	

TABLE B.5: LOW-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			Type of transfer switch: manual			
21	Complex for pumping and cleaning wastewater (vul. Biologichna)	Generator	Fuel type: Diesel; Prime Power: 100 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	3	67,678	
22	Complex for pumping and cleaning wastewater (vul. Biologichna)	Generator	Fuel type: Diesel; Prime Power: 250 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	2	109,384	
23	Complex of machines and mechanisms of Kharkivvodokanal (Yvileiniy avenue)	Generator	Fuel type: Diesel; Prime Power: 5 kW; Voltage: 220 V; Phase(s): 1-phased; Generator type: portable; Type of transfer switch: manual	1	2,346	
24	Complex of machines and mechanisms of Kharkivvodokanal (Yvileiniy avenue)	Generator	Fuel type: Diesel; Prime Power: 10 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable; Type of transfer switch: manual	1	9,168	
25	Complex of machines and mechanisms of Kharkivvodokanal (Yvileiniy avenue)	Generator	Fuel type: Diesel; Prime Power: 100 kW; Voltage: 380 V; Phase(s): 3-phased; Generator type: portable;	1	22,560	

TABLE B.5: LOW-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			Type of transfer switch: manual			

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

Stage 3: Equipment is not needed for at least six to nine months, or longer, or cannot be procured in a short period of time.

Justification: The vodokanal requires the supply and installation of alternative power sources, like high-voltage generators, to ensure water supply and wastewater system workability during city blackouts in line with the EOP, to keep the continuous operation of water and WWPSs at the minimal level.

TABLE B.6: HIGH-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
1	Complex for pumping and cleaning wastewater (vul. Biologichna)	Generator	Fuel type: Diesel; Prime Power: 2000 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic; Additional specs: with additional heating of the coolant; with automatic battery charging	1	Requires additional design work for estimation	• For installation of DGs, development of design documentation is required. Additional needs for installation can be identified during design documentation development; • Additional installation of Automatic Reserve Activation (AVR) in the electrical room is required (can be designed and developed by special orders); • Installation, testing and commissioning from representatives of manufacturer is required; • Additional installation of a control station with frequency convertor (FC) on the pumping equipment is required
2	Water Treatment Complex - "Donets." WPS 3 1st lift	Generator	Fuel type: Diesel; Prime Power: 2000 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic; Additional specs: with additional heating of the coolant; with automatic battery charging	1	Requires additional design work for estimation	

TABLE B.6: HIGH-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
3	Water Treatment Complex - "Donets." WPS 3 2nd lift	Generator	Fuel type: Diesel; Prime Power: 2000 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic; Additional specs: with additional heating of the coolant; with automatic battery charging	1	Requires additional design work for estimation	
4	WPS №10	Generator	Fuel type: Diesel; Prime Power: 700 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic; Additional specs: with additional heating of the coolant; with automatic battery charging	1	Requires additional design work for estimation	
5	WPS №25	Generator	Fuel type: Diesel; Prime Power: 700 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic; Additional specs: with additional heating of the	1	Requires additional design work for estimation	

TABLE B.6: HIGH-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
			coolant; with automatic battery charging			
6	WPS №29	Generator	Fuel type: Diesel; Prime Power: 700 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic; Additional specs: with additional heating of the coolant; with automatic battery charging	1	Requires additional design work for estimation	
7	WPS №28	Generator	Fuel type: Diesel; Prime Power: 1000 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic; Additional specs: with additional heating of the coolant; with automatic battery charging	1	Requires additional design work for estimation	
7	WPS №25	Generator	Fuel type: Diesel; Prime Power: 2000 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic;	1	Requires additional design work for estimation	

TABLE B.6: HIGH-VOLTAGE GENERATOR NEEDS FOR KHARKIVVODOKANAL						
NO.	**LOCATION**	**TYPE**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
			Additional specs: with additional heating of the coolant; with automatic battery charging			
8	WPS №25	Generator	Fuel type: Diesel; Prime Power: 2000 kW; Voltage: 6 kV; Phase(s): 3-phased; Configuration: Y; Generator type: stationary; Generator installation: outdoor; Type of transfer switch: automatic; Additional specs: with additional heating of the coolant; with automatic battery charging	1	Requires additional design work for estimation	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

B.3.2 CONTROL STATION WITH FREQUENCY CONVERTER NEEDS

Stage 2: Urgent, equipment is needed within 3 months.

Justification: Installation of control stations with FCs will significantly improve facilities' energy efficiency and increase the reliability of the city's water supply and sewage. A control station with FCs will help to stabilize operation and provide significant energy savings.

TABLE B.7: CONTROL STATION WITH FREQUENCY CONVERTER NEEDS FOR KHARKIVVODOKANAL						
NO.	**LOCATION**	**NAME**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
1	WPS (vul. Oshepkova)	Pumping equipment control station	With frequency converter Motors: 0,75 kW, ~3x380V - 1 pcs.	1	2,000	• For new installation; • Control stations with FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric or Siemens; • Delivery to the site and testing and commissioning need to be done with support of manufacturer representative; • Additional requirements for installation, testing, and commissioning of control stations
2	WPS (Saltivskyi Shosse); WPS (Manushko); WPS (Grekivskiy); WPS (Usenka); WPS (12go Kvitnya); WPS (Geroiv Kharkova); WPS (Roganskiy); WPS (Peremogy)	Pumping equipment control station	Specifications for each site: With frequency converter Motors: 1,5 kW, ~3x380V - 1 pcs.	8	20,000	

TABLE B.7: CONTROL STATION WITH FREQUENCY CONVERTER NEEDS FOR KHARKIVVODOKANAL						
NO.	**LOCATION**	**NAME**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
3	WPS (Petra Grigorenka); WPS (Valtera); WPS (Poltavskiy Shlah); WPS (Fr. Krala); WPS (Klochkivskiy); WPS (Studentskiy)	Pumping equipment control station	Specifications for each site: With frequency converter Motors: 2,2 kW, ~3x380V - 1 pcs.	6	18,000	with FC need to be identified by manufacturer
4	WPS (Electrovozniy)	Pumping equipment control station	With frequency converter Motors: 4 kW, ~3x380V - 1 pcs.	1	4,000	
5	WPS (Tankopia); WPS (Industrialnomu)	Pumping equipment control station	Specifications for each site: With frequency converter Motors: 5,5 kW, ~3x380V - 1 pcs.	2	10,000	
6	WPS (Serhia Grycevicha); WPS (Velikiy Kilceviy)	Pumping equipment control station	Specifications for each site: With frequency converter Motors: 7,5 kW, ~3x380V - 1 pcs.	2	12,000	
7	WPS (Klochkovskiy)	Pumping equipment control station	With frequency converter Motors: 11 kW, ~3x380V - 1 pcs.	1	7,000	
8	WPS (Druzbi Narodiv); WPS (Astronomichniy); WPS (Mohnatskiy)	Pumping equipment control station	Specifications for each site: With frequency converter Motors: 18,5 kW, ~3x380V - 1 pcs.	3	25,000	

* Total price is indicative and includes only the cost of equipment without any additional costs. Price depends on manufacturer, availability, and country where equipment will be ordered.

B.3.3 POWER TRANSFORMER NEEDS

Stage 2: Urgent, equipment is needed within three months.

Justification: The existing Soviet-era oil-filled power transformers of the 1970s and 1980s are well past their lifetimes and cannot provide reliable power supply to facilities. Constant failovers further reduce the life of older transformers that fail in critical situations.

TABLE B.8: POWER TRANSFORMER NEEDS FOR KHARKIVVODOKANAL

NO.	LOCATION	TYPE OF PT	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
1	Complexes for pumping and treatment water - "Donets;" Filter station; Center of Water Treatment №1 and 2	Power Transformer ТМГ-400/6/0,4 У1	3 Phases; Type: Oil; Rated Power: 400 kVA; HV/LV: 6/0,4 kV; Climatic performance (according GOST 15150-69): У1	2	22,000	• For the replacement of old equipment; • Only purchasing of equipment and delivery to the site is required; • Installation works will be done by vodokanal personnel • Before purchasing, specifications of each exact power transformer need to be clarified with vodokanal representatives
2	Center of Water Treatment №1, 1st and 2nd lifts; Internal needs of pumping station	Power Transformer ТМ-250/6/0,4 У1	3 Phases; Type: Oil; Rated Power: 250 kVA; HV/LV: 6/0,4 kV; Climatic performance (according GOST 15150-69): У1	4	35,000	
3	Center of Water Treatment № 2, 1st lift; Internal needs of pumping station	Power Transformer TMA-180 /6/0,4	3 Phases; Type: Oil; Rated Power: 180 kVA; HV/LV: 6/0,4 kV	2	17,500	• Only purchasing of equipment and delivery to the site is required; • Installation works will be done by vodokanal personnel • Before purchasing, specifications of each exact power transformer need to be clarified with vodokanal representatives
4	Center of Water Treatment № 2, 2nd lift; Internal needs of pumping station	Power Transformer TV-315 /6/0,4	3 Phases; Type: Oil; Rated Power: 315 kVA; HV/LV: 6/0,4 kV	2	23,000	
5	Center of Water Treatment № 3, 1st lift; Internal needs of pumping station	Power Transformer TM-250 /6/0,4	3 Phases; Type: Oil; Rated Power: 250 kVA; HV/LV: 6/0,4 kV	2	18,000	
6	Center of Water Treatment № 3, 2nd lift; Internal needs of pumping station	Power Transformer TTU 400 /6/0,4	3 Phases; Type: Oil; Rated Power: 400 kVA; HV/LV: 6/0,4 kV	2	26,000	
7	Pumping Station "Roganska;"	Power Transformer	3 Phases;	1	9,000	

NO.	LOCATION	TYPE OF PT	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
	Internal needs of pumping station	ТМ 200 /6/0,4	Type: Oil; Rated Power: 200 kVA; HV/LV: 6/0,4 kV			
8	Pumping Station "Roganska;" Internal needs of pumping station	Power Transformer ТМ 400 /6/0,4	3 Phases; Type: Oil; Rated Power: 400 kVA; HV/LV: 6/0,4 kV	1	14,000	
9	Chlorotransfusion station "Kochetok;" Internal needs of pumping station	Power Transformer ТМ 320 /6/0,4	3 Phases; Type: Oil; Rated Power: 320 kVA; HV/LV: 6/0,4 kV	1	12,000	
10	Complexes for pumping and treatment water - "Dnipro;" PS №3	Power Transformer ТСЗЛУ-630/10/0,4 У3	3 Phases; Type: Dry; Rated Power: 630 kVA; HV/LV: 10/0,4 kV; Climatic performance (according GOST 15150-69): У3	3	58,000	
11	Complexes for pumping and treatment water - "Dnipro;" PS №3	Power Transformer ТМГФ-630/10/0,4 У1	3 Phases; Type: Oil; Rated Power: 630 kVA; HV/LV: 10/0,4 kV; Climatic performance (according GOST 15150-69): У1	3	63,000	
12	Complexes for pumping and treatment water - "Dnipro;" PS №1	Power Transformer ТМГФ-400/10/0,4 У1	3 Phases; Type: Oil; Rated Power: 400 kVA; HV/LV: 10/0,4 kV; Climatic performance (according GOST 15150-69): У1	2	30,000	
13	Complexes for pumping and treatment water - "Dnipro"	Power Transformer ТМГ-100/10/0,4 У1	3 Phases; Type: Oil; Rated Power: 100 kVA; HV/LV: 10/0,4 kV;	2	4,000	

TABLE B.8: POWER TRANSFORMER NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	TYPE OF PT	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
			Climatic performance (according GOST 15150-69): У1			
14	Complex for pumping and cleaning wastewater	Power Transformer ТМГ-100/6/0,4 У1	3 Phases; Type: Oil; Rated Power: 100 kVA; HV/LV: 6/0,4 kV; Climatic performance (according GOST 15150-69): У1	2	9,400	
15	City sewage treatment facilities "МОСВ №2 Bezludivskiy"	Power Transformer ТМГ-250/6/0,4 У1	3 Phases; Type: Oil; Rated Power: 250 kVA; HV/LV: 6/0,4 kV; Climatic performance (according GOST 15150-69): У1	1	8,600	
16	City sewage treatment facilities "МОСВ №2 Bezludivskiy"	Power Transformer ТМГ-400/6/0,4 У1	3 Phases; Type: Oil; Rated Power: 400 kVA; HV/LV: 6/0,4 kV; Climatic performance (according GOST 15150-69): У1	4	44,000	
17	N/A	Power Transformer ТМГ-630/6/0,4 У1	3 Phases; Type: Oil; Rated Power: 630 kVA; HV/LV: 6/0,4 kV; Climatic performance (according GOST 15150-69): У1	1	20,000	
18	WPS №28, 29	Power Transformer ТМГ-630/6/0,4 У1	3 Phases; Type: Oil; Rated Power: 630 kVA; HV/LV: 6/0,4 kV; Climatic performance (according GOST 15150-69): У1	2	40,000	

* Total price is indicative and includes only the cost of power transformers, without any additional delivery costs.

B.3.4 CABLE PRODUCT NEEDS

Stage 1: Equipment is needed immediately.

Justification: Some electrical networks and wiring do not meet modern electrical installation safety requirements, which reduces the reliability of the city's water supply and sewage. Kharkivvodokanal requires a supply of cable products for the rapid rehabilitation of multiple electrical networks, as well as for emergency repairs in case of damage from missile and artillery attacks.

TABLE B.9: CABLE PRODUCT NEEDS FOR KHARKIVVODOKANAL					
NO.	**NAME**	**SPECIFICATIONS**	**LENGTH, QUANTITY**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
1	Power Cable АВВГ 4x2,5 мм^2	Electric conductor: Aluminum; Number cross-section wires: 4; Cross-Section, mm²: 2,5; Insulation: PVC plastic	500 m	220	• Only purchasing of cable products and delivery to the site is required; • Installation and rehabilitation works will be done by vodokanal personnel
2	Power Cable АВВГ 4x4 мм^2	Electric conductor: Aluminum; Number cross-section wires: 4; Cross-Section, mm²: 4; Insulation: PVC plastic	200 m	120	
3	Power Armored Cable ААШв 3x185 мм^2	Armore: aluminum reinforcement; Electric conductor: Aluminum; Number cross-section wires: 3; Cross-Section, mm²: 185; Insulation: impregnated paper	200 m	10,500	
4	Power Armored Cable ААШв 3x120 мм^2	Armore: aluminum reinforcement; Electric conductor: Aluminum; Number cross-section wires: 3; Cross-Section, mm²: 120; Insulation: impregnated paper	50 m	2,000	
5	Power Armored Cable ААБл 3x185 мм^2	Armore: steel reinforcement Electric conductor: Aluminum; Number cross-section wires: 3; Cross-Section, mm²: 185; Insulation: impregnated paper	2,000 m	102,000	
6	Power Armored Cable АСБб 3x185 мм^2	Armore: steel reinforcement Electric conductor: Aluminum; Number cross-section wires: 3; Cross-Section, mm²: 185;	800 m	51,000	

TABLE B.9: CABLE PRODUCT NEEDS FOR KHARKIVVODOKANAL					
NO.	**NAME**	**SPECIFICATIONS**	**LENGTH, QUANTITY**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
		Insulation: impregnated paper			
7	Flat Power Armored Cable КПБП 3x25 мм2	Armore: steel reinforcement Electric conductor: Couper; Number cross-section wires: 3; Cross-Section, mm²: 25; Insulation: HDPE	200 m	2,600	
8	Power Armored Cable ААБл 3x95 мм²	Armore: steel reinforcement Electric conductor: Aluminum; Number cross-section wires: 3; Cross-Section, mm²: 95; Insulation: impregnated paper	1,400 m	59,000	
9	Power Armored Cable ААБл 3x70 мм²	Armore: steel reinforcement Electric conductor: Aluminum; Number cross-section wires: 3; Cross-Section, mm²: 70; Insulation: impregnated paper	3,400 m	130,000	
10	Self-Supporting Insulated Wire СИП 4x25	Electric conductor: Aluminum; Number cross-section wires: 4; Cross-Section, mm²: 25; Insulation: Cross-linked polyethylene	2,000 m	6,000	
11	Wire ПВС 3x2,5	Electric conductor: Couper; Number cross-section wires: 3; Cross-Section, mm²: 2,5; Insulation: PVC plastic	300 m	400	
12	Wire ПВ-3 1x50	Electric conductor: Couper; Number cross-section wires: 1; Cross-Section, mm²: 50; Insulation: PVC plastic	700 m	5,700	
13	Cable Connector Heat Shrink Tubing 3 СТТП-10 70-120	Number of cores: 3; Voltage (no more): 10 kV; Cross-Section, mm²: 70-120; Connection method: Bolt	100 pcs	11,000	
14	Cable Connector Heat Shrink	Number of cores: 3; Voltage (no more): 10 kV;	100 pcs	13,300	

TABLE B.9: CABLE PRODUCT NEEDS FOR KHARKIVVODOKANAL					
NO.	NAME	SPECIFICATIONS	LENGTH, QUANTITY	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
	Tubing 3 СТТП-10 150-240	Cross-Section, mm²: 150-240; Connection method: Bolt			
15	Power Armored Cable ААБ-6 3x120 мм^2	Armore: steel reinforcement Electric conductor: Aluminum; Number cross-section wires: 3; Cross-Section, mm²: 120; Insulation: impregnated paper	100 m	4,800	
16	Power Cable АВВГ 4x25 мм^2	Electric conductor: Aluminum; Number cross-section wires: 4; Cross-Section, mm²: 25; Insulation: PVC plastic	300 m	800	
17	Power Cable АВВГ 4x16 мм^2	Electric conductor: Aluminum; Number cross-section wires: 4; Cross-Section, mm²: 16; Insulation: PVC plastic	300 m	600	

* Total price is indicative and includes only the cost of cable products, without any additional delivery costs.

B.3.5 ULTRASONIC FLOW METER NEEDS FOR MONITORING WATER SUPPLY NETWORKS

Stage 3: Equipment is not needed for at least six to nine months, or longer, or cannot be procured in a short period of time.

Justification: Installation of new and replacement of old ultrasonic flow meters will allow for technological accounting of water supply zones and control of the volumes and parameters of resources, understanding of consumption volumes, and creating the basis for immediate reaction in case of increase in consumption volumes.

TABLE B.10: ULTRASONIC FLOW METER NEEDS FOR KHARKIVVODOKANAL						
NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
1	Multiple water supply zones in the Kharkiv city of (on water supply networks)	Ultrasonic Flow Meters	Ultrasonic Flow Meter УВР 011А1.1	51	174,420	• For new installation; • Only purchasing of equipment and delivery to the site is required; • Installation works will be done by vodokanal personnel • Before purchasing, diameters of each Ultrasonic Flow Meter need to be confirmed with vodokanal representatives
2	Main water pipelines (branches of	Ultrasonic Flow Meters	Ultrasonic Flow Meter УВР 011А1.1	34	116,280	• For replacement of outdated equipment;

TABLE B.10: ULTRASONIC FLOW METER NEEDS FOR KHARKIVVODOKANAL						
NO.	**LOCATION**	**NAME**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
	regional consumers) of the Complexes for pumping and treatment water "Donetsk" and "Dnipro"					• Only purchasing of equipment and delivery to the site is required; • Installation works will be done by vodokanal personnel • Before purchasing, diameters of each Ultrasonic Flow Meter need to be confirmed with vodokanal representatives
3	Artesian wells of the I elevation of the water supply section for Piatykhatky village	Ultrasonic Flow Meters	Ultrasonic Flow Meter УВР 011А1.1	5	17,100	

* Total price is indicative of the most expensive model and includes only the cost of equipment, without associated delivery costs.

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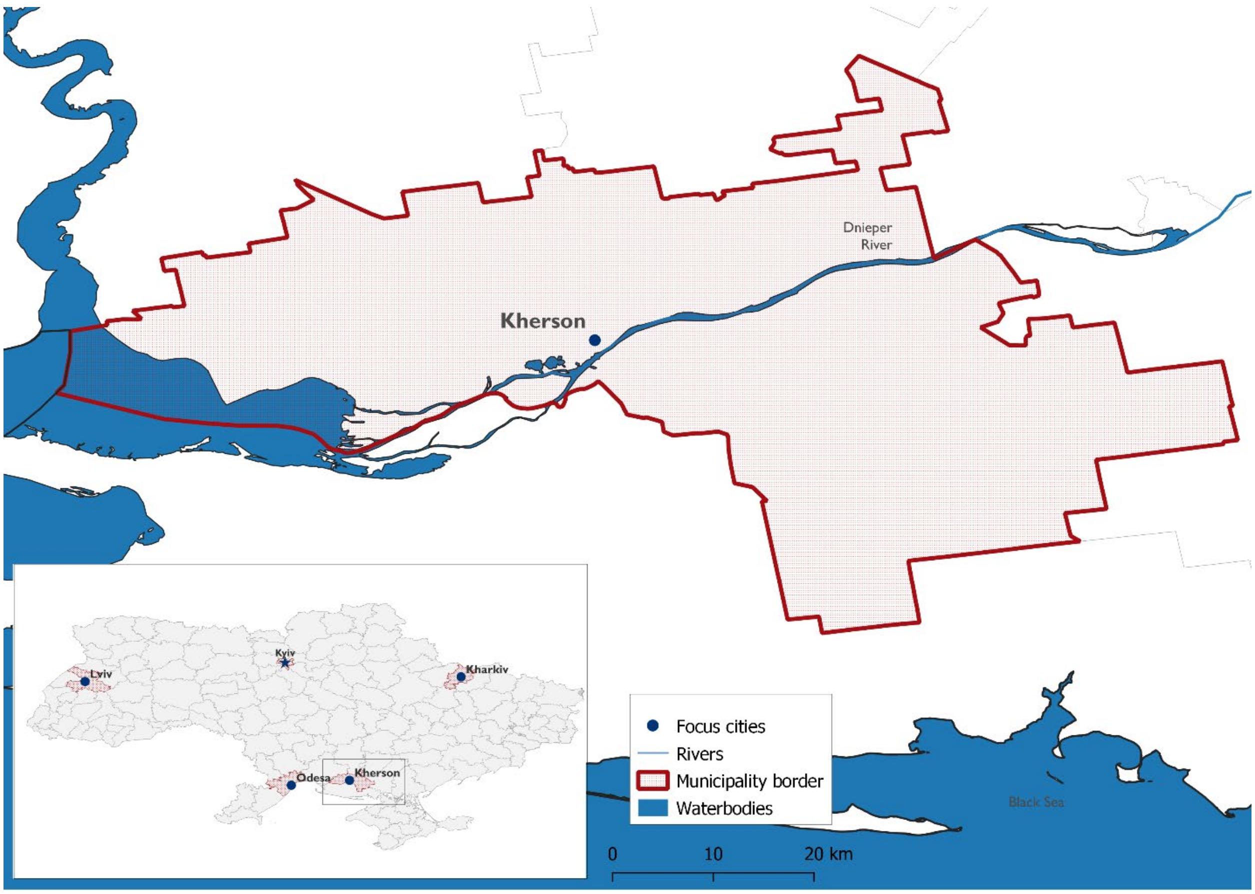
ANNEX C: KHERSONVODOKANAL

KHERSON
Municipal City Enterprise Production (MCE) Department of Water Supply and Sewerage of Kherson City (Khersonvodokanal) Pre-War Population (# of people): **279,131** Current Population (# of people): **~55,000** Net Population Change: **-81%** Pre-War Employees (# of staff): **929** Current Employees (# of staff): **600** Net Employee Change: **-35%**



C.1 KHERSONVODOKANAL PROFILE

Summary

- A significant portion of Khersonvodokanal's power supply infrastructure was previously transferred from high- to low-voltage equipment with the additional installation of frequency controllers. These modifications and outside support from donors and other organizations have met nearly all the vodokanal's backup power needs.
- The Khersonvodokanal facilities were commissioned in the 1970s and 1980s, but since then the electric power equipment has not been replaced or reconstructed. Given that most water supply and wastewater infrastructure was constructed during the Soviet era, Khersonvodokanal personnel carry out extensive repairs and remain dependent on components produced in Russia and Belarus. Existing electrical equipment does not provide the necessary energy security, as it has repeatedly failed to perform at critical times. Kherson's location results in constant shelling of the city by the Russian army, with facilities and operations and maintenance personnel often coming under fire. This causes continuous day-to-day unpredictable damage to Khersonvodokanal's assets that requires immediate repair, producing a great need for repairs and replacement of equipment. No contractors are currently willing to work in the city.
- Stage 1 needs will cost approximately United States dollar (USD) 290,000–310,000, Stage 2 needs will cost approximately USD 160,000–180,000, and Stage 3 needs will cost approximately USD 650,000–700,000.

