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Technology guideline for energy efficiency in pumping stations

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Preface

Energy efficiency is a key pillar in Ukraine's strategy for economic modernization, energy security, and climate action, particularly as the country aligns with EU energy policies and decarbonisation commitments and energy security. However, multiple barriers, including financial constraints, regulatory challenges, technological limitations, geopolitical challenges and limited access to relevant information have hindered the widespread adoption of energy-efficient measures. In recent years, Ukraine has taken significant steps to establish policy and financial mechanisms that encourage energy savings in the industrial and municipal sectors, helping to reduce reliance on fossil fuels, lower production costs, and enhance competitiveness.

In Ukraine a large proportion of the electricity is generated in coal fired power plants, and the national level of CO2 emissions from electricity production is high. At the same time, the energy sector in Ukraine is characterized by a very low energy efficiency, as most of the power generation and consumption facilities were designed and build in the Soviet Union where energy resources were abundant and there was little concern over the environmental impacts or global warming. Most of these facilities are worn out and suffering from poor maintenance, which has further lowered the operational efficiency and reliability. Furthermore, many of these systems are significantly oversized which leads to even lower efficiency and high maintenance costs. The present situation with an ongoing war with Russia, which has led to widespread damage to power generation facilities throughout Ukraine, has caused a severe shortage of electricity and hiking electricity prices.

In early 2024 the Government of Ukraine requested urgent assistance under the Energy Partnership Programme between Ukraine and Denmark (UDEPP) with the conduct of energy audits in pumping stations for water pumping in public utility infrastructure; and traction substations, contact network, and rolling stock in public electric transport systems.

In Ukraine there is a widespread use of pumping stations for water transport, and irrigation purposes, and they account for a significant share of the sector's electricity consumption. Other typical areas of applications of water pumping systems are drinking water and sewerage systems.

Audits were conducted in two pumping stations (Pumping station No. 4 of the Dnipro-Donbass channel; and the Irpin pumping station located in the Kyiv Region) under the 2024 TORs for UDEPP Output 3.2 (Technology catalogue and technical guidelines for energy efficiency and fuel substitution in industry). In continuation of the audits in water pumping stations, the present technology guideline for energy efficiency in water pumping stations were developed. The technical guideline aims to inspire and support Ukrainian water utilities, as well as energy auditors, in the adoption of energy-efficient technologies and practices. It is based on the results of two comprehensive energy audits conducted at representative water lift pumping stations within public utility infrastructure. The audited pumping stations were selected to ensure broad relevance of the specific equipment assessed. The onsite audits were carried out by national energy auditors, while international auditors provided expert guidance, sparring, and quality assurance remotely.

Content

1 The pumping system technology at the audited entities

1.1 The audited entities

Energy audits were performed on two typical water lift pumping stations in Ukraine:

1) The Dnipro-Donbass Channel which provides intra-basin and inter-basin redistribution of water resources from the Dnipro River (Kamianske Reservoir) to the Siverskyi Donets River in order to meet the needs of the population and economic sectors of Dnipropetrovsk, Kharkiv, and Donetsk regions. The length of the channel is 263 km. The lifting section consists of 12 pumping stations, the total lifting height is 72 m. The total water transport capacity of the system is 120 m3/s. Out of the six parallel pumping systems installed in each pumping station, only one or two are operational at present.
2) Irpin Pumping Station which is a submersible pump station (made of monolithic reinforced concrete) used to pump excess (flood / stormwater / drainage) water from the Irpin River into the Kyiv Reservoir. The total water transport capacity of the station is 60.4 m3/s.

Figure 1-1 General view of the station and the Dnipro-Donbass Channel

1.2 Key pumping system components

The main elements of the water lift pumping systems are:

1) Pump units with fixed or variable blade angle
2) Electric motors with or without variable speed control
3) Transformers
4) Sluices or valves preventing back flow

Besides the main components there is a range of auxiliary systems and facilities:

- Maintenance of technological equipment (lifters, cranes)
- Heating shutters (electric heaters for melting ice in winter)
- Drainage pumping (water level control in the drainage systems of the station)

- Ventilation (moisture removal)
- Lighting (internal and external)
- Heating (local electrical devices)
- Oil removal
- Fire fighting
- Pump station building including machine and storage rooms and premises for operators

1.3 Cross cutting observations

The type of audited pumping stations is characterized by a stable pumping head. Pumps are operated on/off with constant flow and pump head. At the Dnipro-Donbas canal it is additionally possible to adapt the pump characteristics to the required pumping head defined by the difference in water levels before and after the pumping station in order to maximize the pumping efficiency by manually adjusting the angle of the pump blades.

