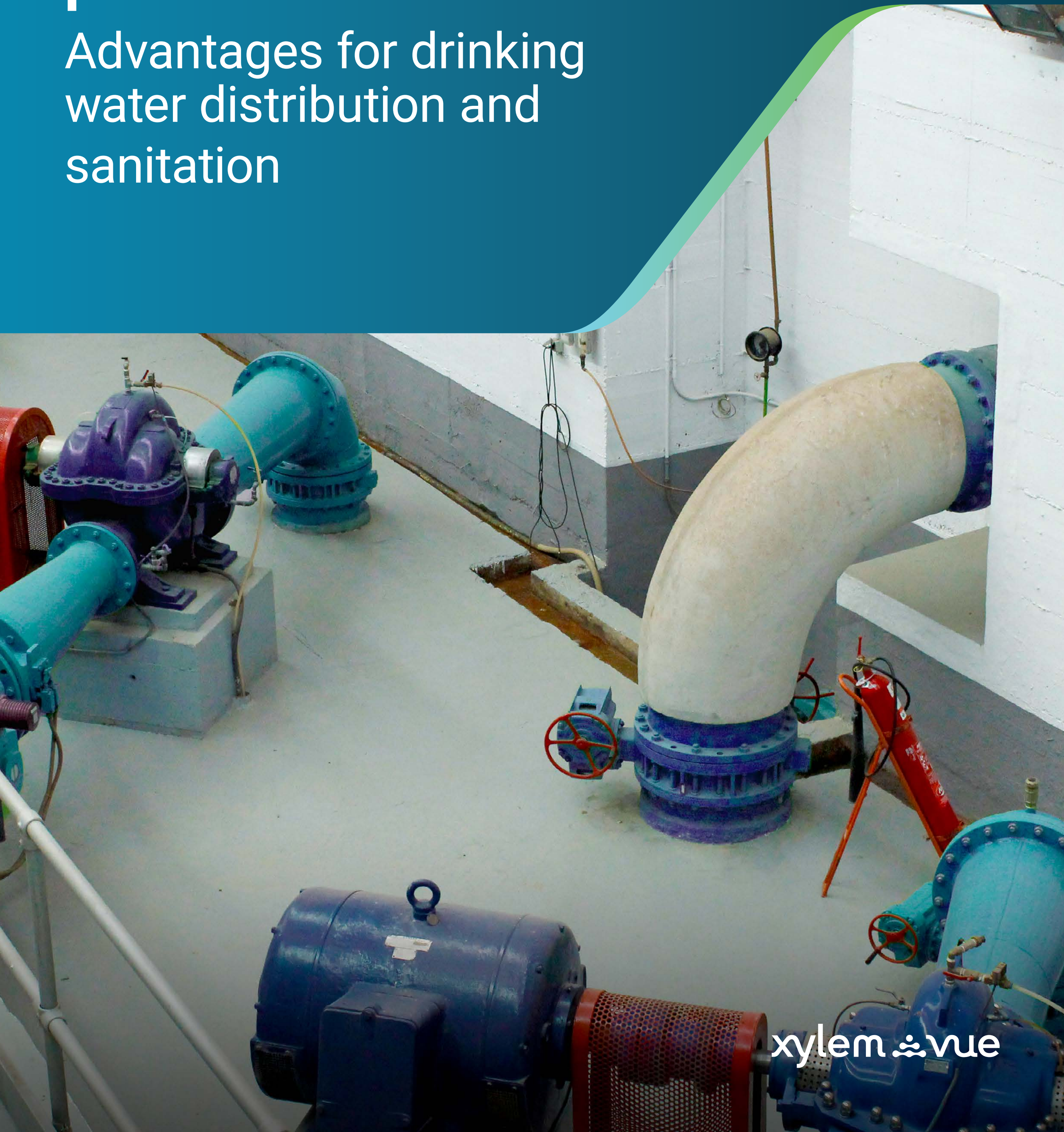
Whitepaper

Energy optimization plan for water networks

Advantages for drinking water distribution and sanitation



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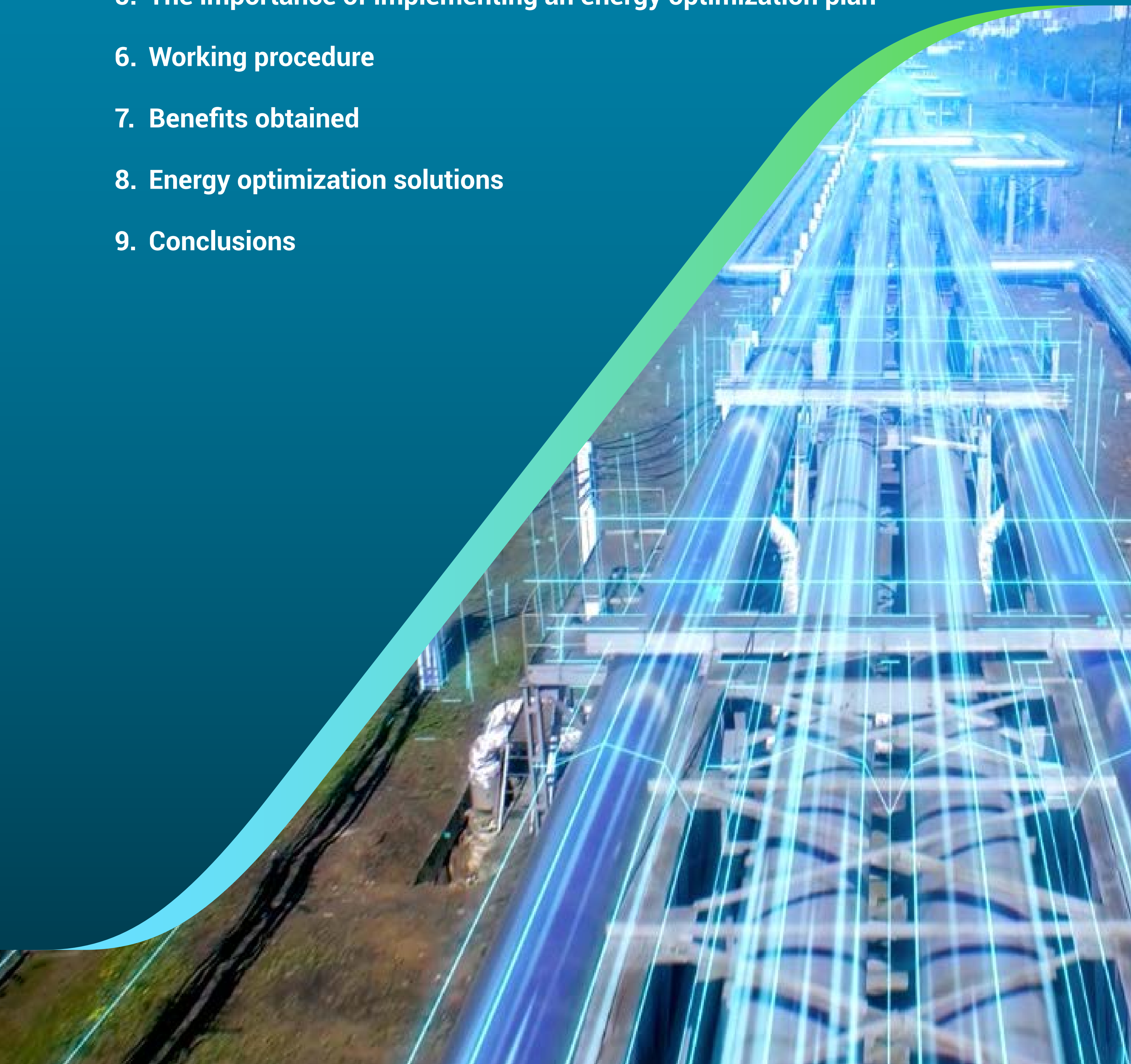
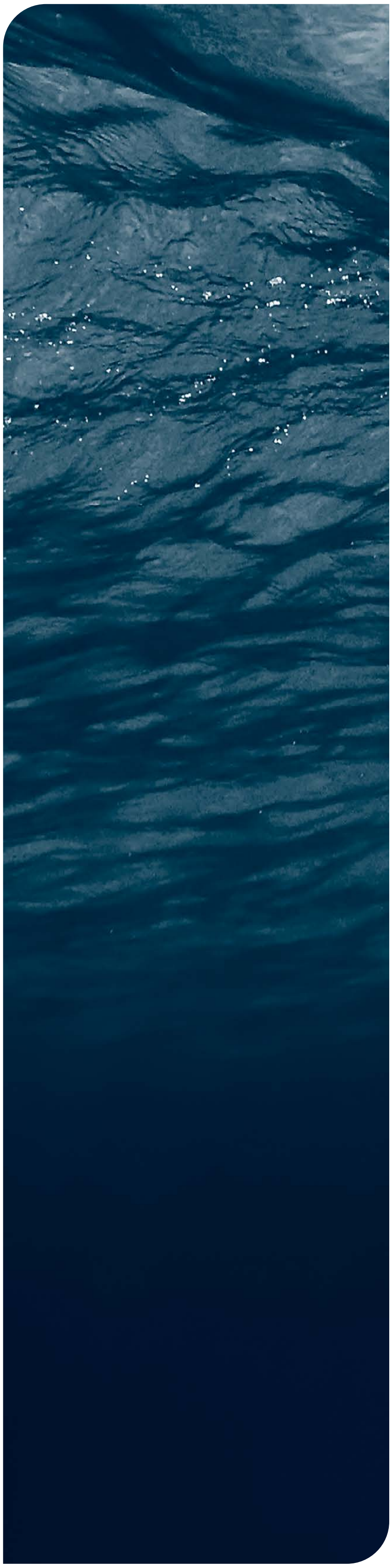


1. Introduction



We are currently experiencing major changes in the world, underscoring the need to rethink processes with a view to optimizing them.

Global warming is causing unpredictable climate change resulting in extreme weather phenomena, in which long periods of drought are interspersed with episodes of torrential rain, which are difficult to manage.

In many cases, this makes it difficult to obtain quality water to supply an ever-growing population, leading to increased demand for energy, which is not always available.