Site Visit Overview

Three CDM Engineering Ukraine engineers conducted Khersonvodokanal's site visit between February 21 and 23, 2023. During the site visits, multiple meetings with Khersonvodokanal management took place, as well as tours of water pumping stations (WPSs), wastewater pumping stations (WWPSs), and the wastewater treatment plant (WWTP).

General Overview

Municipal Communal Enterprise (MCE) "VUVKH of Kherson" (Khersonvodokanal) is a utility company founded in 1886 to provide water supply and wastewater services to Kherson residents. Prior to the Russian invasion in March 2022, Khersonvodokanal had 929 employees providing water supply and wastewater services to 284,000 residents and 6,657 enterprises and organizations. Kherson relies entirely on groundwater for its water supplies, sourced from 146 artesian wells, supplied through six main pumping stations of the second lift and 63 pumping stations of the third lift to 929 km of piped networks. Raw sewage is collected and transported along 297 km of pipelines to 17 sewage pumping stations and city treatment facilities and is ultimately discharged into the Viryovchyna River. Given that the city is supplied entirely by groundwater, there is no drinking water treatment plant, though drinking water is disinfected with hypochlorite before being discharged to the network.

Most of the pipe networks were built and put into operation decades ago. The standard amortization service life of these pipelines is 20 years, and to date, 55% of the pipelines have reached or exceeded their standard service life (498 km out of 929 km of water supply networks and 171 km out of 297 km of sewerage networks). To supply energy to the water and wastewater facilities, the company maintains 38 transformer substations and 110 km of cable power transmission lines.

Between March and October 2022, Kherson was occupied by Russian Federation armed forces. During the occupation, scheduled maintenance of the water supply and sewage system was not performed, resulting in significant deterioration of the networks. After the liberation of Kherson, the number of inhabitants was between 50,000 and 55,000 and the vodokanal maintained 600 employees.

Since liberation, Kherson has been subjected to daily artillery fire. As a result, the Khersonvodokanal central administration building and central control room were completely destroyed; computer equipment, servers, and archives were burned; and staff were injured or killed. The loss of data and records made it difficult to collect general information about the company for this assessment. The team gathered information from discussions with Khersonvodokanal operational staff and through direct visits to the facilities, direct observation of the equipment, and assessment of current conditions.

During their retreat, Russian Federation troops took with them the most recently acquired specialized equipment (loaders, excavators, sludge trucks, trucks, computers, servers, etc.); what was not taken was heavily damaged. The Khersonvodokanal staff currently work on Soviet machinery from the 1980s, which they have repaired and restored with their own resources. After the liberation, Kherson was without electric power for 21 days. As a result, water intakes, WPSs, WWPSs, and the WWTP were de-energized, and Kherson had no centralized water supply or sewage system during this period. By the beginning of December 2022, Khersonvodokanal, the national electricity transmission operator Ukrenergo, and the local distribution system operator had restored electricity and water supply to the city and centralized wastewater collection services.

Khersonvodokanal does not supply treated water for the heating network, as MCE "Khersonteploenergo" provides heat from a regional combined heat and power plant that has its own groundwater water intake and water treatment system.

C.1.1 OVERVIEW OF NETWORK AND FACILITIES

Water System Overview

TABLE C.1: WATER SYSTEM OVERVIEW – KHERSONVODOKANAL

	CATEGORY	DATA	NOTES
WATER	Water Intakes	2	Both are groundwater intakes.
	Capacity of Water Intakes (m^3/day)		Data not available.
	Source Types	Groundwater	
	Groundwater Wells	146	
	Max. Well Depth (m)		Data not available.
	Surface Water Bodies	N/A	Only supplied by groundwater.
	Length of Water Distribution Pipelines (km)	929	
	Water Pipe Max. Diameter (m)		Data not available.
	(Main) Water Pumping Stations	6	
	(Local) Water Pumping Stations	63	
	Treatment Plant Capacity (m^3/day)	N/A	Drinking water is not treated, only disinfected prior to distribution.
	Treated Water Storage Capacity (m^3/day)		Data not available.
	Pre-War Demand (m^3/day)	60,000	
	Current Water Demand (m^3/day)	20,000–27,000	
	Change in Water Demand (m^3/day)	-55%–-67%	
	Pre-War Supply (m^3/day)		Data not available.
	Current Supply (m^3/day)		Data not available.
	Change in Supply		Data not available.
	Water Provided to Teploenergos (m^3)	0	

Before the occupation, total water consumption was 60,000 m^3/day. Today, water consumption is between 20,000 and 27,000 m^3/day. The main cascade of wells that supply the city is in the village of

Antonovka, approximately 8 km northeast of Kherson. At the time of the assessment, Antonovka is under constant attack from the Russian army, resulting in the loss of power to the wells. Repair personnel from Khersonvodokanal and the local power grid service providers are unable to restore power supply to these wells given the direct attacks by Russian Federation soldiers. Several attempts to restore power to the wells proved unsuccessful. To address this challenge and supply clean water to the city, Khersonvodokanal brought online reserve wells drilled in 2018 as backup sources. The capacity of these wells does not cover the pre-war needs of the city, though current water consumption has decreased such that these additional wells provide sufficient supply. Following de-occupation of the left-bank portion of Kherson oblast, Kherson will likely start to see its population return, thus increasing the city's water demand and consumption. To address this issue, the power supply to the main cascade of wells requires prompt restoring.

Khersonvodokanal has established source water protection zones (or sanitary protection zones) for water supply sources around existing wells to preserve groundwater quality and prevent contamination. In the area of the sanitary protection zones, some of the WPSs, WWPSs, and WWTP have suffered attacks, leading to broken windows and doors and partially damaged building structures. Operations and maintenance personnel are repairing this type of damage.

Wastewater System Overview

TABLE C.2: WASTEWATER SYSTEM OVERVIEW – KHERSONVODOKANAL

	CATEGORY	DATA	NOTES
WASTEWATER	Length of Sewerage Network (km)	297	
	Main Collector Pipes		Data not available.
	Wastewater Pumping Stations	17	
	Treatment Plant Capacity (m^3/day)	250,000	
	Pre-War Total Wastewater Flow (m^3/day)	60,000	
	Current Total Wastewater Flow (m^3/day)	35,000	
	Change in Total Wastewater Flow	-42%	

The existing sewage treatment plant was constructed and put into operation in 1974 with a capacity of 100,000 m^3/day, and later increased to 250,000 m^3/day. The 83-hectare sewage treatment plant complex consists of mechanical and biological treatment and sludge fields. Mechanical treatment consists of an intake section, sand traps, and grease traps. The wastewater is then fed to biological treatment, which consists of squeeze tanks and secondary settling tanks. The facilities also contain a sludge treatment line. Due to population decline and closure of industrial enterprises due to the war, the maximum daily wastewater flow rate has decreased significantly from 60,000 m^3/day before the war to about 35,000 m^3/day today. This results in sub-optimal operation of the equipment and concomitant wear and damage.

C.1.2 POWER NEEDS AND SUPPLY

The Khersonvodokanal facilities were commissioned in the 1970s and 1980s, but since then the electric power equipment has not been replaced or reconstructed. Khersonvodokanal has converted all high-voltage pump units (6 kV) to low voltage (0.4 kV). For some pumping stations, the vodokanal installed control stations with frequency converters. Before the full-scale military invasion by the Russian Federation, Khersonvodokanal's electricity consumption was 3,000,000 kWh. After the city was liberated, electricity consumption had fallen to 1,000,000 kWh, which is attributed to the decrease in the population.

Given that most water supply and wastewater infrastructure was constructed during the Soviet era, Khersonvodokanal personnel carry out extensive repairs and remain dependent on components produced in Russia and Belarus. Existing electrical equipment does not provide the necessary energy security, as it has repeatedly failed to perform at critical times. This is particularly acute under conditions of constant emergency switching (related to the shelling of the energy system), incoming currents, and sudden changes in voltage. The equipment requires additional containment resources (e.g., to eliminate oil leaks) and is not energy efficient.

Existing power step-down transformers (6/0.4 kV) are oil-immersed, Soviet-type transformers from the 1960s and 1970s, which need constant routine repairs and are fire hazards under conditions of repeated shelling (in which oil can catch fire on impact). Since the transformers have far exceeded their life expectancies, they do not provide the necessary energy security. The contactors, circuit breakers, switches, and high-voltage cells are all operating well past their service lifetimes and their performance is maintained by regular maintenance and overhauls. The switchgear and safety equipment also do not provide the necessary energy security.

Electrical control rooms lack modern reactive power compensation equipment, increasing grid losses and potentially impacting overall energy efficiency.

The centralized water supply and wastewater disposal facilities in Kherson are provided with 97% of needed backup power sources. The remaining three percent are in an area of the city under ongoing attack and control of the Russian Federation forces. Backup power sources consist of low-voltage diesel generators (0.4 kV), mainly supplied by local volunteer organizations and international donors, and are of different brands and manufacturers, resulting in difficult planning for maintenance needs and the purchase of consumables (e.g., fuel). During blackouts, diesel generators consume a significant amount of fuel, averaging 10,000 liters per month. Inefficient diesel consumption is seen at sites where there is no frequency control or soft start. Diesel generators operate with power factors below the nominal rating (high starting currents, which are reduced by several times after the pump has reached its nominal capacity), and there is a risk of overloading when starting the pumping units. There is no centralized fuel metering system at Khersonvodokanal and given the number of facilities and their dispersed geographic location, this makes it difficult to monitor rational fuel use.

WWTP pumping equipment has no frequency control and no local reactive power compensation, which results in overconsumption of electricity and negative effects of high incoming currents. Due to the process at the WWTP and WWPSs, there are increased concentrations of hydrogen sulfide in the rooms and facilities, including the switchgear rooms. This leads to oxidation of the copper contacts, sulphate deposits on surfaces, and deterioration of electrical contacts. As a result of H_2S degradation, old switchgear and electrical safety equipment at these facilities are in very bad condition, which typically requires complete removal and replacement of any copper wiring and associated components. This also commonly causes malfunctioning instrumentation. Sludge pumps have no frequency control and are operating at flow rates well above optimal levels due to a reduction in overall wastewater flow since the Russian Federation's invasion. They take up and pump not only raw sludge but also the water that needs to be conveyed to the active bioremediation zone in the aeration tanks, disrupting not only the cleaning technology but also wasting electrical energy. Additional installation of pump control panes with frequency convertors on the sludge pump will solve this issue.

Electric boilers provide heat supply for Khersonvodokanal. The ratio of electrical to thermal energy is less than 1.0, which does not meet today's energy efficiency requirements and increases the load on the electrical equipment.

C.1.3 KEY CHALLENGES DUE TO THE WAR

Historically, the power system in the southern regions of Ukraine has experienced a capacity deficit. This was a problem even before the war, addressed by state transmission and distribution company

Ukrenergo building a new 750-kV high-voltage line and 750/330 kV substation, Kakhovskaya. Connections from the vodokanal's facilities to this infrastructure were lost during the temporary occupation of Kherson. Over the course of the last year and since the onset of direct attacks by the Russian Federation on power supply infrastructure, this problem has worsened greatly, reaching a tipping point when missile strikes targeted transformer substations and caused power outages in the city. Improving energy efficiency and energy security of critical infrastructure in southern Ukrainian cities, including Kherson, remains vital for addressing the needs of the population. For a full list of incidents and impacts, see Section C.2.

Since the Russian Federation's invasion in February 2022, Khersonvodokanal continues to operate under difficult conditions. **A significant reduction in the population of Kherson** resulted in a substantial decline of water consumption and wastewater discharge. In addition, the number of Khersonvodokanal staff decreased due to lack of financing and safety situation in the city, including the recent occupation by Russian Federation armed forces.

Kherson's location results in constant shelling of the city by the Russian army, with facilities and operations and maintenance personnel coming under fire. This causes **continuous day-to-day unpredictable damage to different assets of Khersonvodokanal** that requires immediate repair. Military operations damaging critical energy infrastructure of the city leads to **periodic loss of power supply** to critical Khersonvodokanal facilities. Running outdated electrical equipment in emergency modes due to continued loss and restoration of the power supply causes a detrimental effect on their performance, resulting in constant breakdowns and instability of water supply and wastewater systems.

Importantly, **no contractors are currently willing to implement work in the city, considering the enormous risks.** Khersonvodokanal staff carry out all repairs and daily maintenance works.

C.1.4 PRIORITIZED NEEDS TO ENSURE CONTINUOUS SERVICE DELIVERY

Needs fall under three phases depending on specific needs and installation capacity of Khersonvodokanal, the current state of facilities, and emergency operation scenarios. This simplifies delivery and prevents the accumulation of equipment in storage, which is dangerous for Kherson. A detailed list of needs with divisions by the priority stages is provided in Annex C.3. The stages are:

- Supply stage 1 (emergency): Equipment needed as soon as possible.
- Supply stage 2: Equipment needed within the next three months.
- Supply stage 3: Equipment is needed in at least six to nine months (or longer) or cannot be procured in a short period of time.

Considering the difficult situation around the city, prioritized needs include the supply of materials for emergency repairs of continuously damaged infrastructure, replacements for outdated infrastructure, and improved energy efficiency and energy security for Khersonvodokanal. Prioritization also considered how quickly and efficiently Khersonvodokanal maintenance personnel can assemble the equipment, given the current security challenges and likely inability to procure contractor services for installation and repairs. Khersonvodokanal is receiving support from United Nations Children's Fund (UNICEF) and International Committee of the Red Cross (ICRC), who provided needed pumping equipment. To prevent duplication, this assessment excludes pumping equipment needs.

The following priorities were identified for Khersonvodokanal based on this assessment:

- Step-down transformers
- Pumping equipment control stations

- Automatic reactive power compensation installations
- Low-voltage (0.4 kV) switching and protection equipment
- Metering units for treated water and wastewater facilities

Additionally, artillery and air attack recovery considerations should be made for materials required for operational and emergency repairs. For example, this includes cable products with couplings, steel pipes for the installation of repair inserts, and building materials.

Stage 1: As a first priority (Stage 1), power transformers, control stations, electrical switchgear and cable products, and materials for urgent repair of damaged infrastructure need to be provided. The provision of equipment recommended under Stage 1 will cost approximately USD 290,000–310,000 (only equipment/materials, without costs for delivery and pumps control stations with frequency converters).

Stage 2: As a second priority (Stage 2), replacement equipment is needed to increase the stability of water supply and wastewater system. Provision of equipment recommended under Stage 2 will cost approximately USD 160,000–180,000 (only equipment/materials, without costs for delivery and pump control stations with frequency converters). Additional details are provided in Annex C.

Stage 3: For longer-term needs (Stage 3), additional power transformers and electrical cables with switchgears are needed. Addressing Stage 3 needs will cost approximately USD 650,000–700,000.

Step-down transformers (6/0.4 kV)

The replacement of transformers will increase energy security for the Khersonvodokanal facilities and a more modern design without the use of liquid-based dielectrics will significantly reduce fire hazards and maintenance and periodic servicing costs. Replacing the Soviet oil transformers will likewise decrease the number of failures of electric power equipment during frequent emergency switching and starting of pumping equipment—the effect of high incoming currents and sudden voltage increase.

By replacing the pumping equipment with modern and more energy efficient equipment, the nominal capacity of the transformers can be reduced. Before ordering equipment, it will be necessary to collect additional parameters from Khersonvodokanal to ensure correct alignment with existing equipment for smooth operation. These parameters may be included in tenders as technical requirements. Replacement of high-voltage fuses and the readjustment of relay protection settings is required to ensure correct operation of the power equipment.

Pumping equipment control stations

Prefabricated, complete factory-assembled control stations save companies design work and significantly reduce installation time. Such control stations include switching and protection equipment as well as automatic control with frequency control or direct/floating start options. Frequency control reduces electricity consumption; improves the efficient use of pumping equipment while reducing wear and tear and ensuring normal operating conditions (at the required operating point); ensures better water supply and wastewater disposal, thanks to automatic regulation and cascade control; and reduces diesel generator output by reducing starting currents and consequently increasing the power factor.

The installation of control stations would provide the greatest impact on the sludge submersible pump control at the WWTP and well pumps at one underground water intake, identified in the equipment list in Annex C.3. To order control stations, it is necessary to communicate with the manufacturing plants to fill in a questionnaire. Results of this questionnaire can be the basis for any tender procedure, as they represent the technical requirements of the customer. Information for the questionnaire would include the number of pumps; capacity and type of motors; rated and starting currents of the pumps; operation algorithm, including operating/standby modes; lengths of power and control cables; distances to the installation sites of measuring sensors, sensor measurement ranges; and additional design documentation depending on site specifications. Khersonvodokanal staff can connect the control stations and their commissioning with the advice of the manufacturers when required. Additional requirements for installation of control stations may require additional design documentation depending on site specifications.

Low-voltage (0.4 kV) switching and protection equipment

The replacement of Soviet-era low-voltage switching equipment (contactors, circuit breakers, breakers) will significantly improve the energy and fire safety of the facilities. Modern switchgear and safety equipment will also reduce the cost of maintenance. New switching and safety equipment will ensure compliance with modern requirements for energy efficiency, fire protection, and energy safety.

C.1.5 ENERGY AND OPERATIONAL EFFICIENCY

Some of the equipment listed in Annex C.1.4 can significantly impact energy efficiency, and the assessment accounted for these considerations.

Pump control stations with frequency convertors

At facilities where the operating point of the pumping equipment changes periodically (throttling), the installation of pumping control stations with frequency control allows for significant energy savings. It also reduces starting currents, which saves significantly on diesel fuel consumption in the case of introducing a backup power supply.

Automatic reactive power compensation units

Local reactive power compensation is an important component in improving the energy efficiency and energy conservation of Khersonvodokanal, as the company operates many asynchronous and synchronous motors. The installation of automatic reactive power compensation units near high-capacity motors will allow:

- Reduction in grid losses by locally reducing the reactive component of currents in the current collectors;
- Reduction in the voltage drop in the networks;
- Reduction in the reactive current load of Soviet generators in power plants, which are operating under critical conditions due to attacks on the power system; and
- Reduction in the operating costs of the Khersonvodokanal to pay for electricity and reduce fuel consumption in the power plants.

These units should be purchased as a complete prefabricated product, as this will simplify delivery and shorten the time required for installation. Additional technical specifications need to be gathered before the procurement of this equipment to provide a faster and more reliable turnaround period with manufacturers. The greatest return on investment will be seen at sites where engines run more than 5,000 hours per year. The assessment team selected priority facilities according to this principle, which are identified in Annex C.3.

Flow meters for monitoring of water supply networks

The installation of new flow meters will allow for better measuring of water supply and wastewater systems by volume. They will also allow for control of volumes and parameters of resources, monitoring consumption, and detecting leakage.

Metering units for treated water and wastewater

The installation of water metering units at well pumps, WPSs, and WWPSs allows for more accurate calculation of real demand for tariff setting. In addition, it helps to make better use of company resources to formulate technical and economic indicators and statistical data and to develop and implement energy efficiency programs.

Diesel metering with global positioning system (GPS) geo-referencing and central data storage

Implementation of a diesel metering system with GPS tracking devices will allow more efficient use of diesel fuel, given the number of facilities and their locations. Military action requires special attention to the digital security of this system. In addition, the assessment team identified several promising projects as near-term, lower-priority interventions that can reduce energy consumption and improve efficiency:

- Installation of heat pumps at facilities, replacing existing electric boilers;
- Installation of solar collectors on sites, replacing existing electric heaters;
- Replacement of water supply and wastewater manifolds (leakage reduction); and
- Construction of a heat pump at the WWTP to utilize low-potential heat energy from wastewater.

Given that Khersonvodokanal's WWTP has only one underground wastewater intake, the wastewater coming to the treatment plant has a lot of low-potential energy that is currently discharged into the environment instead of being utilized for the benefit of the facilities.

However, these activities can be implemented only as pilots in some stations. These pilot projects can help to assess the economic impact and calculate specific technical and economic indicators, which will form the basis of future interventions to address the facilities' needs.

Future projects that require a long lead time but can improve operations and energy efficiency at Khersonvodokanal include:

- Biogas production from sludge disposal in the WWTP;
- Development of biogas cogeneration at the WWTP;
- Creating fertilizer for farms by recycling sludge in the WWTP (Kherson region is agricultural); and
- Construction of a solar power plant in the sanitary protection zone of the WWTP.

Today, sludge treatment and disposal do not produce biogas and compost/fertilizer that could be used for agricultural purposes. The WWTP has a large sanitary protection zone, but the area is currently empty and is not used for generating electricity for local needs. This list of projects should be considered only after the de-occupation of the left bank of the Kherson region.

C.2 KHERSONVODOKANAL INCIDENTS AND IMPACTS

SUMMARY

Kherson was under Russian occupation from March 2 to November 11, 2022. Since February 24, 2022, due to conflict at the Antonivka Bridge that connects the two banks of the Dnipro River, the village of Antonivka, a suburb of Kherson, was disconnected from electricity and water supply (Kvasnevska 2022). During the occupation, Khersonvodokanal functioned in "normal mode" (Water.kherson.ua 2023). Power outages and repeated shelling caused water and wastewater service disruptions in Kherson, an ongoing problem at the time of the assessment. The security risk complicated repair works, especially in Korabelnyi District where it is currently impossible to work. Demining also continues as of the time of this assessment. Most recently, Khersonvodokanal was disconnected from electricity supply from November 6 until December 13, 2022, when the last group of consumers was reconnected to water supply and sewerage services.

INCIDENT 1: AUGUST 25, 2022

On August 25, 2022, local press reported that Kherson was disconnected from electricity and water supplies due to power outages. Russian attacks resulted in the disconnection of two 750 kV lines that supply electricity from the occupied Zaporizhzhia nuclear power plant. Shelling damaged another 330 kV line from Pivdennoukrainska nuclear power plant (Kavun.city 2022). On August 25, the Zaporizhzhia nuclear power plant was shut down due to shelling; two power units (#5 and #6) were disconnected from the network after shelling from Russian troops previously damaged three of the station's four electricity supply lines, and the last, fourth, line of PL-750 kV "Dniprovska" was disconnected twice due to a fire at the ash dumps. (Berezyna 2022). The same day, two of the power lines were reconnected to the power plant. Electricity and water supply in Kherson resumed in the evening.