Both audits have revealed that most of the equipment is old, worn out and suffering from a poor level of maintenance. Furthermore, the pumping facilities are significantly oversized when compared to the actual utilization.

From energy audits conducted at Ukrainian water lift pumping stations, significant energy saving potentials have been observed, for example the following:

- Large potential in reducing water leaks through sluices and valves
- Oversized pump installations resulting in poor operation efficiency
- Inefficient operation of pumps due to inadequate control equipment
- Obsolete transformers and power equipment

For such reasons, it must be expected that efficiency improvements at the water lift pumping stations may result in significant energy savings. When renovating existing pumping facilities, it is important to consider whether they are oversized and only replace with equipment of sufficient capacity.

2 Main findings of the energy audits

2.1 Mode of operation of stations and control systems

The mode of operation of stations and control systems at both water lift pumping stations can be described as follows:

- There is no centralized control, monitoring and dispatching system in place, the units are controlled manually by the station staff
- The main technological equipment is not constantly operated, the active (planned) use of the main pumping units falls on the periods of filling reservoirs and canal sections
- There is too little preventive maintenance, and too much repair and maintenance work is done in response to break down of equipment leading to frequent unit breakdowns. The station operators carry out maintenance and repair of the equipment during periods when equipment is not in use.
- Some of the auxiliary systems are operated only to a limited extent due to imperfections and malfunctions of these systems and the relatively high level of their energy consumption.

2.2 Typical issues identified during the energy audits

The energy audits at the water lift pumping stations identified a number of issues:

- Wear and technical obsolescence of main and auxiliary equipment is causing excessive energy consumption by equipment, frequent repairs and losses in systems
- Lack of spare parts, often spare parts are taken from non-operational units of stations
- In some cases, the pump characteristics can be adapted to the need for pumping head in order to obtain higher efficiency by rotation of the pump blades, and turning on the units with the required set angle

- Due to the obsolescence and ineffectiveness of the ventilation and heating systems, they are not used to their full extent, which negatively affects the operating conditions of the equipment and leads to frequent breakdowns
- Station premises are not energy-efficient, which leads to excessive costs for their heating and high operating costs
- There is no automated control, monitoring and dispatching system
- There is no system for direct accounting of water (pumping/losses) and no possibility to account for the actual volume of pumped water and the mode of operation of the units
- Silting of the riverbed may cause an additional load on pumping equipment
- Sluice gates are worn and deformed, leading to a backflow of water through them into the lower part of the channel
- Equipment below the water level, drainage pumps, often fail due to an aggressive environment
- Wear and tear of the shut-off fittings of the regulator locks (segmental locks) prevents water from being retained in the upper reaches of the system and leads to excessive pumping of water and increased electricity consumption
- There is a significant consumption of reactive energy

2.3 Electricity consumption for water pumping

The two audited pumping facilities are major power consumers, requiring both a high electric power capacity and a high electricity consumption.

For Dnipro-Donbass Channel the total electric power demand at one of the pumping stations is 18 MW. The total electric power demand for the entire transport channel exceeds 200 MW, the annual power consumption (average for 2020-2022) is 1.640 MWh (used 106 hours/year at max. capacity, or approx. 1.3% of the time) and in total for the entire transport channel more than 20.000 MWh. It is worth noticing the severe oversizing of the equipment, as the power consumption corresponds to only approx.100 hours of operation at maximum capacity.

The Irpin Pumping Station has a total electric power demand of 6.3 MW, and the annual power consumption (average for 2020-2022) is 3.020 MWh. Also here, there is an oversizing of equipment, as the power consumption corresponds to only approx. 500 hours of operation at maximum capacity.

3 Identified efficiency improvement opportunities

The technology guideline for water lift pumping stations has identified the following key energy-saving measures that could significantly reduce electricity consumption:

3.1 Replacement of obsolete transformers and power equipment

Figure 3-1 Obsolete transformers and main power equipment at the Dnipro-Donbass Channel

Selecting transformers with high efficiency is important. New transformers should be specified as Tier 2 transformers. Tier 1 and Tier 2 in the context of transformers typically refer to energy efficiency standards, specifically within the European Union's Ecodesign Directive for power transformers. Tier 2 represents a higher level of energy efficiency than Tier 1, requiring lower no-load and load losses, leading to greater energy savings.