Energy is a key input in water and sanitation services and has a significant impact on their costs. This is exacerbated when supply prices are high in many areas, as is currently the case.

In this context, it is essential to optimize both the processes and the operation of the equipment used in providing these services, so that they work under optimum energy efficiency conditions, avoiding the use of deteriorated equipment or equipment that works outside its peak performance point.

To achieve this goal, the digital transformation of processes is a simple tool to facilitate monitoring and to detect possible deviations in an initial phase.

Thus, any improvement in energy efficiency, whether by saving water, energy or streamlining processes, leads to a direct reduction in costs and increases in process efficiency and sustainability.

Nowadays, it is imperative to implement energy efficiency optimization plans that reduce facilities' energy consumption and CO_2 emissions, striving to introduce environmentally responsible initiatives and encouraging the circular economy. This leads to more efficient processes, with a lower carbon footprint, thus giving businesses a better corporate image, in line with global initiatives championing sustainable production systems to fight climate change.

implementation of a centralized platform capable of extracting data from all devices and consolidating it in one place. This prevents the so-called "spaghetti architecture" or "Frankenstein architecture", optimizing resource management and ensuring a reliable, safe, drinking water supply.

Accordingly, enhancing water resource sustainability requires understanding how device management in utilities improves water cycle efficiency, as well as how to implement a platform to optimize this process.

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2. Content summary

This document contains information on the deployment of an Energy Optimization Plan for a drinking water distribution network and/or sanitation system.

It describes the problems that advocate its implementation, details the best methodology and describes the benefits obtained from its deployment.

3. Current situation

Water and energy are a key part of all the processes that shape our everyday lives. In most cases, water is needed to produce energy, and energy is needed to extract, treat and distribute water, as well as to purify and reuse it.

This is the water-energy link, meaning that the use of both resources must be addressed holistically.

Energy, water and environmental sustainability are closely interlinked and of vital importance, not only from an economic standpoint, but also in terms of sustainable development and the circular economy.

Given the close relationship between water and energy, the design and operation of water systems must take energy considerations into account.

Population growth, the transition to a predominantly urban society and climate change, especially in developing countries, are driving efforts to find comprehensive solutions in this area. These include putting a stop to the inefficient use of critical resources such as water and energy.

Overall, the demand for water-related energy is expected to double in the coming decades, mainly due to population growth, rising living standards and an increasingly scarce water supply in and around population hubs as a consequence of climate change. This will mean that water will have to be transported further, pumped from greater depths and undergo additional treatment before it can be used.

In addition, the increased use of more efficient irrigation systems around the world, which use pumping systems to ensure correct pressure throughout the network, but are more energy-intensive, as well as the use of desalination plants to obtain fresh water, are techniques that require large amounts of energy.

In this fast-moving environment, which often entails resource constraints, utilities must take greater responsibility for the use of resources. This means that optimizing processes to reduce consumption as much as possible is vital.

Reducing CO_2 emissions is a priority to try to mitigate the effects of climate change and ensure sustainable service delivery.

4. Common issues

In drinking water distribution and sanitation systems, attention is usually focused on guaranteeing satisfactory service delivery, while less consideration is given to the amount of energy they use.

However, this is changing, with major efforts being made to optimize processes. This entails the identification of different problems which are, in turn, opportunities for improvement that often lead to significant energy savings in the short term.

It is commonplace to find old, energy-heavy equipment as well as outdated electrical installations which generate major process losses. Simply replacing equipment with an identical, energy-efficient machine can generate major energy savings.