INCIDENT 2: NOVEMBER 6, 2022

On November 6, 2022, Kherson lost access to electricity and water supplies (Gevko 2022). In addition, the city had no water supply and sewerage services. The Operational Command "South" reported that occupation authorities in Kherson intentionally disconnected electricity and water supply to force residents of the city to evacuate alongside Russian Federation forces. First Deputy Chairman of the Kherson Regional Council said that the power outage took place after the Russian Federation army damaged a high-voltage transmission line. When the city was liberated on November 11, repair works began. On November 28, the head of the Kherson Regional Administration stated that electricity supply had resumed to the city wastewater treatment facilities, WPS #4, and sewage pumping stations #4, #5, #12, and #13. He also said that 24% of the city had been reconnected to electricity supply from the network (Kravchenko 2022a). On November 30, the head of the Kherson Regional Administration reported that repair works continued, stating that "the centralized water supply is resuming after the pumping stations are reconnected to electricity supply. For now, water is given with reduced pressure" (Slovoidilo.ua 2022d). Water trucks delivered drinking water during much of this time.

On December 4, the head of the Kherson Regional Administration stated that a WPS that provided water to 70% of consumers was again operational (Interfax.com.ua 2022b). On December 13, deputy head of the Office of the President of Ukraine stated that "centralized water supply has been restored to 90% of consumers" (Interfax.com.ua 2022a). In total, service disruption lasted from November 6 to December 13.

INCIDENT 3: DECEMBER 3, 2022

In response to an information request, Khersonvodokanal announced a partial disruption of services on December 3, 2022, due to shelling. No additional information was available on water and wastewater service disruptions and additional associated impacts. On December 3, 2022, Khersonvodokanal was still working on completely restoring the services to all consumers disrupted after shutdown on November 6, 2022.

INCIDENT 4: DECEMBER 26, 2022

In response to an information request, Khersonvodokanal stated on December 26, 2022, that a shelling had caused a partial disruption of services. No additional details were provided on disruptions to and impacts on water and wastewater services. According to Kherson City Council, "as a result of constant heavy shelling by Russian troops, an extremely dangerous situation has developed in the Korabelny District of Kherson. Many houses do not have electricity and heat supply, water, and some do not have gas" (Slovoidilo.ua 2022b).

INCIDENT 5: JANUARY 19, 2023

In response to an information request, Khersonvodokanal stated that shelling on January 19, 2023, had caused a partial disruption of services. The vodokanal provided no additional details on disruptions to and impacts on water and wastewater services.

C.3 KHERSONVODOKANAL EQUIPMENT NEEDS

After liberation, Kherson was fully provided with backup power sources and Khersonvodokanal no longer needs backup diesel generators. Khersonvodokanal does not have an explicit Emergency Operations Plan (EOP) because of the constant rocket and artillery attacks on the city, creating different challenges each day. The unique situation around the city creates specific needs for both low-voltage and high-voltage equipment and materials for the replacement of damaged and outdated equipment and urgent repairs. Considering the safety satiation around the city, Khersonvodokanal maintenance personnel prioritized equipment that they can assemble quickly and efficiently, given the current difficult circumstances and challenge of hiring contractors.

Equipment needs and supplies are divided into three stages depending on the level of need (from the most urgent to the least):

- Stage 1: Equipment is needed immediately. Stage 1 needs will cost approximately USD 290,000–310,000.
- Stage 2: Urgent; equipment is needed within three months. Stage 2 needs will cost approximately USD 160,000–180,000.
- Stage 3: Equipment is not needed for at least six to nine months or longer or cannot be procured in a short period of time. Stage 3 needs will cost approximately USD 650,000–700,000.

The table below provides the point of contact from Khersonvodokanal for communication regarding equipment procurement and delivery. All equipment and materials should be delivered to the following address: [information available upon request]. While vodokanals were not able to provide GPS coordinates for facilities, the names of facilities where equipment is to be installed are listed in the tables below and should be referenced when discussing delivery and installation with the vodokanal's point of contact. Costs provided in each row in the subsequent tables are total costs, not per unit costs.

POSITION	NAME	CONTACT PHONE	EMAIL
Director	Available upon request	Available upon request	Available upon request

C.3.1 POWER TRANSFORMER NEEDS

Justification: The existing Soviet-era oil-filled power transformers from the 1970s and 1980s are well past their lifetimes and cannot provide reliable power supply to facilities. Constant equipment failures further reduce the lifespan of older transformers, often during critical times such as continuous power outages and short circuits in electrical networks.

TABLE C.3: POWER TRANSFORMER NEEDS FOR KHERSONVODOKANAL

NO.	LOCATION	TYPE OF PS	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
			STAGE 1			
1	WWTP	Power Transformer TRV-630/6/0,4	Type: Dry Rated capacity: 630 kVA Voltage: 6/0,4 kV	2	50,000	Khersonvodokanal maintenance and operations personnel can carry out the installation work. Delivery to Kherson is required. Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer.
2	WWPS-1	Power Transformer TRV-250/6/0,4	Type: Dry Rated capacity: 250 kVA Voltage: 6/0,4 kV	2	35,000	
3	WWPS-2	Power Transformer TRV-250/6/0,4	Type: Dry Rated capacity: 250 kVA Voltage: 6/0,4 kV	2	35,000	
4	WWPS-6	Power Transformer TRV-250/6/0,4	Type: Dry Rated capacity: 250 kVA Voltage: 6/0,4 kV	1	20,000	
			STAGE 2			
5	WWPS-7	Power Transformer TRV-400/6/0,4	Type: Dry Rated capacity: 400 kVA Voltage: 6/0,4 kV	2	40,000	Khersonvodokanal maintenance and operations personnel can carry out the installation work. Delivery to Kherson is required. Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer.
6	Main WWPS	Power Transformer TRV-160/6/0,4	Type: Dry Rated capacity: 160 kVA Voltage: 6/0,4 kV	2	35,000	
7	Garage of special machinery	Power Transformer TRV-160/6/0,4	Type: Dry Rated capacity: 160 kVA Voltage: 6/0,4 kV	1	15,000	
			STAGE 3			
8	WWPS-12	Power Transformer TRV-315/6/0,4	Type: Dry Rated capacity: 315 kVA Voltage: 6/0,4 kV	2	40,000	Khersonvodokanal maintenance and operations personnel can carry out the installation work. Delivery to Kherson is required. Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer.
9	WPS-1, Radial water intake	Power Transformer TRV-315/6/0,4	Type: Dry Rated capacity: 315 kVA Voltage: 6/0,4 kV	1	20,000	
10	WPS-5	Power Transformer TRV-250/6/0,4	Type: Dry Rated capacity: 250 kVA Voltage: 6/0,4 kV	2	35,000	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

C.3.2 CONTROL STATION NEEDS

Justification: The installation of control stations will significantly improve the energy efficiency of the facility and increase the reliability of the city's water supply and sewage.

Water intake wells at WWTP-4 are started in manual mode without cascade control and frequency regulation, resulting in excessive energy consumption and wear and tear on equipment.

Due to the reduced population, the hourly wastewater flow decreased considerably. As a result, the silt pump at the WWTP is currently oversized. A control station with an FC will help to stabilize its operation and provide significant energy savings.

TABLE C.4: CONTROL STATION NEEDS FOR KHERSONVODOKANAL

NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	INDICATIVE PRICE, USD	NOTES
STAGE 1 (EMERGENCY)						
1	WPS-4, water intake wells	Pumping equipment control station	With frequency control Motors: 22 kW, ~3x380V - 6 pcs. 37 kW, ~3x380V - 2 pcs.	1	Requires additional design work for estimation.	Equipment needs to be produced by special orders. Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer. Purchase of spare parts and delivery to the site is required. Installation works by the manufacturer and training of the personnel of the vodokanal is preferable but will depend on the safety situation in the city.
2	WWTP	Pumping equipment control station	With frequency control Motor: 75 kW, ~3x380V	1	Requires additional design work for estimation.	
STAGE 2						
3	WPS-1, Radial water intake	Pumping equipment control station	With frequency control Motor: 75 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	Equipment needs to be produced by special orders. Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer. Purchase of spare parts and delivery to the site is required. Installation works by the manufacturer and training of the personnel of the vodokanal is preferable but will depend on the safety situation in the city.
4	WPS-1, Coast-1	Pumping equipment control station	Direct pump start Motor: 32 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
5	WPS-1, Coast-2	Pumping equipment control station	Direct pump start Motor: 32 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
6	WPS-1, Antonivka village	Pumping equipment control station	Direct pump start Motor: 32 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
7	WPS-1, Coast-3	Pumping equipment control station	Direct pump start Motor: 22 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
8	WPS-1, well №25	Pumping equipment control station	Direct pump start Motor: 11 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	

TABLE C.4: CONTROL STATION NEEDS FOR KHERSONVODOKANAL						
NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	INDICATIVE PRICE, USD	NOTES
9	WPS-1, well №3	Pumping equipment control station	Direct pump start Motor: 11 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
10	WPS-1, well №18	Pumping equipment control station	Direct pump start Motor: 11 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
11	WPS-1, well №5	Pumping equipment control station	Direct pump start Motor: 8 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
12	WPS-1, well №9	Pumping equipment control station	Direct pump start Motor: 5,5 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
13	WPS-1, well №17	Pumping equipment control station	Direct pump start Motor: 5,5 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	
14	Antonivka village, well №18	Pumping equipment control station	Direct pump start Motor: 5,5 kW, ~3x380V - 1 pcs.	1	Requires additional design work for estimation.	

C.3.3 LABORATORY EQUIPMENT NEEDS

Justification: To monitor compliance with Ukrainian sanitary rules and norms for drinking water and wastewater, the vodokanal critically needs laboratory equipment. Required equipment includes devices that measure a minimum list of chemical indicators and the amount of oxygen and Biochemical Oxygen Demand (BOD) levels in the aerotanks.

TABLE C.5: LABORATORY EQUIPMENT NEEDS FOR KHERSONVODOKANAL						
NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES
			STAGE 2			
1	WPS-3, Laboratory	Laboratory spectrophotometer VIS	DR3900	1	10,000	According to SanPiN, this device can measure a minimum list of water chemistry indicators.
2	WWTP, Laboratory	Portable digital oximeter	HQ1130 With optical luminescent dissolved oxygen sensor LDO (reinforced stainless-steel case, 5 m cable), case, accessories	1	400	For measuring oxygen in aeration tanks.
3	WWTP, Laboratory	Sensor (with built-in stirrer) for determining BOD	LBOD IntelliCAL With beakers	1	4,000	For measuring BOD at WWTPs.

TABLE C.5: LABORATORY EQUIPMENT NEEDS FOR KHERSONVODOKANAL						
NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES
4	WWTP, Laboratory	Glasses for BOD	1 set – 6 pcs.	2	200	
5	WWTP, Laboratory	Spectrophotometer	DR 1900 (Hach) With digital thermoblock and test kits	1	4,500	For measuring the oxygen demand at the treatment facilities

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

C.3.4 ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT, AND CABLE PRODUCT NEEDS

Justification: The vodokanal's existing electrical equipment is from the Soviet era (1970s and 1980s) and has exhausted its useful lifetime several times over. The current equipment does not meet modern requirements for safety of electrical installations and energy efficiency and is constantly in need of repair, which reduces the reliability of the city's water supply and sewage. Constant emergency switching further reduces the service life of the equipment, which often fails to operate in critical situations.

Instrumentation and control devices are needed to replace those that have already failed and cannot provide the necessary functions.

The supply of cable products is also needed for rapid rehabilitation of destroyed facilities, as well as for emergency works.

TABLE C.6: ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT, AND CABLE PRODUCT NEEDS FOR KHERSONVODOKANAL						
NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES
STAGE 1 (EMERGENCY)						
1	WWTP	Change-over switch	500A, ~3x380V	1	5,000	For connecting the DG.
2	WWTP	Power Contactor	800A, ~3x380V	3	8,000	
3	WWPS-4	Power Contactor	500A, ~3x380V	3	5,000	
4	WWPS-1	Power Contactor	400A, ~3x380V	2	2 500	
5	WWPS-5	Power Contactor	400A, ~3x380V	2	2 500	
6	WWPS-7	Power Contactor	400A, ~3x380V	2	2 500	
7	WWTP	Power Contactor	400A, ~3x380V	4	5,000	
8	WWTP	Power Contactor	250A, ~3x380V	3	2,000	
9	WWPS-1	Power Contactor	200A, ~3x380V	2	1,000	
10	WWPS-5	Power Contactor	200A, ~3x380V	2	1,000	
11	WPS-1	Power Contactor	100A, ~3x380V	6	3 500	
12	WWPS-4	Circuit breaker	500A, ~3x380V	2	5,000	
13	Main WWPS	Circuit breaker	500A, ~3x380V	2	4 500	
14	WWPS-1	Circuit breaker	400A, ~3x380V	2	4 500	

TABLE C.6: ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT, AND CABLE PRODUCT NEEDS FOR KHERSONVODOKANAL						
NO.	**LOCATION**	**NAME**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES**
15	WWPS-5	Circuit breaker	400A, ~3x380V	2	4 500	
16	WWPS-7	Circuit breaker	400A, ~3x380V	2	4 500	
17	WWTP	Circuit breaker	400A, ~3x380V	2	4 500	
18	WWTP	Circuit breaker	250A, ~3x380V	2	3,000	
19	WWPS-1	Circuit breaker	200A, ~3x380V	2	2,000	
20	WWPS-5	Circuit breaker	200A, ~3x380V	2	2,000	
21	WWPS-7	Circuit breaker	200A, ~3x380V	2	2,000	
22	WWTP	Circuit breaker	200A, ~3x380V	4	3,000	
23	WPS-3	Circuit breaker	100A, ~3x380V	7	4,000	
24	--	Hydrostatic depth probes for WW	SG-25S	12	10,000	
25	--	Hydrostatic depth probes for clean water	SG-25	10	3 500	
26	--	Pressure sensors,	4-20mA, 12-36V	48	12,000	
27	--	Tape-armored power cable, with aluminum core	ASB 10kV; 3x120 mm^2	500	25,000	Linear meters
28	--	Copper power cable with each core insulated and sheathed in a flame-retardant PVC sheath	VVGng 0,4kV; 4x25 mm^2	100	1 500	Linear meters
29	--	Aluminum power cable with each core insulated and sheathed in a flame-retardant PVC sheath	AVVGng 0,4kV; 2x70 mm^2	200	800	Linear meters
30	--	Heat shrinkable high voltage connection sleeves	70-120 mm^2	60	15,000	
31	--	Heat shrinkable low voltage connection sleeves	70-120 mm^2	43	700	
			STAGE 2			
32	Main WWPS	Power Contactor	500A, ~3x380V	2	3,000	
33	WWPS-6	Power Contactor	500A, ~3x380V	3	5,000	
34	WPS-1	Power Contactor	250A, ~3x380V	2	1,000	
35	WPS-1	Power Contactor	100A, ~3x380V	6	3,000	
36	Main WWPS	Circuit breaker	500A, ~3x380V	2	5,000	
37	WWPS-6	Circuit breaker	500A, ~3x380V	2	5,000	
38	WPS-1	Circuit breaker	400A, ~3x380V	2	4,000	
39	WPS-1	Circuit breaker	250A, ~3x380V	6	8,000	
40	WPS-1	Circuit breaker	100A, ~3x380V	12	7,000	

TABLE C.6: ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT, AND CABLE PRODUCT NEEDS FOR KHERSONVODOKANAL						
NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES
STAGE 3						
41	Mechanical workshop	Turning lathe		2	9,000	The existing equipment has outlived its useful lifetime several times.
42	Mechanical workshop	Flat grinding machine		1	5,000	
43	Mechanical workshop	Vertical milling machine		1	5,000	
44	WWPS-12	Power Contactor	350A, ~3x380V	1	1,000	
45	WPS-2	Power Contactor	200A, ~3x380V	14	7,000	
46	WPS-2	Power Contactor	100A, ~3x380V	22	12,000	
47	WPS-5	Power Contactor	100A, ~3x380V	2	1,000	
48	WWPS-12	Circuit breaker	500A, ~3x380V	4	9,000	
49	WPS-2	Circuit breaker	400A, ~3x380V	10	20,000	
50	WPS-5	Circuit breaker	200A, ~3x380V	4	3,000	
51	WWPS-12	Circuit breaker	100A, ~3x380V	7	4,000	
52	WPS-2	Circuit breaker	100A, ~3x380V	18	12,000	
53	WPS-5	Circuit breaker	100A, ~3x380V	2	1,500	

* Total price is indicative and includes only the cost of equipment. Price depends on availability in the warehouses and countries where equipment will be ordered and needs to be clarified by the manufacturer before ordering.

C.3.5 BUILDING MATERIAL NEEDS

Justification: Construction materials are needed to repair the damage caused by shelling and drone attacks. WPS-4 was hit the hardest, requiring repairs to the roof.

TABLE C.7: BUILDING MATERIAL NEEDS FOR KHERSONVODOKANAL						
NO.	NAME	SPECIFICATIONS	UNITS	QTY.	*INDICATIVE PRICE, USD	NOTES
STAGE 1 (EMERGENCY)						
1	Board edging	150x50	м3	8	2,000	Due to the safety reasons, all reparation works must be done by the Khersonvodokanal maintenance and operations personnel.
2	Board edging	100x25	м3	3	800	
3	Steam Barrier	-	м2	400	700	
4	Trapezoidal sheeting	-	м2	370	4,000	
5	Construction nails	150	kg	12	40	
6	Construction nails	100	kg	6	20	
7	Self-tapping roofing screws for wood with washer	4,8x25	pcs	1500	60	

* Total price is indicative. Price depends on availability in the warehouses and needs to be clarified before ordering.

C.3.6 REACTIVE POWER COMPENSATOR NEEDS

Justification: Local reactive power compensation will reduce grid losses by reducing the reactive component of consumer currents, the voltage drop in the grid, and the reactive current load on power plant generators.

TABLE C.8: REACTIVE POWER COMPENSATOR NEEDS FOR KHERSONVODOKANAL

NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES
			STAGE 1 (EMERGENCY)			
1	WWTP	Automatic reactive power compensator	6 levels of regulation, 0,4 kV, 150 kVAr	1	2,000	Equipment needs to be produced by special orders. Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer. Purchase of spare parts and delivery to the site is required. Installation works by the manufacturer and training of the personnel of the vodokanal is preferable but will depend on the safety situation in the city.
2	WWTP	Automatic reactive power compensator	6 levels of regulation, 0,4 kV, 100 kVAr	1	1,500	
			STAGE 2			
3	Main WWPS	Automatic reactive power compensator	6 levels of regulation, 0,4 kV, 150 kVAr	1	2,000	Equipment needs to be produced by special orders. Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer. Purchase of spare parts and delivery to the site is required. Installation works by the manufacturer and training of the personnel of the vodokanal is preferable but will depend on the safety situation in the city.
4	WWPS-4	Automatic reactive power compensator	6 levels of regulation, 0,4 kV, 100kVAr	2	1,500	
5	WWPS-6	Automatic reactive power compensator	6 levels of regulation, 0,4 kV, 100 kVAr	2	1,500	

C.3.7 FLOW METER NEEDS

Stage 3: Equipment is not needed for at least 6–9 months, or longer, or cannot be procured in a short period of time.

Justification: installation of flow meters will allow for monitoring of water and wastewater flow and consumption, supporting key decisions such as pump operating modes and technological parameters, and supporting the future development of programs to improve energy efficiency.

TABLE C.9: FLOW METER NEEDS FOR KHERSONVODOKANAL

NO.	LOCATION	NAME	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
1	WPS-1	Flowmeter for clean water	Medium – clear water; Flow max – 550 m^3/hour; Flow min – 25 m^3/hour	2	140,000	Preferred manufacturer is Siemens. Only purchasing of materials and delivery to the site is required

TABLE C.9: FLOW METER NEEDS FOR KHERSONVODOKANAL						
NO.	**LOCATION**	**NAME**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
2	WPS-2	Flowmeter for clean water	Medium – clear water; Flow max – 1500 m3/hour; Flow min – 45 m3/hour.	2		
3	WPS-3	Flowmeter for clean water	Medium – clear water; Flow max – 750 m3/hour; Flow min – 20 m3/hour.	2		
4	WPS-4	Flowmeter for clean water	Medium – clear water; Flow max – 1600 m3/hour; Flow min – 25 m3/hour.	2		
5	WPS-5	Flowmeter for clean water	Medium – clear water; Flow max – 425 m3/hour; Flow min – 50 m3/hour.	2		
6	WPS-6	Flowmeter for clean water	Medium – clear water; Flow – 40 m3/hour;	1		
7	WWTP	Flowmeter for wastewater	Medium – wastewater; Flow max – 2180 m3/hour; Flow min – 550 m3/hour.	2	360,000	Preferred manufacturer is Siemens. Only purchasing of materials and delivery to the site is required
8	WWPS-1	Flowmeter for wastewater	Medium – wastewater; Flow max – 800 m3/hour; Flow min – 265 m3/hour.	2		
9	WWPS-2	Flowmeter for wastewater	Medium – wastewater; Flow max – 700 m3/hour; Flow min – 225 m3/hour.	2		
10	WWPS-3	Flowmeter for wastewater	Medium – wastewater; Flow max – 146 m3/hour; Flow min – 22 m3/hour.	1		
11	WWPS-4	Flowmeter for wastewater	Medium – wastewater; Flow max – 2180 m3/hour; Flow min – 200 m3/hour	2		
12	WWPS-5	Flowmeter for wastewater	Medium – wastewater; Flow max – 200 m3/hour; Flow min – 50 m3/hour	2		
13	WWPS-6	Flowmeter for wastewater	Medium – wastewater; Flow max – 400 m3/hour; Flow min – 100 m3/hour	1		
14	WWPS-7	Flowmeter for wastewater	Medium – wastewater; Flow max – 300 m^3/hour; Flow min – 25 m^3/hour	2		
15	WWPS-8	Flowmeter for wastewater	Medium – wastewater; Flow max – 160 m^3/hour; Flow min – 16 m^3/hour	2		
16	WWPS-9	Flowmeter for wastewater	Medium – wastewater; Flow max – 39 m^3/hour; Flow min – 6 m^3/hour	2		
17	WWPS-10	Flowmeter for wastewater	Medium – wastewater; Flow max – 125 m^3/hour; Flow min – 30 m^3/hour	2		

TABLE C.9: FLOW METER NEEDS FOR KHERSONVODOKANAL						
NO.	**LOCATION**	**NAME**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
18	WWPS-11	Flowmeter for wastewater	Medium – wastewater; Flow max – 200 m^3/hour; Flow min – 100 m^3/hour	1		
19	WWPS-12	Flowmeter for wastewater	Medium – wastewater; Flow max – 400 m^3/hour; Flow min – 50 m^3/hour	2		
20	WWPS-13	Flowmeter for wastewater	Medium – wastewater; Flow max – 400 m^3/hour; Flow min – 50 m^3/hour	2		
21	WWPS-14	Flowmeter for wastewater	Medium – wastewater; Flow – 63 m^3/hour	1		
22	WWPS-15	Flowmeter for wastewater	Medium – wastewater; Flow max – 80 m^3/hour; Flow min – 23 m^3/hour	2		
23	WWPS-16	Flowmeter for wastewater	Medium – wastewater; Flow max – 100 m^3/hour; Flow min – 28 m^3/hour	2		

* Total price is indicative of the most expensive model and includes only the cost of equipment, without associated delivery costs.