Tier 1 transformers meet the initial minimum energy performance standards (MEPS) set by the EU Ecodesign directive, whereas Tier 2 transformers meet the more stringent MEPS that came into effect on July 1, 2021. They are designed to be more energy-efficient than Tier 1 transformers, resulting in lower energy consumption and reduced operating costs. The no-load losses and the load losses of Tier 1 transformers are respectively 30% and 20% higher, respectively, than the losses of Tier 2 transformers.

Replacement of outdated transformer equipment with modern analogues is an important step for increasing energy efficiency, reliability, and safety of power supply. Outdated transformer equipment is characterized by:

- Insulation wear: Over time, the insulation of transformers and other equipment loses its properties, increasing the risk of short circuits and fires
- Efficiency losses: The efficiency of old equipment decreases over time, leading to higher electricity losses
- Outdated technology: Outdated equipment often does not meet modern quality requirements for electricity and may have limited functional capabilities

The main reasons for replacing the technically obsolete equipment are:

- Reduction of electricity losses: New transformers have a higher energy efficiency, which reduces electricity losses during transmission
- Reduced OPEX

- Possibility of remote monitoring: Modern systems allow for remote monitoring of equipment condition and timely detection of potential problems.
- Reduction in the number of accidents: New equipment is more reliable and less prone to failure
- Increased service life: Modern equipment has a longer operational life, reducing costs for repairs and replacements
- Possibility to use new technologies: Modern transformers can be equipped with automatic control and management systems, increasing the reliability of power supply and optimizing operating modes
- Improvement in power quality: Modern transformers provide more stable voltage and lower harmonic distortions
- Enhancement of power supply reliability
- Environmental advantages: Reduction of energy losses leading to decreased emissions of CO_2 and other emissions from energy production into the atmosphere
- Use of environmentally friendly materials: Modern transformers are made using more environmentally friendly materials

While Tier 2 transformers may have a slightly higher initial cost, the long-term operational savings and reduced maintenance needs make them a cost-effective solution.

The implementation of Tier 2 standards throughout EU is expected to result in an estimated annual energy saving of 16 TWh, which is equivalent to preventing 3.7 million tons of carbon emissions.

Example: Replacing outdated transformer equipment with modern analogs at Pumping Station Dnipro-Donbass

Approximate cost of equipment

№	Equipment	Approximate cost, 1 000 UAH:	Average value, 1 000 UAH:
1	Transformers 35/6 kV	4 150 - 8 290	6 220
2	Transformers 35/0.4 kV	410 - 2 070	1 240
3	Switching devices (35 kV)	1 000 – 3 000	2 000
4	Reactors (if necessary)	500 – 1 500	1 000
5	Power cables (35 kV and 6 kV)	500 – 2 000	1 250
6	Own needs system (SNS)	500 – 1 500	1 000
7	Protective relay devices	1 000 – 3 000	2 000
8	Ventilation and cooling systems	200 - 800	500
9	Cabinets and control panels	300 – 1 000	650
10	Power accounting system	100 - 500	300
		Total amount based on average values:	16 160

Calculation of economic indicators with 20% energy savings

Investments, 1 000 UAH	Net savings, 1 000 UAH/year	Simple payback period, years
16 160	2 157*	7,5