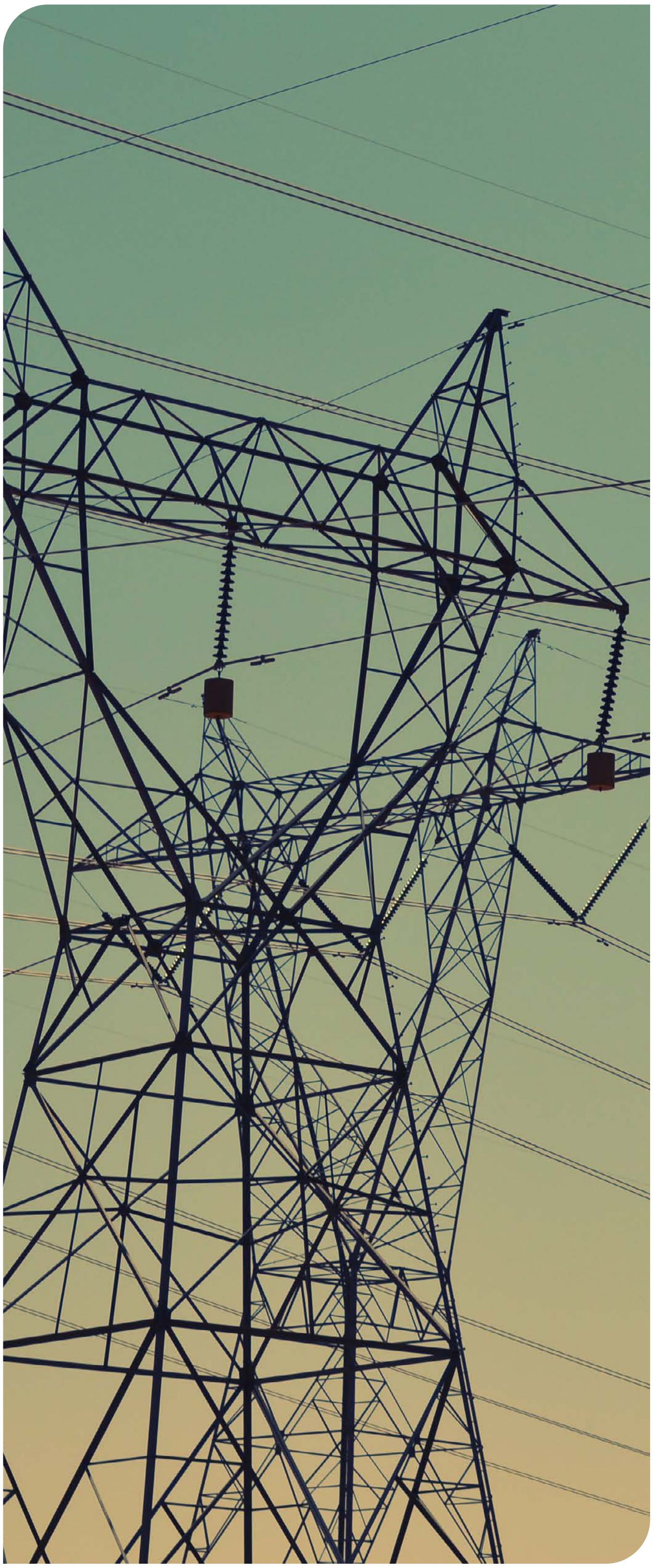
Furthermore, facilities often contain oversized apparatus that does not run at its peak. The energy it consumes is subsequently dissipated, usually as a result of a throttled valve, thus meaning it works inefficiently.

It is essential to identify these underperforming machines and to carry out the corresponding maintenance work, together with changes in their operating parameters, so that they run efficiently and make maximum use of energy.

Another problem that usually arises in water distribution systems is that they do not have the best electricity tariff to suit their operating conditions. In most cases, either because the initial tariff was suitable in the past, but the system has changed its mode of operation, or because the tariffs have changed and have not been updated.

Although tariff adjustment is not a measure that can reduce energy consumption, it can considerably decrease the economic cost of operating the facility.

Finally, it is commonplace to find utilities which have no idea what their energy consumption is and, by extension, what their current energy status is. In this case, these operators need to be given the means to measure and characterize their energy use and propose corrective actions for improvement.



5. The importance of implementing an energy optimization plan

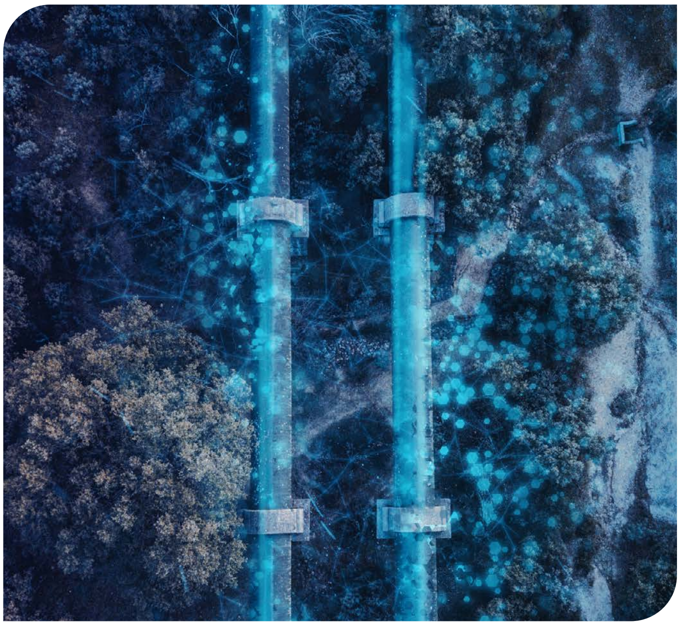
Organizations are constantly seeking to enhance their general performance. To do so, they establish strategies to increase and streamline their efficiency, while reducing costs.

Today, many utilities are managing their strategic inputs, such as energy, and some choose to do so in a structured and systematic way. Others do so based on the results of energy audits, or by detecting improvements from within the organization.

The importance of implementing an Energy Optimization Plan lies in the realization that many isolated energy efficiency initiatives serve for little if they are not sustained over time.

In general, isolated changes in technologies, without systematic organizational support, do not normally generate value or bring stability over time. Thus, the benefits resulting from this type of initiatives, such as cost and greenhouse gas emission reductions, turn out to be one-off actions which are often short-lived.

It is therefore extremely important to establish protocols and methods that guarantee that the benefits of energy efficiency are permanent and continuous.



6. Working procedure

The most important way to achieve energy efficiency in a utility is not only to have an energy saving plan, based on a study or diagnosis, but also to have an Energy Optimization Plan that guarantees continuous improvement.