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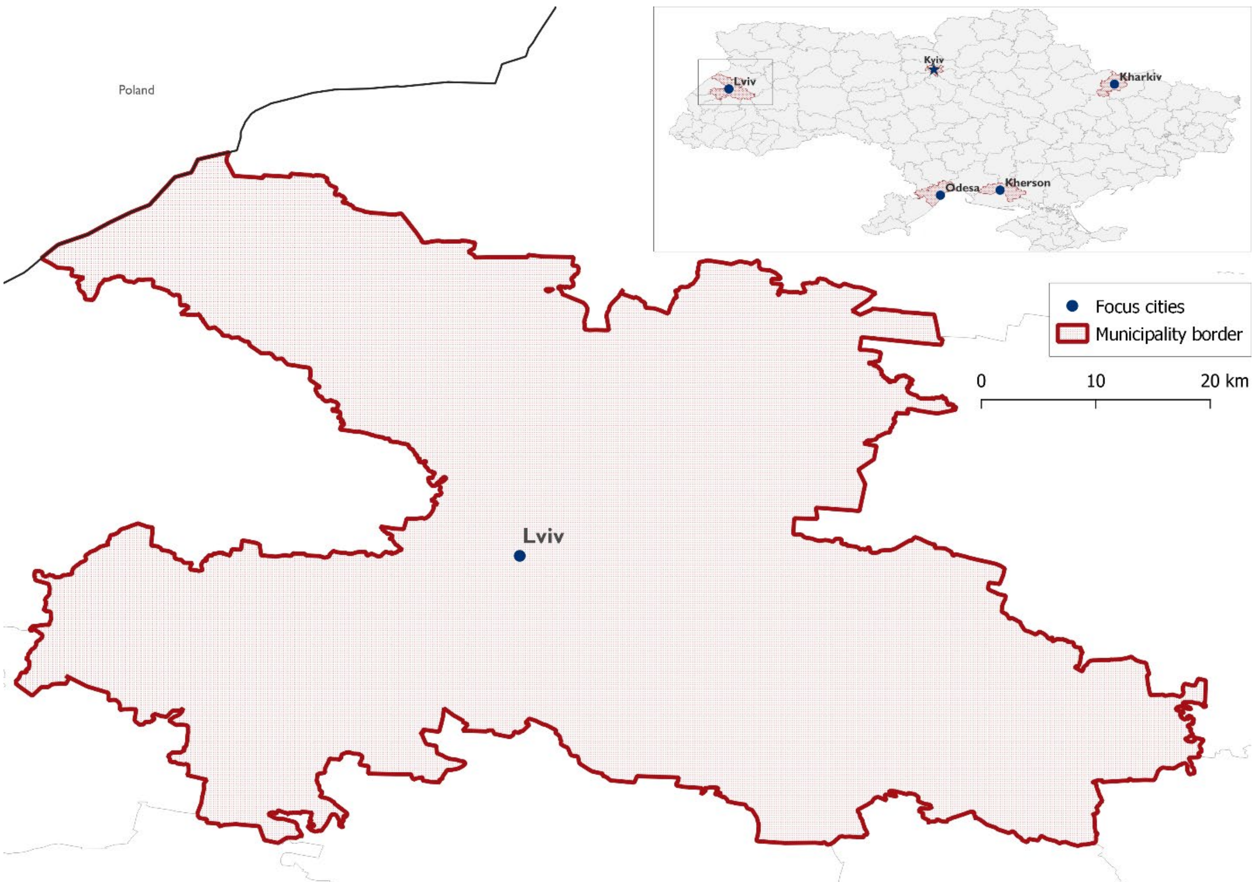
ANNEX D: LVIVVODOKANAL

LVIV
Lviv Municipal Communal Enterprise (LMCE) Lvivvodokanal Pre-War Population (# of people): **717,273** Current Population (# of people): **~930,000** Net Population Change: **~27%** Pre-War Employees (# of staff): Data not available. Current Employees (# of staff): **1,989** Net Employee Change: Data not available.



D.1 LVIVVODOKANAL PROFILE

Summary

- Most of Lvivvodokanal's high-voltage power supply infrastructure for water pumping stations (WPSs) was replaced with low-voltage equipment with the additional installation of frequency controllers. These modifications allowed donors and other organizations to provide support, covering up to 80 percent of backup power supply needs for water systems. However, needs for backup power supply to wastewater systems are currently only covered up to 10 percent.
- Lvivvodokanal mostly relies on outdated and energy-intensive high- and low-voltage equipment commissioned in the 1940–1990s. Much of the pumping equipment, especially on wastewater pumping stations (WWPSs), is outdated, without variable drives or frequency converters, and requires replacement. An additional priority for improved the resilience of electrical equipment is the reconstruction and modernization of outdated 35/10/6 kilovolt (kV) electrical substations and 0.4 kV electrical rooms. Implementation of these recommendations will require a more detailed assessment and engineering design and should be considered in parallel with the modernization and replacement of outdated equipment and the reconstruction of existing power supply systems.
- Stage 1 will cost approximately USD 2,000,000–2,200,000. Stage 2 will cost approximately USD 1,000,000–1,200,000. Stage 3 will cost approximately USD 1,500,000–1,600,000.

Site Visit Overview

Three CDM Engineering Ukraine engineers conducted Lvivvodokanal's site visits on March 2–3, 2023. During the site visits multiple meetings with Lvivvodokanal management took place, as well as tours of water and wastewater pumping stations.

General Overview

The Lviv Municipal Communal Enterprise (LMCE) "Lvivvodokanal" (Lvivvodokanal) was established in 1901 to provide the city of Lviv and 67 villages of the region with drinking water, wastewater removal, and wastewater treatment services. Lvivvodokanal is owned by the territorial community of the city of Lviv and is overseen by the Lviv City Council's Department of Housing and Infrastructure. Lvivvodokanal provides water supply to Lvivteploenergo for heating supply purposes and is the teploenergo's only water source.

D.1.1 OVERVIEW OF NETWORK AND FACILITIES

Water System Overview

TABLE D.1: WATER SYSTEM OVERVIEW – LVIVVODOKANAL

CATEGORY		DATA	NOTES
WATER	Water Intakes	17	
	Capacity of Water Intakes (meters [m]^3/day)	452,000	
	Source Types	Groundwater	
	Groundwater Wells	197	
	Max. Well Depth (m)	250	
	Surface Water Bodies	N/A	Only supplied by groundwater.
	Length of Water Pipelines (kilometers [km])	655 (main)	1,750 km of total piped water supply network.
	Water Pipe Max. Diameter (m)	1.4	

TABLE D.1: WATER SYSTEM OVERVIEW – LVIVVODOKANAL			
CATEGORY		DATA	NOTES
	(Main) Water Pumping Stations	27	
	(Local) Water Pumping Stations	23	
	Treatment Plant Capacity (m³/day)		Data not available.
	Treated Water Storage Capacity (m³)	200,000	
	Pre-War Demand (m³/day)	240,000	
	Current Water Demand (m³/day)	370,000	
	Change in Water Demand	54%	
	Pre-War Supply (m³/day)		Data not available.
	Current Supply (m³/day)		Data not available.
	Change in Supply		Data not available.
	Water Provided to Teploenergos (m³)	127,400	Amount provided for 2022. Lvivvodokanal is their only source.

The city of Lviv is located on the ridge of the European watershed, in an area poor in natural water sources. The city's water supply comes exclusively from groundwater sources, located at distances ranging from 20 to 110 km from of the city. The design capacity of these water intakes is 452,000 m³/day. Groundwater is extracted from 197 artesian wells that reach a maximum depth of 250 m and are combined in 17 water intakes located in the Lviv region.

The water extracted at the water intakes flows to the city through 655 km of main water pipelines with a maximum diameter of 1,400 mm. Lviv's complex landscape and large elevation changes necessitate 27 WPSs comprised of two, three, or four and 23 local WPSs. WPSs were constructed between 20 to 100 years ago. Treated water storage capacity is over 200,000 m³, though the total number of storage reservoirs is unknown. The length of the urban distribution networks is 850 km, with an additional 245 km of branches from the main lines.

Wastewater System Overview

TABLE D.2: WATER SYSTEM OVERVIEW – LVIVVODOKANAL			
	CATEGORY	DATA	NOTES
WASTEWATER	Length of Sewerage Network (km)	605	
	Main Collector Pipes	70	
	Wastewater Pumping Stations	10	
	Treatment Plant Capacity (m³/day)	490,000	
	Pre-War Total Wastewater Flow (m³/day)	280,000	
	Current Total Wastewater Flow (m³/day)	300,000	
	Change in Total Wastewater Flow	7%	

The wastewater system consists of 605 km of sewerage networks, including 70 km of main collectors and 10 WWPSs. Household, industrial, and stormwater effluents and runoff move through the closed collector Poltva to reach the wastewater treatment plant (WWTP), which has a design capacity of 490,000 m³/day. The WWTP includes both mechanical and biological treatment processes.

Each district of Lviv receives water from a different water intake. As of the beginning of 2022, prior to the war, the population of Lviv was approximately 730,000. After the war started, Lviv received approximately 200,000 additional temporarily displaced people, increasing the population by approximately 27 percent. This has resulted in an increase in water demand from approximately 240,000 m³/day prior to the Russian Federation's invasion to 370,000 m³/day currently, and wastewater flows of approximately 280,000 m³/day prior to the invasion to 300,000 m³/day currently.

D.1.2 POWER NEEDS AND SUPPLY

Lvivvodokanal mostly relies on Soviet-era, outdated, and energy-intensive equipment with no significant automation system, due to a lack of financing for complex maintenance and upgrade needs. The vodokanal needs significant reconstruction of the electrical substations that power the facilities. These issues result in large-scale energy consumption just to keep the water and wastewater systems operable. In addition, given that most water supply and wastewater infrastructure was constructed during Soviet control, Lvivvodokanal remains dependent on components produced in Russia and Belarus. Lvivvodokanal does not have energy efficiency policies, resource efficiency usage plans, or assigned personnel responsible for energy management. According to standards from the International Organization for Standardization, Lvivvodokanal has not implemented a certified energy management system.

The total annual energy consumption by Lvivvodokanal overall and annual energy consumption by the WWTP for the last three years (2020–2022) are presented in Table D.3.

TABLE D.3: ANNUAL ENERGY CONSUMPTION OF LVIVVODOKANAL FOR 2020-2022

Year	2020	2021	2022
Total annual energy consumption of WWTP, kilowatt hours (kWh)	32,033,789	30,965,790	30,591,114
Total annual energy consumption, kWh	106,877,574	102,417,338	98,047,585

Lvivvodokanal carried out facility improvements for the water supply system recently, including installation of frequency converters, pump replacement, and necessary equipment repairs. Less attention has been paid to the needs of the wastewater system. Annual energy effectiveness indicators for Lvivvodokanal over the last three years (2020–2022) are presented in Table D.4, calculated as the total power consumed by each system per m³ of water or wastewater produced.

TABLE D.4: ANNUAL ENERGY EFFECTIVENESS INDICATORS OF LVIVVODOKANAL FOR 2020–2022

Year	2020	2021	2022
Total annual energy effectiveness of water supply system, kWh/m³	0.860	0,831	0.807
Annual energy effectiveness (power consumed per m³ of wastewater treated) of WWTP, kWh/m³	0.24-0.25	0.33-0.34	0.36-0.37

D.1.3 KEY CHALLENGES DUE TO THE WAR IN UKRAINE

Lviv is in the western part of Ukraine near the border with Poland; thus, the city was not under occupation or near active war zones when the full-scale invasion by the Russian Federation began on February 24, 2022. From the start of the war through October 10, 2022, when Russian Federation forces began targeted missile strikes on critical infrastructure, Lvivvodokanal facilities did not experience significant damage or long-term power outages. Since October 10, 2022, however, interruptions to the power supply due to damaged power supply facilities or emergency outages have impacted water and wastewater service delivery. For a full list of incidents and impacts, see section D.2.

Lvivvodokanal's leadership began improvements to the water supply and wastewater systems prior to February 2022. These improvements have thus far allowed the vodokanal to navigate continuous power outages caused by attacks on critical infrastructure facilities. However, the lack of financing for replacement and upgrade of outdated equipment, a problem faced by most vodokanals since Ukraine's independence in 1991, and dependence on components produced in Russia and Belarus have created a number of key challenges.

The **increase in the number of consumers,** primarily internally displaced persons (IDPs) arriving in Lviv, has put stress on Lvivvodokanal's water and wastewater infrastructure. The increase in the number of consumers has increased the load on already outdated equipment and requires that the vodokanal's assets be modernized to accommodate these additional consumers.

Additionally, Lvivvodokanal's mostly **outdated, energy-intensive equipment** often does not work properly during increasing consumer demand and continuous power outages. The **lack of backup emergency power supply** in water and wastewater facilities during blackouts or short power outages causes interruptions in water supply and wastewater services. While 80 percent of the needed backup power supply equipment (e.g., generators) for water supply systems have backup power, only 10 percent of wastewater systems have backup power. Finally, the ongoing war destroyed a significant portion of the **supply chains for spare parts** required for proper maintenance and repairs of existing equipment produced in Russia or Belarus.

D.1.4 PRIORITIZED NEEDS TO ENSURE CONTINUOUS SERVICE DELIVERY

Before the start of the full-scale invasion, Lvivvodokanal began to develop emergency operation plans (EOPs) in case of full-scale power outages and to implement measures to improve the stability of the water and wastewater systems. Though the vodokanal was unable to share these plans with the assessment team, the plans have made it possible to ensure backup power for water supply and wastewater systems to varying degrees. The focus for ensuring the continuous provision of services during emergency situations for Lvivvodokanal should be on installation of backup power sources for the wastewater systems, though in line with Lvivvodokanal's cited priorities, delivery of vehicles to support repairs is prioritized first in this assessment.

A detailed list of needs with divisions by the priority stages is provided in Annex D.3. The stages are as follows:

- Stage 1: Equipment needed as soon as possible. Emergency stage.
- Stage 2: Equipment needed within the next 3 months
- Stage 3: Equipment is not needed for at least 6–9 months (or longer), or cannot be procured in a short period of time

Stage 1: While not a direct solution for backup and emergency power supply, Lvivvodokanal urgently needs special vehicles (Stage 1). Provision of the vehicles recommended under Stage 1 will cost approximately USD 2,000,000–2,200,000.

Stage 2: The assessment identified the following priority needs to ensure the continued provision of services during emergency situations in line with the EOP (Stage 2):

- Supply and installation of frequency converters on the existing pumping equipment at wastewater pumping stations.
- Supply and installation of diesel generators on WWPSs

The cost to cover needs under Stage 2 is approximately USD 1,000,000–1,200,000 (approximate cost of the equipment itself, not including additional materials and costs for development of design documentation, delivery, installation, testing, and commissioning works).

Stage 3: To cover efficiency improvements, the longer-term needs for Stage 3 are in section D.1.5.

Delivery of special-purpose vehicles

Lvivvodokanal has directly requested the provision of vehicles to support repairs of critical infrastructure. Nearly all cars and special machinery operated by Lvivvodokanal are old, in poor condition, and were manufactured in Russia (resulting in a lack of spare parts for their repairs). This poses risks to repair crews when responding to emergencies and could result in possible termination of the water supply or wastewater services when repairs are not possible.

Frequency converters

The pumping equipment is low-voltage (0.4 kV) and has a mainly direct start without frequency convertors (FCs) or variable drives. This increases the wear and tear of outdated equipment, leading to the overconsumption of electricity. High incoming currents require an increase in the power of the required diesel generators (DG) to provide backup power during emergencies, which is inefficient.

Generators for WWPSs

DGs are needed to provide backup power to focus equipment detailed in Lvivvodokanal's EOPs. While generator needs are relatively small for the water supply system, the wastewater system lacks sufficient generator backups and needs many more.

D.1.5 ENERGY AND OPERATIONAL EFFICIENCY

For longer-term needs (Stage 3), pumping equipment also requires replacement with modern analogs with a cost of USD 1,500,000–1,600,000 (approximate cost of the pumps themselves, excluding additional equipment costs and additional installation of FCs).

An additional, but more global priority under Stage 3 is to improve the stability of water supply and sanitation services and support the reconstruction and modernization of outdated 35/10/6/0.4 electrical substations that supply all WPSs (a detailed assessment and pricing of these needs require additional research and design).

Pump replacement

Lvivvodokanal, like most water and wastewater service providers in Ukraine, has extensive outdated, energy-intensive electrical equipment. This equipment has only been periodically repaired; the vodokanal has not been able to move forward with vital modernization and upgrade efforts. While Lvivvodokanal has modernized several WPSs in recent years, they did not have sufficient finances to replace the equipment at the WWPSs. This necessitates the replacement of existing outdated energy-intensive wastewater pumps with modern ones, with additional installation of frequency converters to increase the efficiency and stability of their operation.

Modernization of outdated electrical substations

An additional priority for improved energy efficiency is the reconstruction and modernization of outdated electrical 35/10/6 kV electrical substations and 0.4 kV electrical rooms, which supply electricity to water pumping stations. Electrical equipment and switchgears of high-voltage substations and electrical rooms largely do not meet Ukrainian-type standard "PTEES" (Rules of Technical Operation of Electrical Installations of Consumers), are physically outdated, and are difficult to maintain due to the absence of spare parts. The reconstruction of these power supply systems needs further assessment.

Like additional options in the long-term perspective, needs for improving energy efficiency may also include the creation of an energy management system, the incorporation of automation systems (e.g., Supervisory Control and Data Acquisition system), and the introduction of alternative energy sources such as solar panels, wind turbines, heat pumps, and/or biogas equipment. Currently, Lvivvodokanal has no such sources.

The implementation of these recommendations will require a more detailed assessment and engineering design and should be considered in parallel with the modernization and replacement of outdated equipment and the reconstruction of existing power supply systems for Lvivvodokanal.

D.2 LVIVVODOKANAL INCIDENTS AND IMPACTS

SUMMARY

Lvivvodokanal has recorded 1,467 incidents of power outages to its facilities since October 10, 2022, when Russia began targeting Ukrainian power infrastructure with missile attacks. The most severe disruptions took place on December 5 and 16, 2022. Financial losses amounted to Ukrainian Hryvnia (UAH) 645,000 due to damaged infrastructure and associated leakage. Lvivvodokanal also spent UAH 720,000 on fuel for backup DGs.

INCIDENT 1: NOVEMBER 23, 2022

Lvivvodokanal stated in response to an information request that eight facilities were disconnected from their power supply on November 23, 2022, due to a missile attack on energy infrastructure. The power outage lasted for four hours. At 6 p.m. on the same day, the Lviv mayor stated that 70 percent of consumers had been reconnected to water supply (Bodnyak 2022). It is unclear how wastewater services were impacted.

INCIDENT 2: NOVEMBER 29, 2022

On November 29, 2022, the local press reported that the Yanivska WPS was disconnected from power supply due to lack of voltage at the pumping station. As a result, consumers in Zaliznychnyi and Frankivskyi Districts were disconnected from water and wastewater services for five hours (Rodak 2022).

INCIDENT 3: DECEMBER 5, 2022

Lvivvodokanal stated in response to an information request that 16 facilities were disconnected from power supply on December 5, 2022, due to power outage caused by a missile attack. The power outage lasted for four hours. It is unclear how wastewater services were impacted.

INCIDENT 4: DECEMBER 16, 2022

Lvivvodokanal stated in response to an information request that 30 facilities were disconnected from power supply on December 16, 2022, due to power outage caused by a missile attack. The power outage lasted for four hours. It is unclear how wastewater services were impacted.

D.3 LVIVVODOKANAL EQUIPMENT LIST

Lvivvodokanal has developed an EOP to ensure water and wastewater service delivery during power outages and blackouts. To carry out these plans, Kyivvodokanal needs backup power supplies to both their wastewater and water facilities. While most backup power supplies cover up to 80 percent of water system backup needs, only 10 percent of the wastewater system needs are adequately backed by emergency power systems. Equipment needs are divided into three stages depending on the level of need (from the most urgent to the least):

- Stage 1: Equipment is needed immediately; Stage 1 needs will cost approximately USD 2,000,000–2,200,000.
- Stage 2: Urgent, equipment is needed within 3 months; Stage 2 needs will cost approximately USD 1,000,000–1,200,000.
- Stage 3: Equipment is not needed for at least 6–9 months or cannot be procured in a short period of time. Stage 3 needs will cost approximately USD 1,500,000–1,600,000.

The point of contact from Lvivvodokanal for communication regarding equipment procurement and delivery is in the table below. All equipment and materials should be delivered to the following address: [information available upon request]. While vodokanals were not able to provide GPS coordinates for facilities, the names of facilities where equipment is to be installed are listed in the tables below and should be referenced when discussing delivery and installation with the vodokanal's point of contact. Costs provided in each row in the subsequent tables are total costs, not per unit costs.

POSITION	NAME	CONTACT PHONE	EMAIL
Deputy Chief Engineer	Available upon request	Available upon request	Available upon request

D.3.1 GENERATOR NEEDS

Stage 2: Urgent, equipment is needed within 3 months.

Justification: Supply and installation of alternative power sources such as low-voltage generators will ensure wastewater system operations during power blackouts in line with Lvivvodokanal's Emergency Operation Plan.

TABLE D.5: GENERATORS NEEDS FOR LVIVVODOKANAL'S WASTEWATER FACILITIES

NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
1	WWPS - "Bryukhovychi Ivasyuk"	Generator	Fuel type: Diesel Prime Power: 20 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging.	1	9,000	• For chosen power of DG, additional installation of FC is required (see table D.6 below); • Vodokanal maintenance team can install DG onsite; • Automatic Reserve Activation (AVR) must be installed in the electrical room (can be designed and developed by special orders); • The manufacturer requires their representatives to test and commission the equipment after installation; and • Contracts for follow up maintenance from the manufacturer and fuel/oil supply are required.
2	WWPS - "Bryukhovychy Pryluky"	Generator	Fuel type: Diesel Prime Power: 50 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary	1	15,000	

TABLE D.5: GENERATORS NEEDS FOR LVIVVODOKANAL'S WASTEWATER FACILITIES						
NO.	**LOCATION**	**TYPE**	**SPECIFICATIONS**	**QTY.**	***INDICATIVE PRICE, USD**	**NOTES/ADDITIONAL REQUIREMENTS**
			Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging			
3	WWPS - "Vynniki-2 (Striletska)"	Generator	Fuel type: Diesel Prime Power: 100 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging	1	20,000	
4	WWPS - "Lapaivka"	Generator	Fuel type: Diesel Prime Power: 110 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging	1	21,000	
5	WWPS - "Medovoi Pecheri"	Generator	Fuel type: Diesel Prime Power: 140 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging	1	27,500	
6	WWPS - "Ryasne-2"	Generator	Fuel type: Diesel Prime Power: 350 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor	1	70,000	

TABLE D.5: GENERATORS NEEDS FOR LVIVVODOKANAL'S WASTEWATER FACILITIES						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
			Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging			
7	WWPS - 4	Generator	Fuel type: Diesel Prime Power: 650 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging	1	120,000	
8	WWPS - 5	Generator	Fuel type: Diesel Prime Power: 650 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant; with automatic battery charging	1	120,000	
9	WWPS - "Bryukhovychi"	Generator	Fuel type: Diesel Prime Power: 350 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: portable on a trailer Generator installation: outdoor Type of transfer switch: manual Additional specs: with additional heating of the coolant, with automatic battery charging and 40m of flexible power cable	1	100,000	
10	WWPS - "Glynyansky Tract"	Generator	Fuel type: Diesel Prime Power: 50 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic	1	15,000	

TABLE D.5: GENERATORS NEEDS FOR LVIVVODOKANAL'S WASTEWATER FACILITIES						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	*INDICATIVE PRICE, USD	NOTES/ADDITIONAL REQUIREMENTS
			Additional specs: with additional heating of the coolant, with automatic battery charging			
11	WWPS – "Holodnoivka"	Generator	Fuel type: Diesel Prime Power: 90 kW Voltage: 400 V Phase(s): 3-phased Configuration: Y Generator type: stationary Generator installation: outdoor Type of transfer switch: automatic Additional specs: with additional heating of the coolant, with automatic battery charging	1	19,000	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

D.3.2 FREQUENCY CONVERTER NEEDS

Stage 2: Urgent, equipment is needed within 3 months.

Justification: The vodokanal requires supply and installation of FCs alongside the installation of generators in Table D.5. Installation of FCs will improve the energy efficiency of the WWPS and increase the reliability of the city's water supply and sewage systems.