*Electricity tariff 8,1 UAH/kWh

3.2 Installation of a modern centralized remote monitoring and control system

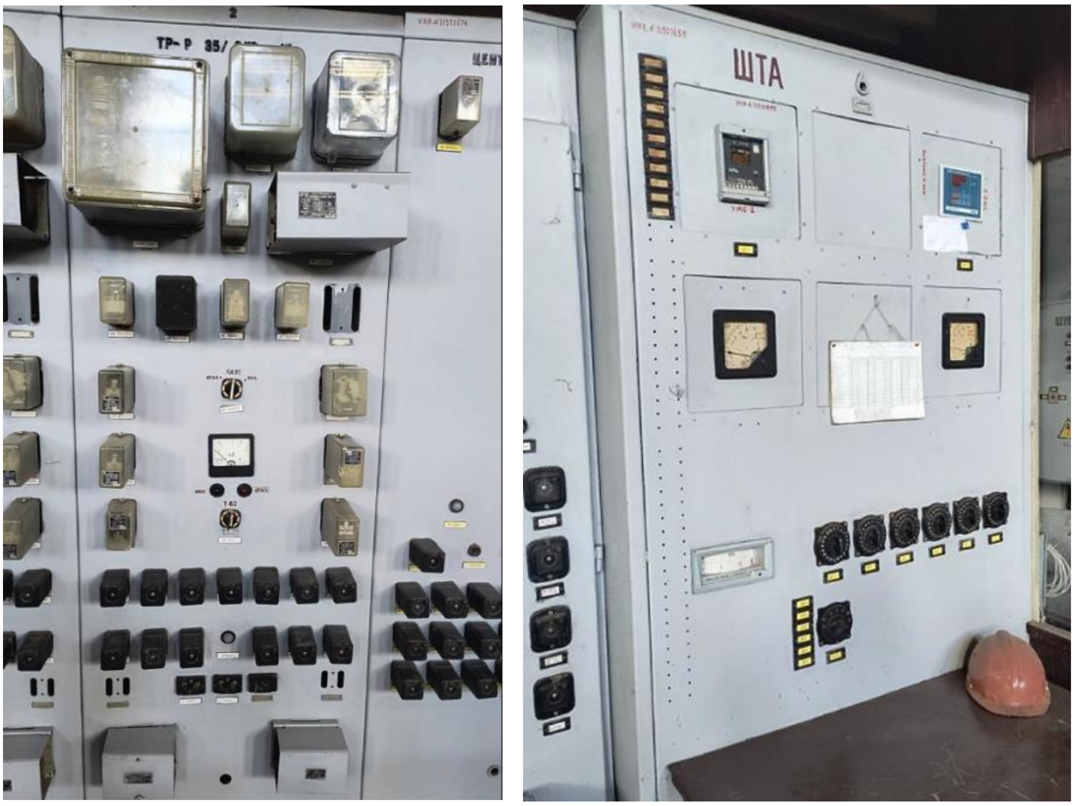

Figure 3-2 Outdated control and monitoring cabinets

It is recommended to carry out equipment modernization and install internet communication channel to provide a modern centralized control system from the dispatcher panel. Remote monitoring and control allow for quick responses to production changes and prevention of potential issues.

A modern centralized control system can provide a number of benefits:

- By monitoring equipment condition, problems can be detected and addressed early, thereby reducing downtime. Redundancy and remote access is minimizing the impact of unexpected events
- Installing the Pult.Online server in the cloud give the possibility to organize the management and monitoring of geographically distributed objects
- Additional features such as energy consumption monitoring, equipment diagnostics, integration with dispatch systems, and redundancy

Example: Provide a modern centralized control system from the dispatcher panel at Pumping Station Dnipro-Donbass			
Approximate cost of equipment			
№	Equipment	Approximate cost, 1 000 UAH:	Average value, 1 000 UAH:
1	Controllers and control cabinets	2 000 – 5 000	3 500
2	Sensors and actuators	1 000 – 3 000	2 000
3	SCADA system and software	500 – 2 000	1 250

4	Installation and commissioning	1 000 – 4 000	2 500
5	Design and engineering	500 – 1 500	1 000
		Total amount based on average values:	9 250
Calculation of economic indicators with 20% energy savings			
Investments, 1 000 UAH		Net savings, 1 000 UAH/year	Simple payback period, years
9 250		2 157*	4,3

*Electricity tariff 8,1 UAH/kWh

3.3 Replacement of motors

Figure 3-3 Examples of corroded windings in worn out electric motor

Figure 3-4 Examples of corroded windings in worn out electric motor

Replacing the old electric motors with modern ones with more efficient operational characteristics can result in significant electricity savings. In the two audited types of pumping stations pumps are operated for constant flow and do not require speed regulation. It is therefore proposed to use synchronous motors (SDM) designed to drive mechanisms with increased starting characteristics that do not require speed regulation.

15-20% energy savings can be obtained by replacing existing electric motors with more energy efficient ones. New motors should be specified to at least meet the minimum requirements in Commission Regulation (EC) No 640/2009. The major part of the potential savings is due to the often poor condition of the old and warned out motors with dampness or contamination of the insulation of the electric motor windings.