An Energy Optimization Plan is made up of the following phases:

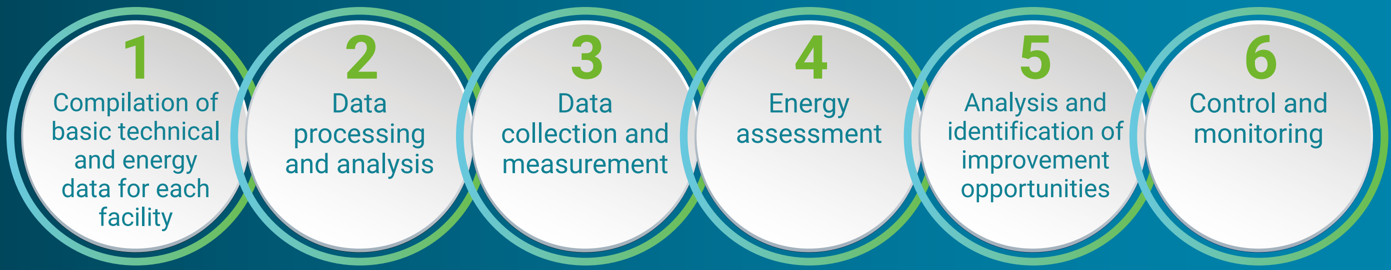


Figure 1: Phases of an Energy Optimization Plan

The implementation of an Energy Optimization Plan provides the following benefits:

1. Reliable knowledge of the facility's equipment and the energy consumption of each facility.

2. Detection of the factors affecting energy consumption.

3. The operating point and performance of each piece of equipment is measured in order to ascertain its efficiency.

4. The different energy-saving opportunities are identified, evaluated and prioritized based on their cost-effectiveness.

6.1. Compilation of basic data

In this phase, the energy data that influence the analysis of the Energy Optimization Plan's objectives are recorded and classified.

The minimum data to be collected are listed below:

- List of processes and technical characteristics of energy-consuming equipment
- Detailed characteristics of energy uses within the scope of the audit, including relevant variables
- Historical and current energy performance data
- Future plans that could affect energy performance.
- Design, operation and maintenance documents

The energy distribution system and how it is managed:

- Current energy tariff or a reference rate (tariff) to be used for financial analysis.
- Other relevant economic facts and figures
- Knowledge of how the organization manages its energy use and consumption.

6.2. Data processing and analysis

In this phase, all the information obtained is classified and organized so it can be used for future calculations.

Computer tools are used to group data, digitalize documents and adapt formats.

With the information obtained in the previous points, an analysis of the facility can be performed to identify the processes and the relevance of the energy consumption associated with each one. This can then be used to see which processes consume the most energy.

This data can be used to define a field-work strategy, pinpointing the most interesting areas from an energy point of view.

By analyzing the data obtained up to this point, a comprehensive picture of the energy and operating situation of the facility can be obtained, and a pre-diagnosis can be made.

6.3. Data collection and measurement

A survey of electrical and hydraulic parameters must be carried out in the field to calculate losses and the energy balance of the equipment involved in the facility's processes which is included in the Energy Optimization Plan.

This information will determine where significant savings can be made and generate the corresponding proposals to implement savings measures.

Measurements should be focused on establishing the baseline of the processes and the facility as a whole.

Local measurements of the variables described in the previous data collection exercise must be carried out using portable instrumentation.

Measuring the system's electrical and hydraulic parameters is a fundamental part of the Energy Optimization Plan. The success or failure of the Energy Optimization Plan depends on the correct measurement of these parameters.

6.4. Energy assessment

Once all the information has been collected and the measurements have been taken, a diagnosis of the facilities must be carried out.

The digital transformation of the water cycle has driven the development of IoT technologies, resulting in protocols and networks designed for low-power, wide-coverage scenarios, such as:

- Calculation of losses to obtain the specific balance in each system.
- Calculation of energy indicators and their statistical analysis
- Construction of energy balances, operation analysis and maintenance practices.

The following figure shows the typical breakdown of energy losses in water distribution system facilities.