TABLE D.6: FREQUENCY CONVERTER NEEDS FOR LVIVVODOKANAL'S WASTEWATER FACILITIES							
NO.	LOCATION	QTY. OF FCS REQUIRED	EXISTING EQUIPMENT			*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			TYPE OF PUMP	YEAR	SPECIFICATIONS OF THE MOTORS		
1	WWPS - "Bryukhovychi Ivasyuk"	2	AHC-60	2003	Quantity: 1 Prime Power: 5.5 kW Voltage: 400 V Phase(s): 3-phased	3,000	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			AHC-60	2003	Quantity: 1 Prime Power: 5.5 kW Voltage: 400 V Phase(s): 3-phased	3,000	
2	WWPS - "Bryukhovychy Pryluky"	3	Wilo SEV 80.80	2010	Quantity: 1 Prime Power: 12.6 kW	4,500	• FC needs to be designed and manufactured by special order;

TABLE D.6: FREQUENCY CONVERTER NEEDS FOR LVIVVODOKANAL’S WASTEWATER FACILITIES							
NO.	**LOCATION**	**QTY. OF FCS REQUIRED**	**EXISTING EQUIPMENT**			***INDICATIVE PRICE, USD**	**NOTES/ ADDITIONAL REQUIREMENTS**
			TYPE OF PUMP	**YEAR**	**SPECIFICATIONS OF THE MOTORS**		
					Voltage: 400 V Phase(s): 3-phased		• Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			Wilo SEV 80.80	2010	Quantity: 1 Prime Power: 12.6 kW Voltage: 400 V Phase(s): 3-phased	4,500	
			Wilo SEV 80.80	2010	Quantity: 1 Prime Power: 12.6 kW Voltage: 400 V Phase(s): 3-phased	4,500	
3	WWPS - “Vynniki-2 (Striletska)”	2	КФС 160/45	2001	Quantity: 1 Prime Power: 37 kW Voltage: 400 V Phase(s): 3-phased	7,000	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			КФС 160/45	2001	Quantity: 1 Prime Power: 55 kW Voltage: 400 V Phase(s): 3-phased	9,000	
4	WWPS - ”Lapaivka”	3	CM 150-125-315/4	2001	Quantity: 1 Prime Power: 22 kW Voltage: 400 V Phase(s): 3-phased	5,500	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			ФГ 144/ 46	2000	Quantity: 1 Prime Power: 37 kW Voltage: 400 V Phase(s): 3-phased	7,000	
			ФГ 144/ 46	2000	Quantity: 1 Prime Power: 37 kW Voltage: 400 V Phase(s): 3-phased	7,000	

TABLE D.6: FREQUENCY CONVERTER NEEDS FOR LVIVVODOKANAL'S WASTEWATER FACILITIES							
NO.	LOCATION	QTY. OF FCS REQUIRED	EXISTING EQUIPMENT			*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			TYPE OF PUMP	YEAR	SPECIFICATIONS OF THE MOTORS		
5	WWPS - "Medovoi Pecheri"	3	СМ 150-125-315/4	1997	Quantity: 1 Prime Power: 37 kW Voltage: 400 V Phase(s): 3-phased	7,000	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			СМ 150-125-315/4	2008	Quantity: 1 Prime Power: 22 kW Voltage: 400 V Phase(s): 3-phased	5,500	
			СД 250/ 22,5	1997	Quantity: 1 Prime Power: 40 kW Voltage: 400 V Phase(s): 3-phased	7,500	
6	WWPS - "Ryasne-2"	2	СМ 200-150-500/4б	1991	Quantity: 1 Prime Power: 132 kW Voltage: 400 V Phase(s): 3-phased	25,000	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			СМ 200-150-500/4б	2001	Quantity: 1 Prime Power: 132 kW Voltage: 400 V Phase(s): 3-phased	25 000	
			СМ 200-150-500/4a	2001	Quantity: 1 Prime Power: 132 kW Voltage: 400 V Phase(s): 3-phased	25,000	
			СМ 200-150-500/4a	2003	Quantity: 1 Prime Power: 160 kW Voltage: 400 V Phase(s): 3-phased	30,000	
7	WWPS - 4	2	СМ 250-200-400/4a	1995	Quantity: 1 Prime Power: 200 kW Voltage: 400 V Phase(s): 3-phased	35,000	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance;
			СМ 250-200-400/4a	1997	Quantity: 1 Prime Power: 250 kW Voltage: 400 V Phase(s): 3-phased	45,000	

TABLE D.6: FREQUENCY CONVERTER NEEDS FOR LVIVVODOKANAL'S WASTEWATER FACILITIES							
NO.	LOCATION	QTY. OF FCS REQUIRED	EXISTING EQUIPMENT			*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			TYPE OF PUMP	YEAR	SPECIFICATIONS OF THE MOTORS		
							• Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
8	WWPS - 5	2	CM 250-200-400/4a	1991	Quantity: 1 Prime Power: 250 kW Voltage: 400 V Phase(s): 3-phased	45,000	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			CM 250-200-400/4a	1997	Quantity: 1 Prime Power: 250 kW Voltage: 400 V Phase(s): 3-phased	45,000	
9	WWPS - "Bryukhovychi"	3	CM 200-150-500/4 and CM 200-150-500/4 (combined)	2018	Quantity: 2 Prime Power: 160 + 160 kW Voltage: 400 V Phase(s): 3-phased	Requires additional design work for estimation.	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			СД450/ 95	1997	Quantity: 1 Prime Power:315 kW Voltage: 400 V Phase(s): 3-phased	55,000	
10	WWPS - "Glynyansky Tract"	2	Flygt NZ3153	2009	Quantity: 1 Prime Power: 15 kW Voltage: 400 V Phase(s): 3-phased	5,000	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC;
			Flygt NZ3153	2009	Quantity: 1 Prime Power: 15 kW Voltage: 400 V Phase(s): 3-phased	5,000	

TABLE D.6: FREQUENCY CONVERTER NEEDS FOR LVIVVODOKANAL'S WASTEWATER FACILITIES							
NO.	LOCATION	QTY. OF FCS REQUIRED	EXISTING EQUIPMENT			*INDICATIVE PRICE, USD	NOTES/ ADDITIONAL REQUIREMENTS
			TYPE OF PUMP	YEAR	SPECIFICATIONS OF THE MOTORS		
							• Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
11	WWPS - "Holodnoivka"	4	Flygt NZ3231/ 665-480	2007	Quantity: 1 Prime Power: 22 kW Voltage: 400 V Phase(s): 3-phased	5,500	• FC needs to be designed and manufactured by special order; • Preferable manufacturer is Schneider Electric; • Manufacturer representative must deliver to the site and install, test, and commission FC; • Vodokanal must purchase spare parts for follow-up maintenance; • Manufacturer must train Vodokanal representatives; and • Manufacturer must identify additional requirements for installation, testing, and commissioning of FC.
			Flygt NZ3231/ 665-480	2007	Quantity: 1 Prime Power: 22 kW Voltage: 400 V Phase(s): 3-phased	5,500	
			СД 144/46	2007	Quantity: 1 Prime Power: 55 kW Voltage: 400 V Phase(s): 3-phased	9,000	

* Total price is indicative and includes only the cost of equipment without any additional costs. Price depends on the manufacturer, availability, and country where equipment will be ordered.

D.3.3 PUMP REPLACEMENT AND FREQUENCY CONVERTOR NEEDS

Stage 3: Equipment is not needed for at least 6–9 months or cannot be procured in a short period of time.

Justification: The replacement of outdated energy-intensive pumps manufactured in post-Soviet countries (with limited spare parts for repairs) will improve the energy efficiency of the WWPS and increase the reliability of the city's water supply and sewage systems. If vodokanals replace the pumps, the capacity of DGs for WWPS backup power supply needs to be reevaluated. The highest priorities in this section are the replacement of pumps at WWPS-4 with additional installation of FCs, replacement of pumps at WWPS-5 with additional installation of FCs, and replacement of the pumps on WWPS "Medovoi Pecheri" with additional installation of FCs.

TABLE D.7: PUMP REPLACEMENT AND FREQUENCY CONVERTOR NEEDS FOR LVIVVODOKANAL								
NO.	LOCATION	EXISTING EQUIPMENT			RECOMMENDED EQUIPMENT		*INDICATIVE PRICE OF NEW PUMP, USD	NOTES/ ADDITIONAL REQUIREMENTS
		TYPE OF PUMP	YEAR	SPECIFICA-TIONS OF THE MOTORS	TYPE OF NEW PUMP	SPECIFICA-TIONS		
1	WWPS - "Bryukhovychi Ivasyuk"	AHC-60	2003	Quantity: 1 Prime Power: 5.5 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3085. 160 SH/ 253	Q=35m3/h H=15m P=2,4kW U=400 V	3,500	• Vodokanal maintenance team can install new pumps; • Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.
		AHC-60	2003	Quantity: 1 Prime Power: 5.5 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3085. 160 SH/ 253	Q=35m3/h H=15m P=2,4kW U=400 V	3,500	
2	WWPS - "Bryukhovychy Pryluky"	Wilo SEV 80.80	2010	Quantity: 1 Prime Power: 12,6 kW Voltage: 400 V Phase(s): 3-phased	Flygt NP3153.182 HT	Q=140m3/h H=60m P=7.5kW U=400 V	15,000	• Vodokanal maintenance team can install new pumps; • Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.
		Wilo SEV 80.80	2010	Quantity: 1 Prime Power: 12,6 kW Voltage: 400 V Phase(s): 3-phased	Flygt NP3153.182 HT	Q=140m3/h H=60m P=7.5kW U=400 V	15,000	
		Wilo SEV 80.80	2010	Quantity: 1 Prime Power: 12,6 kW Voltage: 400 V Phase(s): 3-phased	Flygt NP3153.182 HT	Q=140m3/h H=60m P=7.5kW U=400 V	15,000	
3	WWPS - "Vynniki-2 (Striletska)"	КФС 160/45	2001	Quantity: 1 Prime Power: 37 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3202.185 SH/ 273	Q=157m3/h H=43.4m P=32kW U=400 V	28,000	• Vodokanal maintenance team can install new pumps;

TABLE D.7: PUMP REPLACEMENT AND FREQUENCY CONVERTOR NEEDS FOR LVIVVODOKANAL								
NO.	**LOCATION**	**EXISTING EQUIPMENT**			**RECOMMENDED EQUIPMENT**		***INDICATIVE PRICE OF NEW PUMP, USD**	**NOTES/ ADDITIONAL REQUIREMENTS**
		TYPE OF PUMP	**YEAR**	**SPECIFICA-TIONS OF THE MOTORS**	**TYPE OF NEW PUMP**	**SPECIFICA-TIONS**		
		КФС 160/45	2001	Quantity: 1 Prime Power: 55 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3202.185 SH/ 273	Q=157m3/h H=43.4m P=32kW U=400 V	28,000	• Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.
4	WWPS - "Lapaivka"	CM 150-125-315/4	2001	Quantity: 1 Prime Power: 22 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3202.185SH / 274	Q=120m3/h H=42m P=32kW U=400 V	28,000	• Vodokanal maintenance team can install new pumps; • Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.
		ФГ 144/ 46	2000	Quantity: 1 Prime Power: 37 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3202.185SH / 274	Q=120m3/h H=42m P=32kW U=400 V	28,000	
		ФГ 144/ 46	2000	Quantity: 1 Prime Power: 37 kW Voltage: 400 V Phase(s): 3-phased;	Flygt NZ3202.185SH / 274	Q=120m3/h H=42m P=32kW U=400 V	28,000	
5	WWPS - "Medovoi Pecheri"	CM 150-125-315/4	1997	Quantity: 1 Prime Power: 37 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3202.180 HT/456	Q=270m3/h H=26,6m P=37kW U=400 V	28,500	• Vodokanal maintenance team can install new pumps;

TABLE D.7: PUMP REPLACEMENT AND FREQUENCY CONVERTOR NEEDS FOR LVIVVODOKANAL								
NO.	LOCATION	EXISTING EQUIPMENT			RECOMMENDED EQUIPMENT		*INDICATIVE PRICE OF NEW PUMP, USD	NOTES/ ADDITIONAL REQUIREMENTS
		TYPE OF PUMP	YEAR	SPECIFICATIONS OF THE MOTORS	TYPE OF NEW PUMP	SPECIFICATIONS		
		СМ 150-125-315/4	2008	Quantity: 1 Prime Power: 22 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3202.180 HT/456	Q=270m3/h H=26,6m P=37kW U=400 V	28,500	• Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.
		СД 250/ 22,5	1997	Quantity: 1 Prime Power 40 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3202.180 HT/456	Q=270m3/h H=26,6m P=37kW U=400 V	28,500	
6	WWPS - ”Ryasne-2”	СМ 200-150-500/4б	1991	Quantity: 1 Prime Power: 132 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3231/ 665-480	Q=451m3/h H=47m P=105kW U=400 V	65,000	• Vodokanal maintenance team can install new pumps; • Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.
		СМ 200-150-500/4б	2001	Quantity: 1 Prime Power: 132 kW Voltage: 400 V Phase(s): 3-phased;	Flygt NZ3231/ 665-480	Q=451m3/h H=47m P=105kW U=400 V	65,000	
		СМ 200-150-500/4а	2001	Quantity: 1 Prime Power: 132 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3231/ 665-480	Q=451m3/h H=47m P=105kW U=400 V	65,000	
		СМ 200-150-500/4а	2003	Quantity: 1 Prime Power: 160 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3231/ 665-480	Q=451m3/h H=47m P=105kW U=400 V	65,000	
7	WWPS - 4	СМ 250-200-400/4а	1995	Quantity: 1 Prime Power: 200 kW Voltage: 400 V	Flygt NZ3231/ 736-480	Q=800m3/h H=50m P=170kW U=400 V;	92,000	• Vodokanal maintenance team can install new pumps;

TABLE D.7: PUMP REPLACEMENT AND FREQUENCY CONVERTOR NEEDS FOR LVIVVODOKANAL								
NO.	LOCATION	EXISTING EQUIPMENT			RECOMMENDED EQUIPMENT		*INDICATIVE PRICE OF NEW PUMP, USD	NOTES/ ADDITIONAL REQUIREMENTS
		TYPE OF PUMP	YEAR	SPECIFICATIONS OF THE MOTORS	TYPE OF NEW PUMP	SPECIFICATIONS		
				Phase(s): 3-phased				• Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.
		CM 250-200-400/4a	1997	Quantity: 1 Prime Power: 250 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3231/ 736-480	Q=800m3/h H=50m P=170kW U=400 V	92,000	
		СД2400/75 6	1997	Quantity: 1 Prime Power: 500 kW Voltage: 6000 V Phase(s): 3-phased	Flygt CZ3335/ 905	Q=2500m3/h H=46m P=375kW U=400 V	230,000	
8	WWPS - 5	CM 250-200-400/4a	1991	Quantity: 1 Prime Power: 250 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3231/ 665-480	Q=800m3/h H=50m P=105kW U=400 V	71,000	• Vodokanal maintenance team can install new pumps; • Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.
		CM 250-200-400/4a	1997	Quantity: 1 Prime Power: 250 kW Voltage: 400 V Phase(s): 3-phased	Flygt NZ3231/ 665-480	Q=800m3/h H=50m P=105kW U=400 V	71,000	
		16ФВ-19	1997	Quantity: 1 Prime Power: 400kW Voltage: 6000 V Phase(s): 3-phased	Flygt NZ3231/ 665-480	Q=800m3/h H=50m P=105kW U=400 V	71,000	
9	WWPS - "Bryukhovychi"	CM 200-150-500/4 and CM 200-150-500/4 (combined)	2018	Quantity: 2 Prime Power: 160 + 160 kW Voltage: 400 V Phase(s): 3-phased	Flygt CZ3240/805-520	Q=400m3/h H=90m P=215kW U=400 V	127,000	• Vodokanal maintenance team can install new pumps;

TABLE D.7: PUMP REPLACEMENT AND FREQUENCY CONVERTOR NEEDS FOR LVIVVODOKANAL								
NO.	LOCATION	EXISTING EQUIPMENT			RECOMMENDED EQUIPMENT		*INDICATIVE PRICE OF NEW PUMP, USD	NOTES/ ADDITIONAL REQUIREMENTS
		TYPE OF PUMP	YEAR	SPECIFICATIONS OF THE MOTORS	TYPE OF NEW PUMP	SPECIFICATIONS		
		СД450/ 95	1997	Quantity: 1 Prime Power:315 kW Voltage: 400 V Phase(s): 3-phased	Flygt CZ3240/805-520	Q=400m3/h H=90m P=215kW U=400 V	127,000	• Each new pump requires additional installation of FC; • Staff must submit a special order with FC design and manufacturing specifications; • Manufacturer representative must deliver, install, test, and commission FC; and • Vodokanal must purchase spare parts for potential follow-up maintenance.

* Total price is indicative and includes only the cost of equipment without any additional costs. Price depends on the manufacturer, availability, and country where equipment will be ordered.

D.3.4 ELECTRICAL SUPPLY SYSTEM NEEDS

Stage 3: Equipment is not needed for at least 6–9 months, or longer, or cannot be procured in a short period of time.

Justification: Most of the electrical equipment in high-voltage electrical substations (35/10/6 kV) and electrical rooms (0.4 kV) are outdated and do not meet requirements of technical operations and maintenance rules and health and safety requirements and cannot ensure the stability of electrical supply. The highest priorities in this list are the reconstruction of the 35/6 kV electrical substation on WPS "Volia Dobrostanska" with additional installation of FCs on the pumping equipment, relocation of a 6kV cable line that powers WPS "Sykhiv" with additional installation of FCs on the pumping equipment, and reconstruction/modernization of the 35/6/0.4 kV electrical substation that powers WPS "Kamenobrid" with additional installation of FCs on the pumping equipment.

TABLE D.8: ELECTRICAL SUPPLY SYSTEM NEEDS FOR LVIVVODOKANAL					
NO.	LOCATION, NAME OF THE SITE	YEAR OF COMMISSIONING	INSTALLED CAPACITY, KW	SOURCE OF THE POWER SUPPLY OF FACILITY AND PROBLEMATIC ISSUES	NEEDS
1	WPS "Volia Dobrostanska"	1901	2000 kW	In 1901 steam engines were used to supply water to Lviv. In 1930, an electrical substation with a voltage of 30 kV was built, from which all pumping units were powered. In the late 40s, this WPS switched to a voltage of 35 kV without reconstructing the	Lvivvodokanal developed the design documentation for the reconstruction of the Electrical Substation 35/6 kV and need funding for reconstruction. Approximate costs for realization of this project: USD 2,580,000.

TABLE D.8: ELECTRICAL SUPPLY SYSTEM NEEDS FOR LVIVVODOKANAL					
NO.	LOCATION, NAME OF THE SITE	YEAR OF COMMISSIONING	INSTALLED CAPACITY, KW	SOURCE OF THE POWER SUPPLY OF FACILITY AND PROBLEMATIC ISSUES	NEEDS
				construction part and replacing high-voltage equipment of 30 kV. Electrical equipment of Electrical Substation 35/6 kV does not meet requirements of Technical Operations and Maintenance Rules, Health and Safety Requirements, and needs of reconstruction.	They need FC installation on pumping equipment.
2	WPS "Sykhiv"	1973	2000 kW	During the construction of the railway bridge and Sykhiv str. cable power line-6kV, which feeds the WPS was placed under a bulk road. The embankment is about 5 m. It is impossible to repair this section of the cable line.	Lvivvodokanal developed the design documentation for relocation of 6 kV cable line, but still need funding for the implementation of this project. Approximate costs for realization of this project:140,000 USD. They need FC installation on pumping equipment prime power 200 kW.
3	WPS "Kamenobrid"	1952	1640 kW	Kamenobrid's power supply comes from Electrical Substation 35/6/0.4 kV. The substation is equipped with equipment from the late 1940s and early 1950s. The equipment of the substation is no longer in production, and it is not possible to find spare parts for repair and proper maintenance.	The development of design documentation for the reconstruction/modernization of the electrical substation and implement the project is needed. Installation of FCs on pumping equipment prime power 200 kW is required.
4	WPS "Velikopole"	1928	1200 kW	Velikopole's power supply comes from the Electrical Substation 30/0.4 kV. In the 1930s, the substation switched to a voltage of 35 kV; in 1976 it failed and the Vodokanal reconstructed the substation using outdated equipment available in warehouses. Currently, electrical equipment is outdated.	The development of design documentation for the reconstruction/modernization of the of Electrical Substation 30/0.4 kV and implement the project is needed. Installation of Frequency Converters on pumping equipment is required.
5	WPS "Bibrka"	1969	2500 kW	Bibrka's power supply comes from Electrical Substation 35/10 kV of PJSC "Lvivoblenergo" and from Electrical Substation 35/10 kV, which is on the Lvivvodokanal balance sheet. The 10 kV switchgear is made single-section, which does not meet the technical requirements. Water intake wells are powered from one line 10 kV, without any backup source.	The development of design documentation is needed, and reconstruction of Electrical Substations 35/10 kV, RU-10 kV, and power lines-10 kV wells, which will make it possible to power from different power lines. Installation of Frequency Converters on pumping equipment is required.

TABLE D.8: ELECTRICAL SUPPLY SYSTEM NEEDS FOR LVIVVODOKANAL					
NO.	LOCATION, NAME OF THE SITE	YEAR OF COMMISSIONING	INSTALLED CAPACITY, KW	SOURCE OF THE POWER SUPPLY OF FACILITY AND PROBLEMATIC ISSUES	NEEDS
6	WPS "Glinna Navariya"	1973	2000 kW	Glinna Navariya's power supply comes from Electrical Substation 35/6 kV. The substation is powered from the power grids of PJSC "Lvivoblenergo" under the III category of reliability, which does not meet the technical requirements and the category of reliability for electrical supply. Electrical equipment of the Electrical Substation is obsolete and requires reconstruction and modernization.	The development of design documentation is needed, and the reconstruction of the Electrical Substation 35/6 kV, which will meet the technical requirements for the category of reliability of power supply. Installation of Frequency Converters on pumping equipment is required.
7	WPS "Malechkovichi"	1931	350 kW	Malechkovichi's power supply comes from one power line 6 kV, RU-6 kV single-section, which does not meet the requirements of the category of reliability of power supply. The substation's equipment is outdated and requires modernization or replacement.	The development of design documentation and the reconstruction of the electrical supply system in line with the proper category of reliability.
8	WPS "Zboisha"	1965	1050 kW	Zboisha's power supply is from two 6 kV power lines. One of them passes through residential areas and was repeatedly damaged during the construction of private buildings and is currently in poor condition. The 6 kV side and 0.4 kV side of the Electrical Substation are obsolete and require reconstruction and modernization.	The development of design documentation and the replacement power line 6 kV and for reconstruction and modernization of the Electrical Substation.
9	WPS "Zarudtsi"	1965	8000 kW	Zarudtsi's power supply is from the Electrical Substation 35/6 kV. The electrical scheme of the substation circuit does not comply with modern rules of technical operation (there are no 35 kV vacuum switches of 35 kV lines Kulykiv, Zhovkva and a 35 kV sectional vacuum circuit breaker). Electrical equipment of Substation 35/6 kV is outdated; it's hard to find spare parts for repair and the equipment requires modernization or replacement.	The development of design documentation is needed, and the reconstruction of Electrical Substation 35/6 kV is required. Installation of Frequency Converters on pumping equipment is required.
10	WPS "Yanivska"	1928	1050 kW	Since commissioning of Yanivska, modernization and reconstruction of the high voltage 6 kV side of the electrical substation have not been done, though they did partially modify the 0.4 kV side.	The development of design documentation and the reconstruction of the Electrical Substation is needed.