Example: Replacement of two existing pump motors at Pumping Station Dnipro-Donbass			
Motor option	Investments, 1 000 UAH	Net savings, 1 000 UAH/year	Simple payback period, years
1 000 kW	12 435	576*	21,6
1 750 kW	19 950	118*	168**

*Electricity Tariff 8,1 UAH/kWh

**The long pay-back time is due to the very low utilization time. At 50% utilization the pay-back period would have been 4,6 years.

3.4 Pumps

Figure 3-5 Old pumping unit with sliding bearings

5-10% electricity savings can be obtained by replacing existing pumps with more energy efficient ones. New pumps should be specified to at least meet the requirements of Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water pumps.
Even bigger savings can be achieved by selecting pumps with integrated controls. The major part of the potential savings is due to deviations from the optimal pumping regime in combination with the constant speed of motor drives. If these deviations occur frequently or are significant it is recommendable to add a variable frequency drive.

Centrifugal industrial pumps with integrated controls can improve energy efficiency and performance by adjusting the pump speed and flow rate in response to changes in system demand. Various pump control systems are available, some with built-in controls that detect and respond to changes in order, while others require external control systems like VFDs.

Pumps equipped with sensors can also detect changes in system demand and adjust the pump speed and flow rate accordingly, resulting in more efficient operation and reduced energy consumption. In addition, built-in diagnostic systems can detect potential issues before they become critical, reducing maintenance costs and downtime.

Pumps with integrated controls can communicate with external systems like BMS or SCADA to provide real-time data on pump performance and energy consumption. This enables operators to optimize pump performance and reduce energy usage.

3.5 Capacitive reactive power compensators

Figure 3-6 Example of 6 kV Capacitor installation

Reactive power compensation is the cheapest and most effective means of improving the technical and economic performance of power supply, which reduces all types of electricity losses. Reactive current causes additionally load on the power transmission lines, leading to an increase in the cross-sections of wires and cables and, accordingly, to an increase in capital costs on external and internal site networks. Reactive power, along with active power, is accounted for by the electricity supplier and is therefore subject to payment at the current rates, making up a significant portion of the electricity bill.

The most effective and efficient way to reduce the reactive power consumed from the network is to use reactive power compensation units (capacitor banks, synchronous motors and synchronous compensators). By connecting a compensating device to the network, power and voltage losses are reduced. The use of high-voltage devices for automatic reactive power compensation is a modern solution that ensures the normal functioning of the power system, allowing cost savings on reactive electricity and reducing the wear of switching devices. Additionally, the use of automatic capacitor installations prevents overcompensation of the power system.

Example: Installation of Capacitive Reactive Power Compensator at Pumping Station Dnipro-Donbass						
Electricity losses, for implementation, kWh/year	Electricity losses, after implementation, kWh/year	Reduction of annual losses in the power supply line, %	Costs before implementation, 1 000 UAH	Costs after implementation, 1 000 UAH	Savings, UAH*	Payback period
108 366,507	48 185	31.97	878	390	488	3.0
751 36,9705	36 765	26.01	609	298	311	4.7
113 899.409	77 753	8.70	923	630	293	5.0

*Electricity tariff 8,1 UAH/kWh

**Cost of Capacitive Reactive Power Compensator 1,471 Mio, UAH

3.6 Variable frequency drive

Variable frequency drives used for adjusting flow or pressure to the actual demand can significantly reduce the power consumption in cases where there is a variable demand for flow or pressure. They control the frequency of the electrical power supplied to the pump motors or fans. This should be considered in cases when:

- The pump application requires precise control
- The application contains a variable load
- The application involves frequent starting and stopping
- The motor is running at full speed with throttled output

3.7 Potential use as a pumped-storage power station

With some modifications it may be possible to use the pumping stations as pumped storage and this may contribute to ensure the economic and financial feasibility of investing in the recommended replacement or upgrading and modernization of facilities and equipment, which may not be feasible under present circumstances where the water transport systems are used only a small part of the year. With the proposed use as pumped storage the water transport system may be utilized for load shifting in the electricity grid 24/7 all year round. The modifications required for using the pumping stations as pumped storage will be costly and weigh down on the feasibility. Thorough analysis of the cost of those modifications and potential income from the use of the pumped storage will be needed as basis for a decision to invest in the proposed pumped storage function.