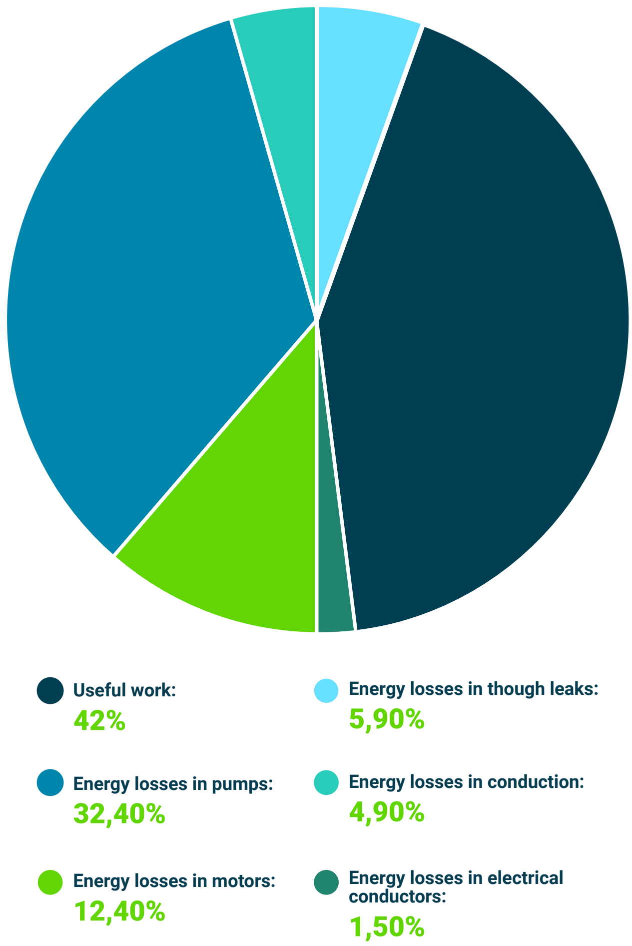


Figure 2: Breakdown of energy losses in water distribution system facilities.

The greatest energy losses usually occur during the transformation of mechanical energy into hydraulic energy (pump to hydraulic network) which, in some cases, can be as much as 40% to 45%. However, once the energy reaches the electric motor, it is not uncommon to find pumping systems registering losses of up to 60%.

It is precisely in this 40%-45% range that the opportunities explored below come into their own, derived from optimizing hydraulic operations. This is also where there are significant energy-saving opportunities.

6.4.1. Calculation of energy indicators

Indicators measure the efficiency and effectiveness of the water distribution system. Although there are a large number of factors in the energy-efficiency scenario, the basic indicators to be monitored are as follows:

a) Energy indicator (EI) (kWh/m³).

This represents the exact ratio between the energy used by a water system's pumping equipment and the total volume of water produced to supply the distribution network.

$$EI = \frac{Total\ energy\ consumed\ by\ equipment\ (kWh/year)}{Volume\ of\ water\ produced\ (m^3/year)}$$

In a water distribution and sanitation plant, this indicator will come down when energy consumption is reduced, thanks to the use of efficient pumping equipment, and when there are fewer energy losses.

b) Unit Indicator (UI) (kwh/m³/m.c.w.)

This represents the ratio between the energy used by the pumping equipment in a water system to raise the total volume of water supplied to the distribution network by one meter of water column.

$$UI = \frac{Total\ energy\ consumed\ to\ raise\ one\ m^3 (kWh/m^3)}{Manometric\ head\ (mcw)}$$

This is the equivalent performance estimate of the system, considering its efficiency in satisfying the needs (increasing flow rate to offset a geometric difference in level).

This index is a real measure of the energy efficiency of the unit, the pump and the system. It can be applied to any pump regardless of operation, parameters or type of system.

c) Economic indicator (€/kWh)

This represents the specific cost per unit of the energy consumed, which depends on several factors, including: the type of electricity tariff, the load factor (which reflects the actual hours of operation compared to calendar hours) and factors that affect energy billing, such as the penalty or bonus for the power factor of the installation.

This indicator is calculated based on the annual energy consumption and billing statistics compiled by the utility, as well as the annual production of drinking water.

$$EUC = \frac{Amount\ of\ electricity\ invoiced\ (€/year)}{Total\ energy\ consumed\ (kWh/year)}$$

Its objective must be set by each utility, depending on its electromechanical infrastructure and related costs.

It is important to constantly measure these indicators in water distribution and sanitation facilities, and especially when measures are being taken to increase energy efficiency, since they can be used to evaluate the progress made and to subsequently draw up appropriate policies and programs.

6.4.2. Building the energy balance

Once the system components' energy efficiencies have been established, the current energy balance of the facility under study must be constructed.

The purpose of building the energy balance is to identify the elements in the system with the highest energy consumption so as to plan the corresponding energy saving measures.

The most significant information obtained from this balance is the breakdown of the energy losses occurring in the energy supply and use chain, as well as differentiating them from useful work, which indicates the amount of energy actually used by the system to carry out the processes.

Everything that is not useful work is a loss. This enables the balance to identify how they are distributed, and which ones have the greatest impact. This, in turn, will indicate where the greatest energy-saving potential lies.

This balance must be constructed by identifying the efficiencies and losses in the different system components.

6.4.3. Analysis of operating conditions

There are two aspects to be analyzed at this point:

- The real pressure and flow conditions under which the pumping systems operate, to ascertain whether they are constant or change periodically.
- The way they operate in terms of level management.

Every piece of equipment, with its respective design, has an optimum pressure-flow rate operating point where all the losses described above are kept to a minimum. When the equipment does not operate at this point, the following issues appear:

- Low energy efficiency
- Shorter lifespan of components, particularly impellers and wear rings
- Cavitation due to low suction flow
- Increased pressure due to environmental deterioration (in case of infrequent use)

6.5. Improvement proposals

A corrective action plan needs to be drawn up based on the analysis of the information obtained during the previous phases, including the operational and maintenance conditions. These measures should enhance energy efficiency and address all potential opportunities for both energy and economic savings, including measures involving no investment, low-investment and high-investment.