TABLE D.8: ELECTRICAL SUPPLY SYSTEM NEEDS FOR LVIVVODOKANAL					
NO.	LOCATION, NAME OF THE SITE	YEAR OF COMMISSIONING	INSTALLED CAPACITY, KW	SOURCE OF THE POWER SUPPLY OF FACILITY AND PROBLEMATIC ISSUES	NEEDS
11	Water intake "Krekhiv"	1967	1148 kW	Krekhiv's power supply runs through one 10 kV power line with a length of 23 km. Power supply scheme does not correspond to the category of reliability of power supply.	The development of design documentation is needed, and a plan to provide a second source of power supply is needed.

D.3.5 CARS AND SPECIAL MACHINERY NEEDS

Stage 1: Equipment is needed immediately.

Justification: Almost all cars and special machinery used by the vodokanal are old, in poor condition, and were manufactured in Russia and Belarus. The special machinery is outdated, and spare parts are difficult to obtain for repairs. Emergency service vehicles, a mobile electrical laboratory vehicle, and a fuel truck are the highest priorities within this category.

TABLE D.9: CAR AND SPECIAL MACHINERY NEEDS FOR LVIVVODOKANAL				
NO.	TYPE	QTY.	*INDICATIVE PRICE, USD	NOTES
1	Emergency Service Vehicles	10	1,100,000	Lack of these vehicles poses a danger to the deployment of repair crews to address emergencies and, as a result, possible termination of the water supply.
2	10 Ton Dump Truck	4	380,000	
3	20 Ton Dump Truck	2	370,000	
4	Fuel Truck	1	115,000	
5	Mobile Electrical Laboratory Vehicle	1	160,000	
6	Truck with a 12 m trailer for pipe transportation	1	110,000	
7	Tower car (car equipped with a device for lifting and moving workers with tools and materials)	1	135,000	

* Total price is indicative and includes only the cost of cars and special machinery without any additional costs and depends on the manufacturer.

D.4 REFERENCES

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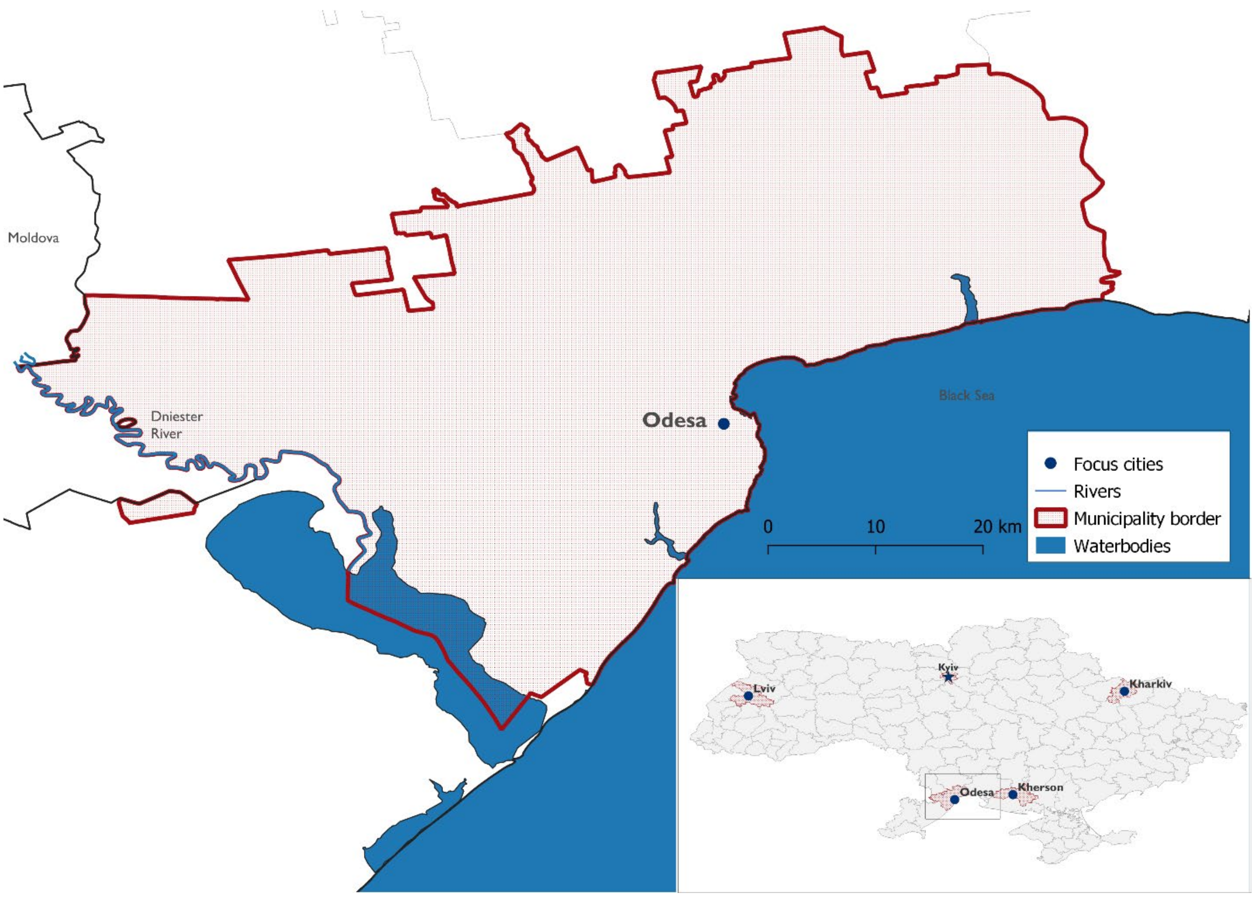
Rodak, Kateryna. 2022. "Large Part of Lviv Disconnected from Water Supply: A List of Streets." November 29, 2022. Zaxid.net. https://zaxid.net/ponad_80_vulits_lvova_zalishilis_bez_vodopostachannya_perelik_n1553608

ANNEX E: INFOXVODOKANAL (ODESA)

ODESA
Infoxvodokanal, Branch of Limited Liability Company Infox Pre-war Population (# of people): 1,010,537 Current Population (# of people): ~1,010,075 Net Population Change: -<1% Pre-war Employees (# of staff): N/A Current Employees (# of staff): N/A Net Employee Change: N/A



E.1 INFOXVODOKANAL (ODESA)

Summary

- Most of Infoxvodokanal's high-voltage power supply infrastructure for water pumping stations (WPSs) has been replaced with low-voltage equipment and the additional installation of frequency controllers. These modifications allowed donors and other organizations to cover most backup power needs, though there is still some need for low-voltage generators and frequency converters.
- All high-voltage equipment is still without backup power sources. Infoxvodokanal management is already in discussions with other donors about addressing these and other longer-term needs and thus did not share information that would have enabled the assessment team to identify Stage 3 needs.
- Stage 1 needs will cost approximately USD 700,000–750,000. Stage 2 needs will cost approximately USD 550,000–600,000.

Site Visit Overview

Three CDM engineers visited Infoxvodokanal on March 21–23, 2023. During the site visit, the team held multiple meetings with Infoxvodokanal management and toured several WPSs.

General Overview

Drinking water was first supplied from the Dniester River to the city of Odesa in 1873. The water supply and wastewater systems gradually expanded with the city's growth through 1991. After the fall of the Soviet Union in 1991, the water supply and wastewater service provider transformed into a private joint-stock company, and the communal enterprise (CE) Odesavodokanal was subsequently formed. However, given challenges with infrastructure maintenance needs, in December 2003 the Odesa City Council leased Odesavodokanal to the limited liability company Infox for a 49-year period. A branch of Infox called Infoxvodokanal was created in 2004 to provide water supply and wastewater services to the city. Today, the company supplies water to the city of Odesa and sells water to vodokanals in settlements within a 50-kilometer (km) radius from the regional center, including Chernomorsk, Belyaevka, Belgorod-Dnestrovsky, and Yuzhny.

Infoxvodokanal provided 2,485,889 cubic meters (m^3) of water to CE Teplopostachannia mista Odesy for district heating purposes in 2022. Infoxvodokanal is their only water supply source.

E.1.1 OVERVIEW OF NETWORK AND FACILITIES

Water System Overview

TABLE E.1: WATER SYSTEM OVERVIEW – INFOXVODOKANAL			
CATEGORY		DATA	NOTES
WATER	Water Intakes	3	Surface water intakes
	Capacity of Water Intakes (m^3/day)	820,000	
	Source Types	Surface water	
	Groundwater Wells	N/A	
	Max. Well Depth (meters [m])	N/A	
	Surface Water Bodies	1	Dniester River
	Length of Water Pipelines (km)	1,853	
	Water Pipe Max. Diameter (m)	1.6	
	(Main) Water Pumping Stations	7	
	(Local) Water Pumping Stations	56	
	Treatment Plant Capacity (m^3/day)	820,000	
	Treated Water Storage Capacity (m^3)		Data not available
	Pre-War Demand (m^3/day)		Data not available
	Current Water Demand (m^3/day)	350,000	
	Change in Water Demand		Data not available
	Pre-War Supply (m^3/day)		Data not available
	Current Supply (m^3/day)	350,000	
	Change in Supply		Data not available
	Water Provided to Teploenergos (m^3)	2,485,889	Amount provided in 2022

The Dniester River supplies drinking water for Infoxvodokanal. The Dniester water intake station consists of five blocks, each of which includes WPSs of the first and second lift. Treatment is carried out at a water treatment plant with 69 filter units. Source water passes through layers of sand with intermediate settling of suspensions in tanks following addition of coagulants. Water is then disinfected with liquid chlorine via an automatic dosing system.

The Odesa water supply network is divided into three districts—Northern, Central, and Southern—and water is allocated to each. Infoxvodokanal did not share information on the number of consumers and water supplied to each district. Water is distributed throughout the city by seven main WPSs and 56 low-capacity booster WPSs that supply water to neighborhoods and residential clusters. During the night, treated water is collected in water storage tanks and stored for peak demand hours. Sodium hypochlorite is added at booster WPSs to account for reduced chlorine concentration during pumping throughout the network. The city's water supply network is designed as a ring system and has a length of approximately 1,853 km.

Wastewater System Overview

TABLE E.2: WATER SYSTEM OVERVIEW – INFOXVODOKANAL			
CATEGORY		DATA	NOTES
WASTEWATER	Length of Sewerage Network (km)	931.7	
	Main Collector Pipes		Data not available
	Wastewater Pumping Stations	25	
	Treatment Plant Capacity (m^3/day)	190,320	
	Pre-War Total Wastewater Flow (m^3/day)		Data not available
	Current Total Wastewater Flow (m^3/day)	190,320	
	Change in Total Wastewater Flow		Data not available

The length of the Odesa's wastewater network is approximately 931.7 km. Industrial and household wastewater is collected in gravity flow collectors and carried to 25 wastewater pumping stations (WWPSs). Up to 190,320 m^3/day of wastewater is pumped through more than 100 pumps to two wastewater treatment plants (WWTPs), the Severnaya WWTP and the Yuzhnaya WWTP. The WWTPs include mechanical and biological treatment and sludge fields.

The Severnaya WWTP receives wastewater from several districts in Odesa, including the central part of the city, Peresyp, Moldavanka, Slobodka, Kotovsky, and part of Malinovsky. Wastewater undergoes mechanical and biological treatment, including pumping through grates, sand traps, primary settling tanks, aeration tanks, and secondary settling tanks. Treated wastewater is then discharged into the Khadzhibey estuary or the Black Sea. Produced sludge is compacted and stored at the storage site on the WWTP's property.

The Yuzhnaya WWTP receives domestic wastewater from the southern part of the city, Kiev District, Tairov, Chernomorka, and the left bank of the Sukhyi estuary. Wastewater undergoes treatment and is then discharged into the Black Sea through a 2 km long deep-sea outlet. Produced sludge is dehydrated in centrifuges and stored at the storage site on the WWTP's property.

E.1.2 POWER NEEDS AND SUPPLY

Infoxvodokanal utilizes both high-voltage (6 kV, 10 kV) and low-voltage (0.4 kV) power equipment. Much of the existing electrical equipment was commissioned between 1930 and the 1990s and, despite significant wear and tear, has not been reconstructed or replaced. This equipment is mostly outdated and requires constant maintenance. Due to the war, the supply of spare parts needed for maintenance and repairs is limited. Infoxvodokanal has no energy efficiency policies, resource efficiency usage plans, or personnel responsible for energy management. According to the data provided, Infoxvodokanal is developing an energy management system, but it has yet to be implemented.

The Dniester water intake is very energy intensive, relying on mostly outdated pumping equipment without proper monitoring and control systems. Surface water intake stations of the first and second lifts have not been reconstructed since they were put into operation between the 1960 and 1980s. They operate on Soviet-era, outdated, high-voltage (6 kV) pumps with synchronous motors. Pump operating modes are inconsistent with seasonal and daily fluctuations (cyclical changes). The lack of accurate automatic regulation, as well as systems for collection and analysis of statistical data, does not allow operational modes to reflect changes in water demand, leading to inefficient use of water resources and increased consumption of electricity. In addition, resultant non-optimal conditions, such as increased pressure in the system, result in damage to water supply networks and the need for maintenance and repairs (with the associated costs).

The total annual energy consumption of Infoxvodokanal for the last three years is provided in Table E.3.

TABLE E.3: INFOXVODOKANAL ANNUAL ENERGY CONSUMPTION FOR 2020–2022			
	2020	2021	2022
Total annual energy consumption of Dniester water intake, kilowatt hour (kWh)	67,437,320	65,314,730	59,831,010
Total annual energy consumption of water supply systems, kWh	24,541,150	23,798,420	21,296,78
Total annual energy consumption of wastewater systems, kWh	14,052,770	14,515,040	13,117,150
Total annual energy consumption of wastewater treatment plants, kWh	23,065,190	23,503,390	18,080,050
Total annual energy consumption for other internal operational needs, kWh	7,332,630	8,223,230	6,769,480
Total annual energy consumption of Infoxvodokanal, kWh	136,429,060	135,354,810	99,927,368

A large amount of Infoxvodokanal's high-voltage WPS electrical equipment has been replaced with low-voltage equipment with the additional installation of frequency controllers (by pressure). These modifications have reduced electricity consumption and improved energy efficiency by maintaining the necessary technological parameters due to frequency regulation. Annual energy effectiveness indicators for Infoxvodokanal over the last three years (2020–2022) are presented in Table E.4, calculated as the total power consumed by each system per m^3 of water or wastewater produced.

TABLE E.4: INFOXVODOKANAL ANNUAL ENERGY EFFECTIVENESS INDICATORS FOR 2020–2022			
Year	2020	2021	2022
Total annual energy effectiveness of Dniester water intake, kWh/m³	0.574	0.559	0.552
Total annual energy effectiveness of water supply systems, kWh/m³	0.225	0.214	0.225
Total annual energy effectiveness of wastewater systems, kWh/m³	0.170	0.167	0.189
Total annual energy effectiveness of wastewater treatment plants, kWh/m³	0.278	0.270	0.260

E.1.3 KEY CHALLENGES DUE TO THE WAR IN UKRAINE

Odesa is located in southern Ukraine, a region with power supply capacity deficits. This was a problem even before the war, which the state power transmission and distribution company Ukrenergo was working to solve by constructing a new 750 kV high-voltage line and 750/330 kV substation. Since the onset of the Russian Federation's direct attacks on critical power supply infrastructure in October 2022, the capacity deficit has grown, as missile attacks target transformer substations. Power supply deficits are particularly acute in Odesa. Multiple missile and drone attacks from the Black Sea have resulted in frequent emergency and stabilization shutdowns, where districts of the city with no direct damage following an incident still had their power supply shut down to stabilize the grid. In some instances, the power supply to Odesa was interrupted for over five days. For a full list of incidents and impacts, see Section E.2.

Infoxvodokanal power outages during local blackouts are thus a key challenge. Since October 2022, power supply to the Dniester surface water intake has been interrupted twice for two hours each time, resulting in a lack of water supply to the treatment facilities and city. To keep water and wastewater services running, Infoxvodokanal has developed an Emergency Operation Plan (EOP) to manage power outages to their facilities. While other donors have provided some backup power supplies to Infoxvodokanal, needs for both low-voltage and high-voltage generators remain. Additionally, **scheduled shutdowns to stabilize the power system** have resulted in constant emergency switching of the electrical equipment. This increases wear and tear of already outdated pumping and other electric equipment, and thus increases breakdown rates.

Though some WPSs and WWPSs have been reconstructed, Soviet-era electric equipment remains in several stations. These must be modernized, including oil transformers for auxiliary needs and low-voltage and high-voltage switching and protective electrical equipment (including obsolete high-voltage cells based on outdated oil circuit breakers and relay protection). This equipment is three to five times past its service life and requires replacement as it does not function properly in conditions of constant emergency shutdowns.

E.1.4 PRIORITIZED NEEDS TO ENSURE CONTINUOUS SERVICE DELIVERY

A detailed list of needs by priority stages is provided in Section E.3. The stages are as follows:

- Supply stage 1 (emergency): Equipment needed as soon as possible.
- Supply stage 2: Equipment needed within the next 3 months.
- Supply stage 3: Equipment is not needed for at least 6–9 months (or longer), or cannot be procured in a short period of time.

Stage 1: To increase the resilience of Infoxvodokanal facilities and systems, low-voltage switching and protective equipment, low-voltage frequency converters, and cable products for emergency repairs should be prioritized. The estimated cost to cover needs under Stage 1 is approximately USD 700,000–750,000 (approximate cost of equipment/materials only, excludes any additional costs for delivery).

Stage 2: As a second priority, equipment is needed for backup power supply for wastewater systems and to increase energy efficiency. This includes auxiliary step-down transformers (6/0.4 kV), low-voltage diesel generators, and components of high-voltage cells required for repairs (e.g., vacuum arc quenching chambers). The estimated cost for Stage 2 needs is approximately USD 550,000–600,000.

Stage 3 needs cover efficiency improvements and are discussed in Section E.1.5.

Low-voltage switching and protective equipment

Existing electrical switchgears, electrical protection equipment, and cable products are outdated and require constant repair, reducing the reliability of the city's water supply and sewage systems. Constant emergency switching further reduces the equipment's functionality, which often does not work in critical situations. Backup power supplies will not increase the resilience of Infoxvodokanal's water and wastewater systems unless old switching and protective equipment is replaced.

In addition, a shortage of spare parts exacerbates the need for repairs and maintenance. Replacement of low-voltage (0.4 kV) circuit breakers, switchgears, and contactors will alleviate these issues. None of this equipment will require additional design, and Infoxvodokanal's technical personnel can perform the installation.

Auxiliary step-down power transformers (6/0.4 kV)

The replacement of these transformers will increase the stability of Infoxvodokanal facilities' electrical systems. The replacement of outdated Soviet-era oil transformers will reduce electric power equipment failures during frequent emergency switching and starting of pumping equipment—the effect of high incoming currents and sudden voltage increases. Before ordering this equipment, it will be necessary to collect additional parameters to ensure operation is synced with existing equipment and consider these technical requirements as a part of tender procedures.

Components of high-voltage cells required for emergency repairs

Some components of high-voltage (6 kV) cells, including vacuum arc quenching chambers of vacuum circuit breakers, need to be replaced because they are outdated and do not meet safety requirements outlined by the manufacturer and national rules for safe operation of electrical equipment (PBEES). Infoxvodokanal personnel can replace this equipment; however, the purchase requires detailed discussions with the manufacturer of existing circuit breakers at Infoxvodokanal's facilities.

Low-voltage diesel generators

Low-voltage generators are required to power the low-voltage water supply and wastewater system equipment in line with the EOP. Infoxvodokanal personnel can carry out installation and connection of low-voltage equipment.

E.1.5 ENERGY AND OPERATIONAL EFFICIENCY

Infoxvodokanal management did not share information with the assessment team required to identify exact needs and evaluate approximate costs for energy and operation efficiency improvements. Infoxvodokanal is already in discussions with other donors including the United Nations Development Programme to cover these needs, and vodokanal management is trying to prevent overlap. A description of short-term needs (Stage 3) for improved understanding of Infoxvodokanal's facilities and plans is presented below, but this is not intended to inform additional equipment procurement and delivery.

A number of Infoxvodokanal emergency needs are difficult to address in the short term due to significant engineering and design requirements and extensive procurement timelines of nine months or longer. This is particularly relevant for backup power supplies for water supply and wastewater system high-voltage pumping equipment. Providing high-voltage (6 kV) backup and emergency supply will require detailed design and likely extensive procurement times. Most of the high-voltage equipment that needs to be replaced is located at the WPS for the Dniester water intake.

WPSs of the Dniester surface water intake's first and second lifts have not been reconstructed since they were put into operation between 30 and 60 years ago. They operate on high-voltage (6 kV) pumps of outdated Soviet-era design, with synchronous motors. High starting currents of synchronous motors (seven times the nominal values) result in high current surges, thermal shocks, and high starting torques. These wear down outdated equipment even faster and greatly increase the power required from backup power sources. To solve this problem, installation of frequency converters is recommended. However, there are high-voltage pumps at each pumping station that operate in parallel, resulting in the need for simultaneous installation of several stations with frequency regulation.

In summary, to increase the resilience of Infoxvodokanal facilities and systems, provide backup power supply for wastewater systems, and increase energy efficiency, Stage 3 needs include the construction of control stations for high-voltage (6 kV) asynchronous motors with frequency control; construction of control stations for high-voltage asynchronous motors based on synchronous starting devices (soft starter); replacement of high-voltage (6 kV) cells, including for backup power from diesel generators; and construction of high-voltage (6 kV) emergency power supplies.

Replacement of outdated electrical equipment in electrical substations and electrical control rooms is also needed and would require additional assessment and design prior to procurement. Replacement of high-voltage (6 kV) equipment in WWPSs and WPSs to low-voltage (0.4 kV) equipment is also needed, including installation of asynchronous low-voltage (0.4 kV) motors, installation of step-down transformers (6/0.4 kV) in block-modular buildings near the outer walls of the stations, installation of low-voltage control stations with frequency control/soft start function, and reconstruction of high-voltage (6 kV) cells.

Projects specific to the introduction of alternative energy sources, such as solar panels, wind turbines, heat pumps, and biogas, can be considered following the replacement and modernization of outdated electrical equipment.

E.2 INFOXVODOKANAL (ODESA) INCIDENTS AND IMPACTS

SUMMARY

Infoxvodokanal only reported one case of infrastructure damage: on April 3, 2022, a missile damaged a 1,200 mm diameter water supply pipeline along Otaman Chepyga Street in the Suvorovskyi District. The vodokanal reported complete service disruption on November 23, 2022, after the blackout in the national electricity system (Infoxvodokanal 2022a).

INCIDENT 1: APRIL 3, 2022

A missile strike on April 3, 2022, damaged the vodokanal’s 1,200 mm diameter pipeline in six places along Otaman Chepyga Street as well as electrical equipment in several facilities. Financial losses amounted to Ukrainian Hryvnia 155,942. Subsequent missile attacks damaged unspecified technical buildings. The incidents did not disrupt the provision of water and wastewater services to consumers.

INCIDENT 2: NOVEMBER 23, 2022

In response to an information request, Infoxvodokanal stated that all its facilities (water and wastewater) were completely disconnected from the power supply due to a missile attack on energy infrastructure on November 23, 2022. The vodokanal also stated that all WPSs and backup lines were disconnected from power supply (Infoxvodokanal 2022a). Water and wastewater service disruption lasted for four to eight hours across the city. On the morning of November 24, Infoxvodokanal announced that the water supply had not yet been restored to part of Suvorovskyi District: “The water supply of the Suvorivskyi and Slobidka Districts will be resumed after the restoration of the energy supply to the relevant water supply facilities” (Infoxvodokanal 2022b).