The pumping stations in the Dnipro-Donbass Channel may be particularly suitable as pumped-storage power stations because the full capacity of the water transport system is only utilized approx. 100 hours per year or less than 1,2% of the time. Besides, the main pumps in the 12 pumping stations with adjustable blade angle are better suited for operation as turbines for power generation than pumps with fixed blades.

3.8 Peak shaving operation

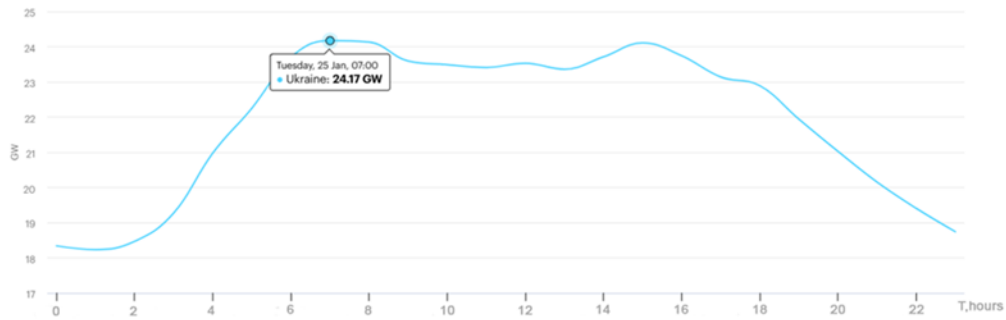

Figure 3-7 Daily load schedule of energy consumption in Ukraine on January 25, 2022

Peak shaving is a strategy to reduce electricity consumption during periods of high demand, often called "peak hours," to minimize costs and prevent overloading the grid. This is achieved by temporarily reducing power usage, for example, by scaling back production or using on-site power sources like batteries or generators. The two audited water lift pumping stations are both operated on/off depending on the actual need for water transport, and their pumping capacity is severely oversized. As the water bodies between which the water is transported have a large surface area and therefore typically require pumping for longer periods of time, it is possible to switch the pumps off for several hours during periods of high electricity demand and related high electricity price.

The main benefits are:

- Reduced Electricity Costs: By shifting consumption away from peak hours, businesses can avoid high demand charges and time-of-use pricing
- Improved Grid Stability: Reducing peak demand helps prevent grid overloading and potential outages
- Increased Reliability: Peak shaving can ensure a more reliable power supply during times of high demand

3.9 Restore sluice gates

Figure 3-8 Flow of water through the sealing elements of the sluice gate

Restoration of deformed or malfunctioning sluice gates of the pumping station has several important advantages such as energy savings, improved reliability and reduced OPEX. It is recommendable to design the pumping facility with possibility to measure the volume of backflow through the sluice gates, and to perform regular inspections and test of the backflow as basis for determining when sluice gates should be restored.

4 Energy savings potential

Electricity consumption in pumping stations make up a very large part of the total energy consumption both in Ukraine and worldwide. In 2020, within EU27, water pumps used 179 TWh of electricity. This was 7.5% of the EU27 total electricity consumption, and close to the combined consumptions of Poland (137 TWh) and Romania (44 TWh).

Every energy saving measure has an energy saving potential, that refers to the amount of energy that can be saved by implementing specific energy efficiency measures. It represents the theoretical maximum reduction in electricity consumption that can be achieved if the measure is fully applied.

Energy saving measure	Energy Saving
Replacement of obsolete transformers and power equipment	10-30%
Installing a modern centralized control system	10-20%
Replacement of motors	15-20%
Replacement of pumps	5-10%
Capacitive reactive power compensators	10-30%

Source: Consultant's experience from EU27

5 The importance of planned preventive maintenance

Currently the maintenance of the audited pumping stations is reactive rather than proactive. This leads to a focus on handling breakdowns and equipment failure after they occur rather than planned preventive maintenance to minimize future breakdowns and equipment failure.

It is highly recommendable to perform regular maintenance, especially after the implementation of EE measures, as such maintenance will extend the service life of equipment, reduce repair costs due to significant breakdowns, maintain operating modes within optimal limits, etc. A planned maintenance scheme is necessary to ensure the performance and maintain an efficient system. Pumping station maintenance typically involves scheduled servicing at least every 3-6 months, and includes visual inspections, lubrication, cleaning, and calibration. It's also crucial to be attentive to factors such as unusual odours, frequent pump activation, high water levels, or visible alarms, which could indicate immediate attention is needed.