A cost-benefit analysis is necessary for those requiring investment. This may be a simple return on investment analysis, or an in-depth assessment based on net present value which takes the lifetime of the asset acquired into account.

In general, the measures defined in each project aim to monitor and optimize the variables that affect energy consumption and costs.

The main measures include the following:

1. Measures to increase motor efficiency.
2. Measures to increase pump efficiency.
3. Measures to reduce losses in electrical installations.
4. Measures related to the energy tariff.

6.5.1. Motor efficiency optimization

Analyzing the operating efficiency of electric motors, and calculating their real efficiency, involves examining the possible causes that affect this efficiency, based on the anomalies detected.

Different corrective measures can be taken to boost the efficiency of an inefficient electric motor, depending on the operating conditions.

Implementation of these remedial measures can substantially improve the efficiency of an electric motor and thereby cut energy losses.

6.5.2. Replacement with a high-efficiency electric motor

This is an alternative when possible repair or maintenance options which do not involve investment, such as replacing a motor, have been exhausted.

Replacing a motor is highly recommended when it breaks down and needs to be repaired. Although this option is costly, the efficiency of standard motors can be enhanced by up to 8% when they are replaced with high-efficiency motors.

6.5.3. Replacement of the pump-motor assembly

This measure is recommended when electromechanical efficiency is very poor, and the energy-saving potential determined during the study is at least 20%.

The general criterion here is that if the potential for improving motor efficiency is greater than 5%, it is more advisable to replace the pump-motor assembly, since the savings potential is assured in both pieces of equipment, making the measure highly cost-effective.

6.5.4. Adapting pumping equipment to the actual operating point

The procedure for establishing a recommendation for this measure consists of defining at least two flow-pressure operating points at which the pumping equipment operates. Subsequently, the characteristics of the installed equipment must be analyzed, and an evaluation made as to whether it is advisable to adapt it to the actual operating conditions (trimming impellers, replacing impellers, or replacing the pumping equipment).

However, any modification can lead to design changes, for example, trimming the impeller outlet diameter may change the pumps' efficiency curves. Therefore, this task should be conducted in consultation with the manufacturer.

6.5.5. Installation of variable frequency drives (VFDs)

The option of applying a variable speed system in the pumping equipment should be proposed and evaluated, especially in systems with direct mains supply, in which water demand is variable.

When evaluating energy consumption, this is often an attractive option, mainly because of VFD energy use levels and cost.

6.5.6. Predictive and corrective maintenance

The implementation of a predictive and preventive maintenance program must be included in the Energy Optimization Plan, if this does not exist. The main benefits to be obtained with a sound facility maintenance program include the following:

- Greater pumping capacity
- Greater equipment reliability
- Better planned, more efficient operations
- Better service to the population
- Less stress on staff
- Lower operating and administration costs
- Increased lifespan of equipment
- Energy savings
- Economic savings

6.5.7. Optimizing the power factor

The objective of this measure is to eliminate the problems caused by a low power factor (PF). In general, if this value is below 90%, steps should be taken to offset this and reach values close to unity, which are very cost-effective.

The mechanism to identify the savings achieved with this measure is as follows:

- When the power factor in the pumping equipment recorded by the utility, or obtained during field measurement of electrical parameters, is less than 0.90 (or 90%), improvement measures should be taken.
- If the low power factor is caused by oversized motors or motors not working in optimum conditions, these motors should be replaced with new high-efficiency motors whose capacity enables them to operate at about 75% of their full load.

6.5.8. Switching to a cheaper tariff

An attractive opportunity to reduce energy consumption costs is to change the tariff contracted with the electricity utility to a cheaper one. This requires a study of the tariffs available.

A tariff optimization project has two stages:

Stage 1. Identifying the tariffs for each and every one of the utility's services, as well as the needs and consumption of each facility. This is essential to start an analysis of the contracted tariffs.

Stage 2. Assessing the potential savings in the cost of electricity with the different tariffs available. In essence, the idea is to compare the amounts that would be paid for each of the tariffs for the service required.

6.5.9. Monitoring demand

In most cases, the cost of electricity varies according to the time of day it is used. This type of tariff, which is often used by water and sanitation systems, is known as an "hourly tariff". In this type of tariff there is generally a "peak time", in which the unit cost of energy is much higher than during the rest of the day.

In facilities using this type of tariff, it is advisable to analyze the alternatives for the implementation of a savings measure that consists of managing consumption during this peak time. This is known as a "demand control scheme", which aims to decrease the hydraulic load during peak times so as to reduce the total billable energy consumption attributable to that period and, as a consequence, the overall amount paid to the utility.

6.5.10. Implementing renewable energies

The introduction of renewable energies in water distribution systems has been widespread in recent times. Pumps working as turbines, solar pumps and biogas production are a clear example of this and generate additional and, in many cases, inexhaustible energy, which makes processes much more sustainable, thus reducing CO_2 emissions and operating costs. stations.

6.6. Control and monitoring

Once an Energy Optimization Plan has been put into practice, it is vitally important to establish a follow-up protocol to ensure that the measures implemented are perpetuated over time and also to detect any changes that may occur in the system.

In this sense, the facility must have the necessary tools to monitor the evolution of the defined control ratios.