INCIDENT 3: DECEMBER 5, 2022

In response to an information request, Infoxvodokanal stated that it experienced a partial disruption of services on December 5, 2022, due to a power outage; all pumping stations and backup lines were disconnected from the power supply (Zharikova 2022a). Infoxvodokanal did not specify if the power outage affected wastewater services.

INCIDENT 4: DECEMBER 11, 2022

A power outage in Odesa resulted in disconnection of Infoxvodokanal's water pumping facilities from their power supply. The power outage did not affect wastewater services. The electricity supply company DTEK stated that the power outage lasted several hours (Pylypiv 2022).

INCIDENT 5: DECEMBER 29, 2022

In response to an information request, Infoxvodokanal stated that it experienced a partial disruption of services on December 29, 2022, due to a power outage; all pumping stations and backup lines were disconnected from their power supplies (Zharikova 2022b). Infoxvodokanal did not specify the impact on wastewater services.

INCIDENT 6: JANUARY 26, 2023

In response to an information request, Infoxvodokanal stated that it experienced a partial disruption of services on January 26, 2023, due to a power outage following a missile attack; all pumping stations and backup lines were disconnected from power supply. The vodokanal did not specify if the power outage affected wastewater services. The duration of the outage was also not specified. Electricity supply was restored to Infoxvodokanal and consumers the same day, according to electricity provider DTEK (Rocco 2023).

E.3 INFOXVODOKANAL (ODESA) EQUIPMENT LIST

Infoxvodokanal has developed an EOP to ensure water and wastewater service delivery during power outages and blackouts. To carry out these plans, Infoxvodokanal needs both low-voltage and high-voltage equipment. Equipment needs are divided into three stages depending on the level of need (from the most urgent to the least):

- Stage 1: equipment is needed immediately; Stage 1 needs will cost approximately USD 700,000–750,000.
- Stage 2: urgent, equipment is needed within 3 months; Stage 2 needs will cost approximately USD 550,000–600,000.
- Stage 3: equipment is not needed for at least 6-9 months or longer, or cannot be procured in a short period of time. Please note that Stage 3 needs are not included in this list due to the lack of information provided for assessment by Infoxvodokanal and other donors currently working with them to fulfil these needs. Please see Section E.1.5 for additional details.

Information on Infoxvodokanal's point of contact regarding equipment procurement and delivery is provided below. All equipment and materials should be delivered to the following address: [information available upon request]. Vodokanals were not able to provide global positioning system coordinates, and the names of facilities where equipment is to be installed should be discussed with the vodokanal's point of contact. Costs provided in each row in the subsequent tables are total costs, not per unit costs.

POSITION	NAME	CONTACT PHONE	EMAIL
Chief Power Engineer	Available upon request	Available upon request	Available upon request

E.3.1 GENERATOR NEEDS

Stage 2: Urgent, equipment is needed within 3 months.

Justification: Supply of the low-voltage generators is required to power low-voltage equipment in case of power outages in line with the EOP.

TABLE E.5: LOW-VOLTAGE GENERATOR NEEDS FOR INFOXVODOKANAL'S FACILITIES (ADDITIONAL INSTALLATION OF FREQUENCY CONVERTERS IS REQUIRED)

NO.	LOCATION	TYPE OF GENERATOR	SPECIFICATIONS	QTY.	INDICATIVE PRICE, USD*	NOTES/ADDITIONAL REQUIREMENTS
1	WPSs WWPSs	Diesel generator (DG)	Fuel type: Diesel Prime Power: 125 kVA Voltage: 400 V Phase(s): 3 phased Configuration: Y Generator type: Stationary Generator installation: Outdoor Type of transfer switch: Automatic Additional specs: With additional heating of the coolant; with automatic battery charging.	3	100,000	• For chosen DG power, additional frequency converter (FC) installation is required. • Vodokanal maintenance team can perform DG installation on site. • Additional installation of Automatic Reserve Activation (AVR) in the electrical room is required (can be designed and developed by special orders). • Testing and commissioning by manufacturer representatives after installation are required. • Contracts for follow-up maintenance from manufacturer and fuel/oil supply are required.
2	WPSs WWPSs	DG	Fuel type: Diesel Prime Power: 100 kVA Voltage: 400 V Phase(s): 3 phased Configuration: Y Generator type: Stationary Generator installation: Outdoor Type of transfer switch: automatic; Additional specs: with additional heating of the coolant; with automatic battery charging.	2	38,000	
3	WPSs WWPSs	DG	Fuel type: Diesel Prime Power: 75 kVA Voltage: 400 V Phase(s): 3 phased Configuration: Y Generator type: Portable Generator installation: outdoor Type of transfer switch: automatic Additional specs: With additional heating of the coolant; with automatic battery charging.	1	25,000	

TABLE E.5: LOW-VOLTAGE GENERATOR NEEDS FOR INFOXVODOKANAL'S FACILITIES (ADDITIONAL INSTALLATION OF FREQUENCY CONVERTERS IS REQUIRED)						
NO.	LOCATION	TYPE OF GENERATOR	SPECIFICATIONS	QTY.	INDICATIVE PRICE, USD*	NOTES/ADDITIONAL REQUIREMENTS
4	WPSs WWPSs	DG	Fuel type: Diesel Prime Power: 70 kVA Voltage: 400 V Phase(s): 3 phased Configuration: Y Generator type: Stationary Generator installation: Outdoor Type of transfer switch: Automatic Additional specs: With additional heating of the coolant; with automatic battery charging.	4	60,800	
5	WPSs WWPSs	DG	Fuel type: Diesel Prime Power: 50 kVA Voltage: 400 V Phase(s): 3 phased Configuration: Y Generator type: Stationary Generator installation: Outdoor Type of transfer switch: Automatic Additional specs: With additional heating of the coolant; with automatic battery charging.	2	22,700	
6	WPSs WWPSs	DG	Fuel type: Diesel Prime Power: 15 kVA Voltage: 400 V Phase(s): 3 phased Configuration: Y Generator type: Stationary Generator installation: Outdoor Type of transfer switch: Automatic Additional specs: With additional heating of the coolant; with automatic battery charging.	1	8,900	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

E.3.2 POWER TRANSFORMER NEEDS

Stage 2: Urgent, equipment is needed within 3 months.

Justification: The existing Soviet-era oil-filled power transformers from the 1960s, 1970s, and 1980s are well past their lifetimes and cannot provide reliable power supply to facilities. Constant equipment failures further reduce the lifespan of older transformers, often during critical times such as continuous power outages and short circuits in electrical networks.

TABLE E.6: POWER TRANSFORMERS NEEDS FOR INFOXVODOKANAL'S FACILITIES

NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	INDICATIVE PRICE, USD*	NOTES/ADDITIONAL REQUIREMENTS
1	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 630 kVA Voltage: 10/0.4 kV	2	41,400	• Infoxvodokanal maintenance and operations personnel can carry out installation work. • Delivery to Odesa is required. • Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer.
2	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 630 kVA Voltage: 6/0.4 kV	2	37,700	
3	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 400 kVA Voltage: 10/0.4 kV	3	42,500	
4	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 250 kVA Voltage: 6/0.4 kV	1	12,800	
5	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 200 kVA Voltage: 6/0.4 kV	1	12,600	
6	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 180 kVA Voltage: 6/0.4 kV	2	23,300	
7	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 160 kVA Voltage: 6/0.4 kV	3	33,900	
8	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 100 kVA Voltage: 6/0.4 kV	4	40,750	
9	WPSs WWPSs	Power Transformer	Type: Dry Rated capacity: 60 kVA Voltage: 6/0.4 kV	1	9,100	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

E.3.3 LOW-VOLTAGE FREQUENCY CONVERTER NEEDS

Stage 1: Equipment is needed immediately.

Justification: Installation of frequency converters will significantly improve the facilities' energy efficiency and increase the reliability of the city's water supply and sewage. Frequency converters will help to stabilize operation and provide significant energy savings.

TABLE E.7: LOW-VOLTAGE FREQUENCY CONVERTER NEEDS FOR INFOXVODOKANAL'S FACILITIES

NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	INDICATIVE PRICE, USD*	NOTES/ADDITIONAL REQUIREMENTS
1	WPSs WWPSs	Low-voltage frequency converter ABB	Motor type: Low-voltage, asynchronous Motor power: 250 kW Voltage: 0.4 kV	3	75,250	• Infoxvodokanal maintenance and operations personnel can carry out installation work. • Delivery to Odesa is required. • Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer.
2	WPSs WWPSs	Low-voltage frequency converter ABB	Motor type: low-voltage, asynchronous Motor power: 200 kW Voltage: 0.4 kV	5	113,500	
3	WPSs WWPSs	Low-voltage frequency converter ABB	Motor type: low-voltage, asynchronous Motor power: 100 kW Voltage: 0.4 kV	11	127,300	
4	WPSs WWPSs	Low-voltage frequency converter ABB	Motor type: low-voltage, asynchronous Motor power: 60 kW Voltage: 0.4 kV	15	123,500	
5	WPSs WWPSs	Low-voltage frequency converter ABB	Motor type: low-voltage, asynchronous Motor power: 40 kW Voltage: 0.4 kV	5	27,200	
6	WPSs WWPSs	Low-voltage frequency converter ABB	Motor type: low-voltage, asynchronous Motor power: 30 kW Voltage: 0.4 kV	2	7,500	
7	WPSs WWPSs	Low-voltage frequency converter ABB	Motor type: low-voltage, asynchronous Motor power: 7.5 kW Voltage: 0.4 kV	1	1,100	

* Total price is indicative and includes only the cost of equipment without any additional cost

E.3.4 ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT NEEDS

Stage 1: Equipment is needed immediately.

Justification: The existing electrical equipment is from the Soviet era and has already exhausted its useful lifetime several times over. The current equipment does not meet modern requirements for electrical installation safety and energy efficiency and is in need of constant repair, which reduces the reliability of the city's water supply and sewage. Constant emergency switching further reduces the service life of the equipment, which often fails to operate in critical situations. Instrumentation and control devices are needed to replace those that have already failed and cannot provide the necessary functions. Cable products are also needed for rapid rehabilitation of destroyed facilities, as well as for emergency works.

TABLE E.8: LOW-VOLTAGE ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT NEEDS FOR INFOXVODOKANAL'S FACILITIES

NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	INDICATIVE PRICE, USD*	NOTES/ADDITIONAL REQUIREMENTS
1	WPSs WWPSs	Circuit breaker	6000A, ~3x380V	1	N/A	
2		Circuit breaker	2500A, ~3x380V	1	6,300	
3		Circuit breaker	1200A, ~3x380V	3	8,000	
4		Circuit breaker	630A, ~3x380V	5	7,100	
5		Circuit breaker	500A, ~3x380V	5	5,600	
6		Circuit breaker	400A, ~3x380V	9	9,300	
7		Circuit breaker	250A, ~3x380V	2	1,150	
8		Circuit breaker	160A, ~3x380V	15	7,150	
9		Circuit breaker	115A, ~3x380V	2	100	
10		Circuit breaker	100A, ~3x380V	2	100	
11		Circuit breaker	80A, ~3x380V	2	230	
12		Circuit breaker	50A, ~3x380V	5	160	
13		Circuit breaker	40A, ~3x380V	5	100	
14		Circuit breaker Schneider 3P	D100A, ~3x380V	10	1,300	
15		Circuit breaker Schneider 3P	D80A, ~3x380V	10	1,100	
16		Circuit breaker Schneider 3P	D63A, ~3x380V	20	1,100	
17		Circuit breaker Schneider 3P	D32A, ~3x380V	20	600	
18		Circuit breaker BA 51-39	800A, ~3x380V	5	1,100	
19		Circuit breaker BA 51-39	600A, ~3x380V	5	1,100	
20		Circuit breaker BA 51-39	320A, ~3x380V	5	1,100	
21		Circuit breaker BA 51-39	250A, ~3x380V	6	1,350	
22		Circuit breaker	100A, ~3x380V	6	1,350	

TABLE E.8: LOW-VOLTAGE ELECTRICAL SWITCHGEAR, PROTECTION EQUIPMENT NEEDS FOR INFOXVODOKANAL'S FACILITIES						
NO.	**LOCATION**	**TYPE**	**SPECIFICATIONS**	**QTY.**	**INDICATIVE PRICE, USD***	**NOTES/ADDITIONAL REQUIREMENTS**
		BA 51-39				
23		Contactor	630A, ~3x380V	2	3,900	
24		Contactor	180A, ~3x380V	2	850	
25		Contactor	160A, ~3x380V	4	880	
26		Contactor	115A, ~3x380V	1	290	
27		Switch boxes YARP-250	250A, ~3x380V	10	1,350	
28		Switch boxes YARP-200	200A, ~3x380V	10	850	
29		Change-over switch boxes YAPR-400	400A, ~3x380V	10	3,300	
30		Change-over switch boxes YAPR-250	250A, ~3x380V	10	2,400	
31		Switch	250A, ~3x380V	2	200	
32		Switch	160A, ~3x380V	6	500	
33		Switch	100A, ~3x380V	10	350	
34		Electromagnetic starter PMLo	80A, ~3x380V	20	5,150	
35		Electromagnetic starter PMLo	63A, ~3x380V	20	4,700	
36		Electromagnetic starter PMLo	40A, ~3x380V	20	4,500	
37		Electromagnetic starter PMLo	32A, ~3x380V	20	2,050	
38		Thermal relay RTLn	80-93A, ~3x380V	20	400	
39		Thermal relay RTLn	63-86A, ~3x380V	20	400	
40		Thermal relay RTLn	55-70A, ~3x380V	20	375	
41		Thermal relay RTLn	48-65A, ~3x380V	20	375	
42		Thermal relay RTLn	30-40A, ~3x380V	20	350	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

Stage 2: Urgent, equipment is needed within 3 months.

TABLE E.9: HIGH-VOLTAGE CELL COMPONENT NEEDS FOR EMERGENCY REPAIRS OF INFOXVODOKANAL'S FACILITIES						
NO.	**LOCATION**	**TYPE**	**SPECIFICATIONS**	**QTY.**	**INDICATIVE PRICE, USD***	**NOTES/ADDITIONAL REQUIREMENTS**
1	WPSs WWPSs	Power supply for the vacuum switch	BP/TEL-220-02A	5	2,300	• Infoxvodokanal maintenance and operations personnel can carry out the installation work. • Delivery to Odesa is required. • Before ordering, technical specifications need to be aligned between vodokanal management and the manufacturer.
2		Vacuum circuit breaker BB/TEL	Inom=720A Vnom=10kV	7	43,500	
3		Vacuum circuit breaker BB/TEL	Inom=720A Vnom=6kV	4	36,000	
4		Recorder of electrical parameters	Novatek RPM-416	3	1,400	

* Total price is indicative and includes only the cost of equipment. Price depends on the manufacturer, availability, and country where equipment will be ordered.

E.3.5 CABLE NEEDS

Stage 1: Equipment is needed immediately.

Justification: Materials are required for emergency and maintenance repairs as well as the connection of new equipment, including DGs.

TABLE E.10: CABLE PRODUCT NEEDS FOR INFOXVODOKANAL'S FACILITIES						
NO.	**LOCATION**	**TYPE**	**SPECIFICATIONS**	**QTY.**	**INDICATIVE PRICE, USD***	**NOTES/ADDITIONAL REQUIREMENTS**
1	–	Cable ASB-10	Aluminum, power, armored 3x240 mm^2	300 m	23,800	
2	–	Cable ASB-10	Aluminum, power, armored 3x185 mm^2	400 m	26,700	
3	–	Cable ASB-10	Aluminum, power, armored 3x150 mm^2	500 m	29,100	
4	–	Cable ASB-10	Aluminum, power, armored 3x120 mm^2	500 m	24,900	
5	–	Cable ASB-10	Aluminum, power, armored 3x95 mm^2	200 m	8,350	
6	–	Cable ASB-10	Aluminum, power, armored 3x70 mm^2	150 m	5,700	
7	–	Cable KGNV	Copper, flexible, frost-resistant 4x70 mm^2	150 m	7,050	
8	–	Cable KG	Copper, flexible, unshielded	100 m	650	

TABLE E.10: CABLE PRODUCT NEEDS FOR INFOXVODOKANAL'S FACILITIES						
NO.	LOCATION	TYPE	SPECIFICATIONS	QTY.	INDICATIVE PRICE, USD*	NOTES/ADDITIONAL REQUIREMENTS
			4x10 mm^2			
9	–	Cable KG	Copper, flexible, unshielded 4x6 mm^2	200 m	1,050	
10	–	Cable KG	Copper, flexible, unshielded 4x4 mm^2	260 m	850	
11	–	Cable KG	Copper, flexible, unshielded 7x1.5 mm^2	150 m	350	
12	–	Cable AVVG	Aluminum, power 3x10 mm^2 + 1x6 mm^2	200 m	250	
13	–	Cable VVG-P ng	Copper, power, non-combustible 3x6.0 mm^2	100 m	280	
14	–	Cable VVG-P ng	Copper, power, non-combustible 3x4.0 mm^2	300 m	550	
15	–	Cable VVG-P ng	Copper, power, non-combustible 3x2.5 mm^2	300 m	400	
16	–	Cable VVG-P ng	Copper, power, non-combustible 3x1.5 mm^2	300 m	250	
17	–	Wire PVS	Copper, power, multicore, flexible 4x35 mm^2	300 m	7,000	
18	–	Wire PVS	Copper, power, multicore, flexible 4x25 mm^2	300 m	4,800	
19	–	Wire PVS	Copper, power, flexible multicore, 4x16 mm^2	300 m	3,050	
20	–	Wire PV	Copper, power, flexible multicore, 4x2.5 mm^2	500 m	170	

* Total price is indicative and includes only the cost of equipment without any additional costs. Price depends on the manufacturer, availability, and country where equipment will be ordered.

E.4 REFERENCES

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ANNEX F: LIST OF KEY INFORMANTS AND CONTACTS

VODOKANALS

KYIVVODOKANAL

- General Director: Information available upon request
- Chief Power Engineer: Information available upon request
- Engineer: Information available upon request

KHARKIVVODOKANAL

- General Director: Information available upon request
- Deputy Director: Information available upon request

KHERSONVODOKANAL

- General Director: Information available upon request
- Deputy Director: Information available upon request

LVIVVODOKANAL

- Director: Information available upon request
- Chief Engineer: Information available upon request

INFOXVODOKANAL (ODESA)

- Main Power Engineer: Information available upon request

VODOKANAL ASSOCIATION

- President: Information available upon request
- Vice President: Information available upon request

GOVERNMENT AND STATE ACTORS

KYIV CITY GOVERNMENT

- Director of the Department of Housing and Communal Infrastructure of the Kyiv City Administration: Information available upon request
- Representative of Department of Housing and Communal Infrastructure of the Kyiv City Administration: Information available upon request

NEURC

- Deputy Head of the Division for Strategic Development of Energy Markets and Public Utilities Sphere, Department for Strategic Development and International Coordination: Information available upon request

HUMANITARIAN ACTORS

UNICEF

- WASH Cluster Lead: Information available upon request
- UNICEF Ukraine WASH Lead: Information available upon request

ANNEX G: SITE VISIT QUESTIONNAIRES

G.1 GENERAL QUESTIONNAIRE

No.	Information request / Запит	Comments / Відповіді
General questions / Загальні запитання		
1.	Official name of Vodokanal **Офіційна назва підприємства**	
2.	Territorial location (City) **Територіальне місце розташування (місто)**	
3.	Legal address of the Vodokanal **Юридична адреса водоканалу**	
4.	Does Vodokanal receive support as part of international aid programs? Indicate which programs you are currently participating in. If the companies provided financial assistance, please specify the source and date. **Чи отримує Водоканал підтримку в рамках програм міжнародної допомоги? Вкажіть, в яких програмах наразі приймає участь. Чи надавали компанії фінансову допомогу, просимо уточнити джерело та дату.**	
5.	Number of consumers (water/wastewater). Please add statistics for 2020, 2021, and 2022. Please separate the data before and after the beginning of the large-scale phase of the war. **Будь ласка, надайте кількість споживачів, яке обслуговує підприємство (водопостачання/водовідведення). Будь ласка, додайте статистику за 2020, 2021, 2022 роки. Просим розмежувати дані до і після 24 лютого 2022 року, початку широкомасштабної фази війни.**	
6.	Volume of water supply provided by the vodokanal for district heating (for 2020, 2021, and 2022). Please separate the data before and after the beginning of the large-scale phase of the war. **Обсяг водопостачання, що забезпечує Водоканал для централізованого опалення (за 2020, 2021, 2022 роки). Просим розмежувати дані до і після 24 лютого 2022 року, початку широкомасштабної фази війни.**	
7.	Please provide information regarding Vodokanal history (date of construction, extension, refurbishment, ownership changes, etc.). **Будь ласка, надайте інформацію щодо історії Водоканалу (дата будівництва, розширення, реконструкції, зміни власника, тощо)**	
8.	Please provide the water supply/sewerage scheme of the city. **Будь ласка надайте ссхему водопостачання/водовідведення міста**	
9.	Has decentralization of some sites/districts been considered to increase reliability in case of power supply problems? **Чи розглядалася децентралізація деяких ділянок/районів для підвищення надійності у разі перебоїв з енергопостачання?**	

No.	Information request / Запит	Comments / Відповіді
10.	Please provide the description/scheme of the main operations. **Будь ласка, надайте опис / схему основних операцій на підприємстві.**	
11.	Please provide plans for the strategic development of Vodokanal. **Будь ласка, надайте плани стратегічного розвитку Водоканалу.**	
12.	Please provide emergency operation plans for Vodokanal. **Будь ласка, надайте плани роботи водоканалу в аварійних ситуаціях.**	
13.	Does the company have the energy audit reports previously completed for the Vodokanal? Please provide the reports if so. **Чи проводився у Компанії раніше енергоаудит? Будь ласка, надайте звіти з раніше проведених енергоаудитів.**	
14.	Does the company have energy efficiency policies? Please provide. Was the company part of energy efficiency improvement programs? **Чи має Компанія політику підвищення енергоефективності? Будь ласка, надайте. Чи приймала участь Компанія у програмах підвищення енергоефективності?**	
15.	Does the company have resource efficiency plans? Please provide any details. Please provide recommendations that were developed earlier and indicate who developed them. **Чи має Компанія плани ефективного використання ресурсів? Будь ласка, надайте подробиці. Просимо надати рекомендації які були розроблені раніше, та вказати хто їх розробляв.**	
16.	Does the company implement and energy management systems? Are they certified according to ISO? **Чи впроваджує водоканал систему енергетичного менеджменту? Чи сертифіковані вони відповідно до ISO?**	
17.	Who is responsible for energy management at the company? **Чи є у водоканалі особа, яка відповідає за енергетичний менеджмент?**	
18.	Please provide the details on annual consumption of electricity last three calendar years (total at water/wastewater treatment plants). **Будь ласка, надайте інформацію про щорічне споживання електроенергії водоканалом за 2020, 2021 та 2022 роки (взагалом, на станціях водоочищення та очищення стічніх вод).**	
19.	Please provide details on annual energy effectiveness for treated water/wastewater (kWh/m3) Please add statistics for 2020, 2021, and 2022. Please separate the data separately before and after February 24, 2022 year (start of the large-scale phase of the Russian invasion). **Будь ласка, надайте данні річної енергоефективності очищеної води/стічних вод (кВт год/м3) за 2020, 2021, 2022 роки. За можливості, просимо розмежувати дані до і після 24 лютого 2022 року (початку широкомасштабної фази війни).**	