The following activities are proposed:

- **Scheduled Maintenance:** Regular servicing is essential to ensure long-term reliability and prevent major issues. The frequency of servicing depends on factors like the type of station, usage, and criticality.
- **Visual Inspections:** Regularly checking for signs of wear and tear, leaks, and other visible issues is a fundamental part of maintenance.
- **Lubrication:** Ensuring that all moving parts are properly lubricated reduces friction and wear, contributing to smoother operation.
- **Cleaning:** Keeping the pump station clean prevents debris from interfering with operation and potentially causing blockages.
- **Calibration:** Regularly calibrating sensors and control systems ensures accurate readings and operation, preventing malfunctions.
- **Beyond Scheduled Maintenance:** Pay attention to signs like unusual odours (potentially indicating blockages or septicity), frequent pump activation (struggling to handle water flow), high water levels (blockage or pump malfunction), and visible alarms.
- **Deep Inspections:** A deep inspection of pump station components, including the wet well, pumps, and electrical components, is recommended every 5 years, or sooner if issues are frequent.
- **Other Preventative Maintenance actions:** To prolong the life of a pump station and ensure optimal performance, consider preventative maintenance like removing debris from wet wells, cleaning interiors and piping, exercising valves, and performing electrical checks.

6 The procurement process for new water lift pumping systems

Procurement of new equipment for pumping stations are a significant investment project which requires careful planning work to secure the most sustainable and cost-efficient solution. For large scale investments, to ensure the best possible adoption of more efficient technology, a more comprehensive techno-economic feasibility analysis is needed in the procurement process.

The procurement process should always be scaled to the project as it can vary greatly depending on whether you are looking into replacing a pump or you are to install an entire new system. This section covers the procurement process if it was a large investment.

For the large investment the procurement process should follow the steps below:

1. A pre-feasibility phase
2. A feasibility phase
3. A tendering phase
4. A tender evaluation phase

After the tender evaluation phase comes steps regarding implementation, testing and commissioning of the pumping system.

6.1 Pre-feasibility phase

The aim of the pre-feasibility phase is to define the project to carry out and evaluate alternative overall solutions so that it can be concluded what the most attractive way forward will be.

The problem in this phase is to decide whether to select a cheap, low-efficient solution or a more expensive and more efficient solution with lower operating costs. These alternatives must be assessed carefully and well documented. Another consideration to be made before the purchase process commences is whether the current functional requirements will remain unchanged in the future.

The easiest way forward will most often be to install new equipment without further consideration, but more careful investigations might uncover alternative solution strategies. As such, a pre-feasibility phase should carefully assess and document the design basis for the project and compare various elements in the solution strategy, by example:

What is the purpose of the project?
It is important to carefully analyse the purpose and functional requirements for the pump station construction or rehabilitation.

The most common reasons for a pumping station rehabilitation project will be the need to adapt to a changed working regime or to ensure safe and uninterrupted operation.

However, a rehabilitation project can also offer a range of other benefits, such as:

- Reduced OPEX (including energy, staff and maintenance)
- Pressure and flow to match better with demand
- Improved working environment
- Reduced carbon footprint
- Compliance with the current regulation

The combined value of these benefits could very well supersede the value of the energy cost savings. It is important, therefore, to consider these already in the pre-feasibility study and highlight those that are deemed most important. Still though, a strategy focused entirely on energy- and cost reductions or reducing carbon emissions can be sufficient justification for the project.

What is the scope of the project?
A new project can cover the replacement of a worn-out component, but it can also be a project covering the implementation of a whole new system covering pumps, motors, transformers, piping etc. A pump station project can therefore be quite comprehensive and will include different disciplines and engineering works to plan and include in the investment estimates.

However, for all cases the expected scope of the project shall be described to make it clear for all relevant parties which works that are underway.

Which demand is to be covered?
An important part of the pre-feasibility study is to make a thorough mapping of the pressure level and water flow demand. This also includes taking any further developments into consideration.
Besides knowing the demand this mapping shall also help with identifying any energy saving opportunities.

Which technology to use?
When the scope of the project has been chosen a fairly accurate budget (CAPEX and OPEX) should be made, in order to determine the necessary financing and cash flow requirements. Furthermore, documentation of the current energy performance should be gathered to be able to determine the energy saving realized by the project.