Firstly, measuring equipment must be deployed to guarantee data collection at the correct intervals. Additionally, data must be processed and analyzed as efficiently as possible to reduce the time the utility spends on this task.

If system information is kept up to date, its evolution can be analyzed over time; the effectiveness of the improvement measures introduced can be evaluated and the need to deploy new actions can be detected.

7. Benefits obtained

Rolling out an Energy Optimization Plan brings a series of short- and long-term benefits, which lead to enhanced use of resources and process optimization for the utility.

Optimizing the performance of equipment means lower energy consumption, which leads to process cost reductions, partly due to the need for less maintenance work.

Energy optimization means the release of fewer CO_2 emissions into the atmosphere. This reduces the processes' carbon footprint, making them more sustainable.

In addition to the intrinsic service benefits, the implementation of an energy optimization system also boosts the company's corporate image, aligning it with the objectives of the circular economy and respect for the environment, which are of vital importance today.

8. Energy optimization solutions

Energy is essential for the functioning of drinking water distribution and sanitation facilities, and it has a significant impact on the costs of providing the service, accounting for between 5% and 30% of total operating costs. This figure can reach up to 40% in some cases, depending on the specific service conditions.

As a result, any progress in energy efficiency, whether by saving water, energy or streamlining processes, leads to a direct cutback in costs and an increase in economic efficiency, which means that utilities are keen to explore any initiative that upgrades energy consumption management in their processes.

Digital transformation helps utilities to pinpoint exactly where the greatest potential for savings lies, and thus propose improvement measures that will lead to the greatest reduction possible in energy consumption and, consequently, to a swifter return on investment.

Energy monitoring is a basic tool for establishing a method to control parameters, interpret results and assist in decision-making with minimal effort, helping users to optimize their processes at all times, with all the benefits that this entails.

The digital transformation of typical facility data provides real-time monitoring of process development and reveals how equipment is performing.

Continuous performance monitoring of equipment at an early stage is useful to anticipate any incidents that may increase energy consumption.

Thus, a facility can be managed so that it always functions very close to its optimal operating point.

The analysis of historical energy and hydraulic data provides automatic information to determine the most appropriate electricity tariff and to make adjustments to the system to cut this cost.

In this sense, integrating electricity billing data with real-time measurements in digital management systems provides constant information on the energy consumption cost of the equipment, detecting any incident in the utility's billing and identifying factors that cause penalties or excessive costs.

In addition, thanks to the use of predictive algorithms, water use and, consequently, energy consumption, can be calculated sufficiently in advance for each infrastructure analyzed, facilitating any upgrading measures that will lead to lower energy consumption and process costs.

The close relationship between water and energy means that it is very important to understand how the infrastructures that need to be optimized function, since this is the only way to adopt measures that will be successful in the long term and that will streamline both the energy and operational efficiency of processes.

This relationship justifies the need for comprehensive knowledge of hydraulic processes to improve the energy efficiency of water distribution and sanitation networks.

9. Conclusions

Today, the world is undergoing a period of major change, highlighting the need to rethink and optimize processes and the operation of the equipment used to carry them out.

Energy optimization means reducing the emission of CO_2 into the atmosphere. This, in turn, means that the carbon footprint of processes drops, making them more sustainable.

The deployment of an Energy Optimization Plan guarantees a series of benefits for the utility in the short and long term, leading to better use of resources, process streamlining and the assurance that the energy optimization initiatives will be sustained over time.

The implementation of an Energy Optimization Plan provides reliable knowledge of the installed equipment and their energy consumption. It also pinpoints the factors that affect energy use, measures the optimum operating point and performance of each piece of equipment in order to determine its efficiency, and identifies, evaluates and prioritizes the different energy-saving opportunities, according to their cost-effectiveness.

Digital transformation provides utilities with quick, easy and accurate knowledge of the areas which have the greatest savings potential, so they can weigh up the improvement measures that will lead to the greatest cuts in energy consumption and, consequently, to a quicker return on investment.

An Energy Optimization Plan must be implemented by specialists with in-depth knowledge of this type of infrastructure, as this is the only way to adopt measures that will be successful in the long term and streamline the energy and operational efficiency of processes.

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1) the tissue in plants that brings water and nutrients upward from the roots.
2) a leading global water solutions company.

Xylem is the connective tissue and system in plants which cleanses and transports water from the root to where it is needed most to sustain life.

And this is the essence of Xylem as a company. We are committed to driving sustainable impact by ensuring our connected technologies and solutions support our customers and the communities they serve, to tackle the water challenges that matter most to them.

For more information on how Xylem can help you, visit xylem.com.

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Xylem Vue is the result of the partnership between Xylem, a global leader in water technology and Idrica, an international pioneer in water data management, analytics and smart-water solutions. Through this partnership, Xylem and Idrica bring together their technology, innovation, and expertise to solve the world's most critical drinking water, wastewater and other water-related challenges.

Our single, integrated software and analytics platform – built by utilities, for utilities – enables utilities to take digital transformation to the next level, maximize investments, identify and solve problems more quickly, operate more efficiently and deliver water more effectively and affordably to their communities.

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