No.	Information request / Запит	Comments / Відповіді
20.	Are there enough generators today for the uninterrupted operation of the water supply/sewerage systems during emergency situations, and to what extent in percentage are the problems of the Vodokanal in backup power supply is satisfied? **Чи достатньо на сьогодні генераторів для безперебійної роботи водоканалу під час аварійних відключень та на скількі % задовільнені проблеми водоканалу в резервному живленні?**	
21.	Please clarify what damage was inflicted on THE Vodokanal on each of the missile attack dates: October 10, October 17, October 22, October 31, November 15, November 23, December 5, December 16, December 29, December 31, January 14 and January 26, February 10. Outside of these dates, were there any additional incidents during the last year that disrupted service delivery? If so, please give the date and the damage that was inflicted. **Уточніть, будь ласка, якої шкоди завдав водоканалу кожен із масових обстрілів енергетичної інфраструктури України: 10 жовтня, 17 жовтня, 22 жовтня, 31 жовтня, 15 листопада, 23 листопада, 5 грудня, 16 грудня, 29 грудня, 31 грудня, 14 січня і 26 січня, 10 лютого? Чи були за останній рік якісь додаткові інциденти, що перешкоджали наданню послуг, окрім цих дат? Якщо так, вкажіть дату та збитки, які були завдані?**	
22.	On which of the above-mentioned dates was there a total shutdown of the water supply facilities, and on which was there a partial shutdown? Were there power outages unrelated to the attacks on energy infrastructure in the last 12 months? **У які із зазначених вище днів відбувалося повне відключення об'єктів водоканалу, а в які – часткове? Чи були за останні 12 місяців перебої у подачі електроенергії, не пов'язані з атаками енергетичної інфраструктури?**	
23.	What steps helped restore the water supply? Was this achieved through power restoration or the use of generation aids such as generators? Please describe in detail each case for each critical facility. **Які кроки допомогли відновити водопостачання у зазначені дні? Це вдалося зробити через поновлення електропостачання чи використання допоміжних засобів генерації, таких як генератори? Будь ласка, опишіть детально кожен випадок для кожного критичного об'єкта.**	
	Contact information / Контактна інформація	
24.	Name of the point of contact (POC) **ПІБ контактної особи для комунікації**	
25.	Mobil phone of the POC **Мобільний номер телефону контактної особи**	
26.	Email of the POC **Электрона пошта контактної особи**	
27.	Name of: 1. Director 2. Technical Director	

No.	Information request / Запит	Comments / Відповіді
	3. Chief Engineer 4. Chief Energy Engineer 5. Head of Production-Technical Department 6. Head of Energy Management Department (if available) Please specify contact information (Full name, email, and phone number) for each of these individuals. **ПІБ: 1. Генеральний директор/Директор** **2. Технічний директор** **3. Головний інженер** **4. Головний енергетик** **5. Керівник відділу ПТО** **6. Керівник відділу енергетичного менеджменту (за наявності)** **Будь ласка, вкажіть контактну інформацію (ПІБ, електронну адресу та номер телефону) для кожної з цих осіб.**	

G.2 QUESTIONNAIRE ON WATER SUPPLY

QUESTIONNAIRE FOR USAID's WASHPaLS #2 PROJECT.
Remote Rapid Assessment of Power Needs for Water and Sanitation Service Providers in Ukraine

Name of the Vodocanal:
Назва Водоканалу

Pump Station / Насосна станція	Capacity of Pump Station / Потужність насосної станції	Diameter of the supply pipeline/Діаметр підвідного трубопроводу. мм	Diameter of the pressure pipeline/Діаметр напірного трубопроводу. мм	Pump characteristics/ Характеристики насосів		Consumption / Споживання, подача, 2020 рік	Consumption / Споживання, подача, 2021 рік	Consumption / Споживання, подача, 2022 рік		Pump Capacity / Потужність насоса	Energy consumption / Споживання енергії 2020	Energy consumption / Споживання енергії 2021	Energy consumption / Споживання енергії 2022 рік		Pump type, Year of installation / Тип насосу, Рік встановлення
				Pressure/ Напір	Consumption/ Витрата			January-February/ Січень-Лютий	March-December/ Березень-Грудень				January-February/ Січень-Лютий	March-December/ Березень-Грудень	
	m3/hour м3/годину	mm/мм	mm/мм	m/м	m3/hour / м3/год	thousand m3 / тис. м3	thousand m3 / тис. м3	thousand m3 / тис. м3	thousand m3 / тис. м3	kW / кВт	kWh / кВт/год	kWh / кВт/год	kWh / кВт/год	kWh / кВт/год	
Water intake / Водозабір															
Surface water intake / Поверхневий водозбір															
Underground water intake / Підземний водозабір															
Water Pump Station 1 / Насосна станція 1	m3/hour м3/годину	mm/мм	mm/мм	m/м	m3/hour / м3/год	тис. м3	тис. м3	тис. м3	тис. м3	кВт	кВт/год	кВт/год	кВт/год	кВт/год	Тип насосу, Рік встановлення
Pump 1 / Насос 1															
Pump 2 / Насос 2															
Pump … / Насос …															
Total power capacity of pumping equipment: / Загальна потужність насосного обладнання:															
ЗАГАЛОМ подано:															
Water Pump Station …. / Насосна станція …..	m3/hour м3/годину	mm/мм	mm/мм	m/м	m3/hour / м3/год	тис. м3	тис. м3	тис. м3	тис. м3	кВт	кВт/год	кВт/год	кВт/год	кВт/год	Тип насосу, Рік встановлення
Pump 1 / Насос 1															
Pump 2 / Насос 2															
Pump … / Насос …															
Total power capacity of pumping equipment: / Загальна потужність насосного обладнання:															

QUESTIONNAIRE FOR USAID's WASHPaLS #2 PROJECT.
Remote Rapid Assessment of Power Needs for Water and Sanitation Service Providers in Ukraine

Name of the Vodocanal: Назва Водоканалу	

Water Treatment Plant / Водоочисні споруди	Capacity of Water Treatment Plant / Потужність водоочисних споруд	Consumption / Споживання, подача, 2020 рік	Consumption / Споживання, подача, 2021 рік	Diameter of the pressure pipeline/Діаметр напірного трубопроводу	Consumption / Споживання, подача, 2022 рік		Pump Capacity / Потужність насоса	Energy consumption / Споживання енергії 2020	Energy consumption / Споживання енергії 2021	Energy consumption / Споживання енергії 2022		Pump type, Year of installation / Тип насосу, Рік встановлення
					January-February/ Січень-Лютий	March-December/ Березень-Грудень				January-February/ Січень-Лютий	March-December/ Березень-Грудень	
	m3/hour м3/годину	thousand m3 / тис. м3	thousand m3 / тис. м3	mm/мм	thousand m3 / тис. м3	thousand m3 / тис. м3	kW / кВт	kWh / кВт/год	kWh / кВт/год	kWh / кВт/год	kWh / кВт/год	
Water intake / Водозабір												
Total volume of treated water / Загальний обсяг очищеної води												
Water Treatment Plant 1 /Водоочисні споруди 1	М3/годину	тис. м3	тис. м3		тис. м3	тис. м3	кВт	кВт/год	кВт/год	кВт/год	кВт/год	Тип насосу, Рік встановлення
Pump 1 / Насос 1												
Pump 2 / Насос 2												
Pump … / Насос …												
Total power capacity of pumping equipment: / Загальна потужність насосного обладнання:												
ЗАГАЛОМ подано:												
Consumption of water for own needs / Споживання води на власні потреби												
Water Treatment Plant... / Водоочисні споруди...	М3/годину	тис. м3	тис. м3		тис. м3	тис. м3	кВт	кВт/год	кВт/год	кВт/год	кВт/год	Тип насосу, Рік встановлення
Pump 1 / Насос 1												
Pump 2 / Насос 2												
Pump … / Насос …												
Total power capacity of pumping equipment: / Загальна потужність насосного обладнання:												
ЗАГАЛОМ подано:												
Consumption of water for own needs / Споживання води на власні потреби												

QUESTIONNAIRE FOR USAID's WASHPaLS #2 PROJECT.
Remote Rapid Assessment of Power Needs for Water and Sanitation Service Providers in Ukraine

Name of the Vodocanal: Назва Водоканалу	

Condition of the water supply network / Стан мережі водопостачання

Lenth of water supply system / Загальна довжина системи водопостачання	km / км	Volume of pumped water / Обсяг перекачуваної води	Water loss / Втрати води 2020	Water loss / Втрати води 2021	Water loss / Втрати води 2022	Number of damages / Кількість пошкоджень 2020	Number of damages / Кількість пошкоджень 2021	Number of damages / Кількість пошкоджень 2022
Pipeline DN 200 / Трубопровід Ду 200								
Pipeline DN 300 / Трубопровід Ду 300								
Pipeline DN 500 / Трубопровід Ду 500								
Pipeline DN 800 / Трубопровід Ду 500								
Pipeline DN 1000 / Трубопровід Ду 1000								

G.3 QUESTIONNAIRE ON WASTEWATER

QUESTIONNAIRE FOR USAID's WASHPaLS #2 PROJECT.
Remote Rapid Assessment of Power Needs for Water and Sanitation Service Providers in Ukraine

Name of the Vodocanal: Назва Водоканалу	

		The volume of electricity consumption at sewage treatment plants / Обсяг споживання електроенергії на каналізаційних очисних станціях		
		2020	2021	2022
The amount of electricity used at wastewater treatment plants / Обсяг використаної електроенергії на станціях очистки стічних вод	thousand kWh / тис. кВтгод			
Wastewater treated at wastewater treatment plants / Стічні води, оброблені на станціях очистки стічних вод	thousand m3 per yer / тис.м3 за рік			
Coefficient at wastewater treatment plants / Коефіцієнт на станціях очостики стічних вод	kW/м3 кВт/м3			

QUESTIONNAIRE FOR USAID's WASHPaLS #2 PROJECT.
Remote Rapid Assessment of Power Needs for Water and Sanitation Service Providers in Ukraine

Name of the Vodocanal: Назва Водоканалу	

Sewage treatment stations / Станції очистки стічних вод	Capacity, thousand m3 per year / Потужність, тис.м³ на рік	Purification method/ Метод очистки		Wastewater treated for 2020, thousand m3 / Очищено стоків за 2020, тис.м³	Wastewater treatedor for 2021, thousand m3 / Очищено стоків за 2021, тис.м³	Wastewater treated for 2022, thousand m3/ Очищено стоків за 2022, тис.м³		Pump capacity kW/ Потужність насоса, кВт -	Consumption of energy for 2020, thousand kWh / Споживання енергії,тис. кВт/год - 2020	Consumption of energy for 2021, thousand kWh / Споживання енергії, тис.кВт/год 2021	Consumption of energy for 2022, thousand kWh / Спожив ання енергії,тис. кВт/год 2022		Type of pump, year of installation / Тип насосу, рік встановлення	Energy effectiveness, kWh/m3, 2020	Energy effectiveness, kWh/m3, 2021	Energy effectiveness, kWh/m3, 2022	
		Biological treatment/ Біологічна очистка	Mechanical treatment/ Механічна очистка			January-February/ Січень-Лютий	March-December/ Березень-Грудень				January-February/ Січень-Лютий	March-December/ Березень-Грудень				January-February/ Січень-Лютий	March-December/ Березень-Грудень

QUESTIONNAIRE FOR USAID's WASHPaLS #2 PROJECT.
Remote Rapid Assessment of Power Needs for Water and Sanitation Service Providers in Ukraine

Name of the Vodocanal: Назва Водоканалу	

Wastewater pump station Каналізаційна насосна станція	Capacity, thousand m3 per year / Потужність, тис.м³ на рік	Diameter of the supply pipeline/Діаметр підвідного трубопроводу. мм	Diameter of the pressure pipeline/Діаметр напірного трубопроводу. мм	Pump characteristics/Характеристики насосів		Pumped Volume for 2020, thousand m3 / Перекачування за 2020, тис.м³	Pumped Volume for 2021, thousand m3 / Перекачування за 2021, тис.м³	Pumped Volume for 2022, thousand m3 / Перекачування за 2022, тис.м³		Pump capacity / Потужність насоса, кВт	Consumption of energy for 2020, thousand kWh / Споживання енергії,тис. кВт/год - 2020	Consumption of energy or 2021, thousand kWh / Споживання енергії, тис.кВт/год 2021	Consumption of energy or 2022, thousand kWh / Спожив ання енергії,тис. кВт/год 2022		Type of pump, year of installation / Тип насосу, рік встановлення	Energy effectiveness, kWh/m3, 2020	Energy effectiveness, kWh/m3, 2021	Energy effectiveness, kWh/m3, 2022	
				Pressure/Напір, м	Consumption/Витрата м3/год			January-February/ Січень-Лютий	March-December/ Березень-Грудень				January-February/ Січень-Лютий	March-December/ Березень-Грудень				January-February/ Січень-Лютий	March-December/ Березень-Грудень

G.4 QUESTIONNAIRE ON BACKUP POWER SOURCES

QUESTIONNAIRE FOR USAID's WASHPaLS #2 PROJECT.
Remote Rapid Assessment of Power Needs for Water and Sanitation Service Providers in Ukraine

Name of the Vodocanal: Назва Водоканалу	

I. GENERAL DATA / ЗАГАЛЬНІ ДАНІ

Item/ Пункт	Parameter name / Найменування параметру	Units / Одиниці виміру	Value / Значення	Notes / Примітки
1. Normal operation mode / Нормальний режим роботи				
1,1	Type of water intake facilities / тип водозабірних споруд	underground / ground підземні / наземні		
1,2	Water consumption during peak hours / Водоспоживання в години пік	thsnd m3/h / тис. м3/год		
1,3	Minimal hourly water consumption / Мінімальне погодинне водоспоживання	thsnd m3/h / тис. м3/год		
1,4	Peak hourly wastewater flow / Пікова годинна витрата стічних вод	thsnd m3/h / тис. м3/год		
1,5	Minimum hourly wastewater flow / Мінімальна годинна витрата стічних вод	thsnd m3/h / тис. м3/год		
1,6	Electric power during peak hours / Електрична потужність в години пік	MW / МВт		
1,7	Minimum electrical power / Мінімальна електрична потужність	MW / МВт		
1,8	Minimum required pressure in the network: / Мінімально-необхідний тиск в мережі:			
	0 lifting / 0 підйом (if there is / якщо є)	bar /атм		
	I lifting / I підйом (if there is / якщо є)	bar /атм		
	II lifting / II підйом (if there is / якщо є)	bar /атм		
	III lifting / III підйом (if there is / якщо є)	bar /атм		
	before the consumer / перед сподивачем	bar /атм		
2 Operating mode without main power supply / Режим роботи без основного джерела електропостачання				
2,1	Hourly water consumption to be provided / Часове водоспоживання, яке необхідно забезпечувати	thsnd m3/h / тис. м3/год		
2,2	Required hourly wastewater flow / Необхідна годинна витрата стічних вод	thsnd m3/h / тис. м3/год		
2,3	Required electrical power of backup power supply sources / Необхідна електрична потужність резервних джерел	MW / МВт		
2,4	Minimum required pressure in the network: / Мінімально-необхідний тиск в мережі:			
	0 lifting / 0 підйом (if there is / якщо є)	bar /атм		
	I lifting / I підйом (if there is / якщо є)	bar /атм		
	II lifting / II підйом (if there is / якщо є)	bar /атм		
	III lifting / III підйом (if there is / якщо є)	bar /атм		
	before the consumer / перед сподивачем	bar /атм		
2,5	Maximum duration of work on backup sources (estimated)) / Максимальна тривалість роботи на резервних джерелах (передбачувана)	hours / години		
3 Backup power sources / Джерела резервного електропостачання				
3.1 Water supply and sewerage facilities that require backup power / Об'єкти водопостачання та водоведення, що потребують резервних джерел електроживлення*				
3.1.1	Ground water intake / Наземний водозабір	quantity / кількість		
3.1.2	Underground water intake / Підземний водозабір	quantity / кількість		
3.1.3	Water treatment facility / Станція водопідготовки	quantity / кількість		
3.1.4	Water Pump Station / Водопровідна насосна станція	quantity / кількість		
3.1.5	Pump room / Бювет	quantity / кількість		
3.1.6	Waste Water Pump Stion / Каналізаційни насосна станція	quantity / кількість		
3.1.7	Wastewater treatment plant / Каналізаційна очисна споруда	quantity / кількість		
3.2 Number and type of backup sources that were previously equipped / Кількість та тип резервних джерел, які були обладнані раніше*				
	Diesel generator … kW/ Дизельний генератор … кВт**	quantity / кількість		
	Diesel generator … kW/ Дизельний генератор … кВт	quantity / кількість		
	…..	….		
	Energy storage … kWh/ Накопичувач … кВтч	quantity / кількість		
	…..	….		
	Total / Всього:	quantity / кількість		
3.3 Number and type of backup sources that must be equipped / Кількість та тип резервних джерел, які необхідно облаштувати				
	Diesel generator … kW/ Дизельний генератор … кВт	quantity / кількість		
	Diesel generator … kW/ Дизельний генератор … кВт	quantity / кількість		
	…..	….		
	Diesel generator … kW/ Дизельний генератор … кВт	quantity / кількість		
	…..	….		
	Total / Всього:	quantity / кількість		
4 Equipment and materials necessary for smooth operation / Обладнання та матеріали, необхідні для безперебійної роботи				
Please add to the questionnaire a list of critically needed materials and equipment that can be purchased in the first place. For example, pump, shut-off valves, pipes, power cables are necessary for current repairs or special vehicles, computers, etc. / Просимо додати до опитувального листа список критично необхідних матеріалів та обладнання, які можуть бути закуплені в першу чергу. Наприклад, насоси, запірна арматура, труби, силові кабеля необхідні для поточних ремонтів або спецтехніка, комп'ютери і т.п.				

* - detailed object information is provided in a separate questionnaire / детальна пооб'єктна інформація наведена в окремому опитувальному листі

* - detailed object information is provided in a separate questionnaire / детальна пооб'єктна інформація наведена в окремому опитувальному листі

** - specify the nominal power of the size and its quantity / вказати номінальну потужність типорозміру та його кількість

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For Facilities where it is planned to install backup sources of power supply, we ask you to provide the existing power supply scheme, parameters of automatic switches, list of the main equipment with an indication of the one that must simultaneously work from the backup source.
Для об'єктів, де передбачається встановлення резервних джерел електропостачання просимо надати існуючу схему електропостачання, параметри автоматичних вимикачів, перелік основного устаткування із зазначенням того, яке має одночасно працювати від резервного джерела.

II. Facilities that require backup power supplies / Об'єкти для яких необхідні резервні джерела електропостачання

Facility Name / Найменування об'єкта	Address / Адреса	Capacity/ Продуктивність (Normal mode / нормальний режим)	Capacity/ Продуктивність (On backup sources / на резервних джерелах)	Head / Напор (Normal mode / нормальний режим)	Head / Напор (On backup sources / на резервних джерелах)	Electric power / електрична потужність (Normal mode / нормальний режим)	Electric power / електрична потужність (On backup sources / на резервних джерелах)	Equipment that must be operated from backup sources / Обладнання, яке має працювати від резервних джерел							Soft start, frequency control / Плавний пуск, частотне регулювання	Existing backup power sources / Існуючі джерела резервного живлення	The need to arrange (replace) a backup source / Необхідність облаштування (заміни) резервного джерела	Distance from the input shield to the backup source / Відстань від ввідної шафи до резервного джерела	Distance from backup source to residential area / Відстань від резервного джерела до житлової забудови	The need for civil works (foundations, sheds, chimneys) / Необхідність загальнобудівельних робіт (фундаменти, навіси, димові труби)	The need for automatic start of a backup source / Необхідність автоматичного запуску резервного джерела	The need for integration into the SCADA system / Необхідність інтеграції у SCADA систему	Availability of up-to-date topographic survey / Наявність актуальної топографічної зйомки
								Type, brand / тип, марка	Installation date / Дата установки	Useful electric power / Корисна електрична потужність	Voltage / Напруга	cos(f)	Nominal current / Номінальний струм	Efficiency/ ККД									
--	--	m3/h м3/год	m3/h м3/год	bar атм	bar атм	kW кВт	kW кВт	--	--	kW кВт	V В	--	A	%	+/-	+/-	+/-	м	м	+/-	+/-	+/-	+/-
Water Intake / Водозабір																							
Water Intake 1 / Водозабір 1																							
Water Intake 2 / Водозабір 2																							
…																							
Water Intake n / Водозабір n																							
…																							
Water treatment facility / Станція водопідготовки																							
Water treatment facility 1 / Станція очищення води 1																							
Water treatment facility 2 / Станція очищення води 2																							
…																							
Water Pump Station / Водопровідна насосна станція																							
WPS 1 / ВНС 1																							
WPS2 / ВНС 2																							
…																							
WPS n /ВНС n																							
…																							
Pump room / Бювет																							
Pump room 1 / Бювет 1																							
Pump room 2 / Бювет 2																							
…																							
Pump room n / Бювет n																							
…																							
Waste Water Pump Stion / Каналізаційни насосна станція																							
WWPS 1 / КНС 1																							
WWPS 2 / КНС 2																							
…																							
WWPS n / КНС n																							
…																							
Wastewater treatment plant / Каналізаційна очисна споруда																							
WWTP 1/ КОС 1																							
WWTP 2/ КОС 2																							
…																							
Administrative buildings / Адміністративні будівлі																							

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II Backup power supplies / Резервні джерела електропостачання

Item/ Пункт	Name of the backup source / Найменування резервного джерела	Name of the facility / Назва об'єкту	Type, brand / тип, марка	Energy source / Джерело енергії	Full capacity/ Повна потужність	Voltage / Напруга	Nominal current / Номінальний струм	Efficiency/ ККД	Automatic start / Автоматичний пуск	Stationary / mobile Стаціонарний / мобільний	The need for integration into the SCADA system / Необхідність інтеграції у SCADA систему	Communication protocol (if required) / Протокол передачі (якщо потрібно)	The need for automatic start of a backup source / Необхідність автоматичного запуску резервного джерела	Additional technological requirements / Додаткові технологічні вимоги	Date of purchase / Дата придбання	Condition, is it necessary to replace / Стан, необхідність заміни	who provided or purchased / хто надав чи закупив
--	--	--	--	--	KWA кВА	V В	A	%	+/-	S / M С / М	+/-	+/-	+/-	--	--	--	
Backup power supplies that need to be equipped / Резервні джерела електропостачання, які необхідно облаштувати																	
															-	-	-
															-	-	-
															-	-	-
															-	-	-
															-	-	-
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															-	-	-
															-	-	-
															-	-	-
															-	-	-
Available backup power sources / Наявні резервні джерела електропостачання																	

G.5 QUESTIONNAIRE ON PRIOR ASSISTANCE RECEIVED

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Name of equipment (materials, financial assistance) received as part of international assistance / Найменування обладнання (матеріалів, фін. допомоги), яка була отримана в рамках міжнародної допомоги	Facility Name / Найменування об'єкта	Date it was provided (can be approximate) / дата надання (приблизно допустимо)	Stakeholder or group who provided it / зацікавлена сторона або група, яка її надала	What problem the equipment solved / яку проблему вирішило обладнання	Challenges supply and using the equipment / Проблеми постачання та використання обладнання	Equipment condition (replacement required) / Стан обладнання (необхідність заміни)	Equipment or supplies needed to continue using the equipment / обладнання або матеріали, необхідні для продовження використання обладнання

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Name of the project / Назва проєкту	Facility Name / Найменування об'єкта	Type of construction / Вид будівництва	Date of realization / Дата реалізації	Goals / Цілі	Scope of work / Обсяги робіт	Result / Результати	Problems that arose during implementation / Проблеми, які виникли при реалізації	Problems during operation / Проблеми під час експлуатації	Source of financing (assistance) / Джерело фінансування (допомоги)
Improving energy security (energy efficiency) / Підвищення енергетичної безпеки (енергоефективності)									
Elimination of damage from attacks / Ліквідація збитків від атак									

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