A conclusive pre-feasibility report must be prepared describing the purpose of the project, the design basis for the project and expected CAPEX and OPEX for each alternative solution identified. The pre-feasibility report shall describe the business case for the project including relevant alternative solutions. The business case shall include an assessment of Total Cost of Ownership (TCO) for alternative solutions calculated as NPV. The report shall be used as basis for deciding on further steps.

6.2 Feasibility phase

The aim of the feasibility phase is to carry out a pre-liminary design for the preferred solution and make a fairly accurate investment budget (CAPEX and OPEX) to determine the needs for funding.

Input and knowledge of suppliers are important and beneficial when carrying out the feasibility study and can also give new inspiration for the configuration of the pumping station and the preferred solutions. Further, vendors can assist with more accurate budget prices.

The feasibility study and the following feasibility report must include all elements necessary to achieve the most optimal solution and may include topics such as:

- Project scope
- Detailed description of the project
- Optimizing the functional requirements to cover
- Optimization of total cost of ownership (TCO) over the estimated life time of the project
- Financial analysis, i.e. CAPEX and OPEX
- Financing options (potentially including fiscal incentives and subsidies)
- Assessment of impacts on the operations of the pumping facility
- Assessment of other impacts
- Project risks
- Overview of approvals and legislative framework
- Time schedule for implementation
- Project organization incl. preferred suppliers
- Recommendations for next steps

The outcome of the Feasibility Study is a report to be used as basis for deciding on the investment.

6.3 Tendering phase

Based on the feasibility study and approval of CAPEX, the preparation for tender will comprise a number of phases.

Final scope definition

The exact scope of the Contractor´s work must be established, and the following items will usually be included:

- Complete pump station construction/rehabilitation task
- Electrical connection
- Control strategy and system (Interface to current control system)
- Delivery and assembly
- Commissioning (in close cooperation with the owner)
- Trial operation
- Noise measurement
- Documentation incl. energy performance and savings
- Hand-over and final project conclusion
- Spare parts and service contract (option)

The list above is highly dependent on the actual project being performed.

Technical specifications

The requirements to equipment must be described unambiguously. It is particularly important to describe the overall delivery performance:

Functionality:

- Waterflow and pressure provided.
- Total efficiency of the system
- Max electrical consumption (at 100% load).
- Piping and connections should be free for leakages (If new piping is installed)
- Control strategy

Environmental requirements:

- Noise and safety requirements

Definition of how the performance test shall be conducted. It is important to be very specific to avoid discussion on methods, timing, sampling, calculation afterwards.

It shall also be described how deviations shall be handled and what shall be fulfilled before a handover can take place.

Performance guarantees

Before setting the conditions for the performance guarantees it is important to evaluate the operation conditions to make sure that it is possible to make the test runs.

Service contract.

Including spare parts and service of the pumping system into the contract will result in a fair price for the operation in the coming years.

6.4 Contracting phase

The quotation evaluation has two main purposes:

- Identifying deviations from the tender documents
- Making the tenders comparable enabling price negotiations

In the technical clarification, it is important to scrutinize the two most attractive quotations to ensure there are no misunderstandings or deviations from the tender documents. After this clarification and final price negotiation, a contract can be completed.

6.5 Installation, commissioning, and operation

It is important to follow the installation and commissioning phase closely to monitor whether important design decisions in the feasibility and tendering phase are followed through.

After the project completion and start of operation it is important to conduct a general evaluation. To do so it is important to collect and document the energy performance. This is both in relation to the performance guarantees but also to verify that the expected energy saving has been achieved. The evaluation of the project could for example cover:

- Does the new system function as expected?
- Did it deliver the calculated energy saving?
- Was it completed within the budget?
- Is there a further optimization potential, which can be realized later?

References

Final report on energy audit of pumping station No. 4 of the Dnipro-Donbass channel: Dnepropetrovsk region, Novomoskovsk district, outside the village of Kotovka (2024)

Final report on the energy audit of the Irpin pumping station, which is located at Kyiv Region, Vyshgorod District, village Demydiv, str. Morska, 1 (2024)

Directive 2009/125/EC of the European Parliament and of the Council and repealing Commission Regulation (EC) No 278/2009

Commission Regulation (EU) No 547/2012 of 25 June 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water pumps Text with EEA relevance

Commission Regulation (EU) No 548/2014 of 21 May 2014 on implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers and amended by Commission Regulation (EU) 2019/1783 of 1 October 2019