White paper
Wastewater pumping

Life cycle costs for wastewater pumping systems

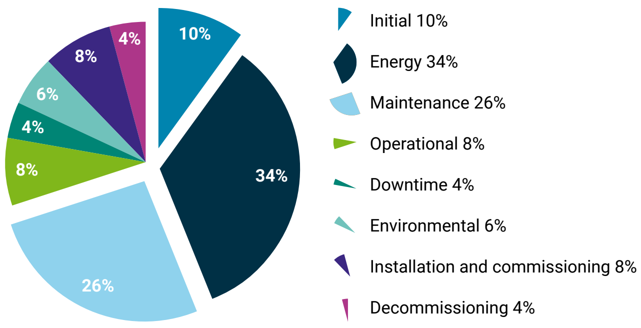
Critical factors for cost-effective investment decisions

Procurement decisions today often focus narrowly on technical compliance and initial purchase price. However, the purchase price typically accounts for less than 10% of the total life cycle cost (LCC) of wastewater pumping systems. Without a full LCC evaluation, decision-makers risk significant hidden costs in energy consumption, maintenance, downtime, and environmental penalties.

Using the proven Hydraulic Institute (HI) framework, a complete LCC analysis reveals the true economic and operational impacts of procurement choices. This understanding of long-term costs often transforms the investment decision.

This white paper provides an overview of all the relevant LCC factors cited by the Hydraulic Institute, but the focus is on the areas of highest importance for wastewater pumping systems: initial investment, energy costs and maintenance costs. Examples and recommendations for how to decrease total costs are also provided.

Naturally the weighting of certain factors in the LCC analysis will depend on local circumstances. For example, in countries with low energy prices or for stations that run infrequently, energy costs may not be a major factor. Similarly, maintenance costs will have less impact in locations where labor is inexpensive. The advantage of an LCC analysis is that it lets the user focus on the factors that matter most for a specific pump system and situation.



Typical life cycle cost breakdown for a wastewater pumping system, highlighting dominant cost contributors over the system lifetime.

LCC calculations can be used on any piece of equipment or system to determine the cost of procurement, operation, maintenance and disposal over its lifetime. While there are a wide range of models used to calculate the total cost over the lifetime of a product, they all share a common objective: to provide an accurate estimate of total costs over time, expressed in today's currency value.

> “The lifecycle cost of any piece of equipment is the total lifetime cost to purchase, install, operate, maintain and dispose of that equipment.”

Hydraulic Institute

Life cycle cost equation

The Hydraulic Institute has defined the following LCC formula for pumping systems, which has become the industry standard:

$$LCC = C_{ic} + C_{in} + C_e + C_o + C_m + C_s + C_{env} + C_d$$

C_{ic} = Initial costs
Initial costs relate to the cost of purchasing pumps, piping and all mechanical and electrical equipment, as well the cost of engineering, testing and inspection, including any spare parts and training.

C_{in} = Installation and commissioning costs
These costs can include the civil work, foundations, connection of piping, electrical wiring and instrumentation. They also cover the cost of setting and grouting equipment on the foundations, provisions for flushing, as well as performance evaluations at start-up. The installation and commissioning of monitoring and control equipment is also included in this item.

Installation time can be minimized or eliminated by selecting a pre-programmed variable-speed drive that requires a minimum of configuration settings.

C_e = Energy costs
These costs include the total energy cost to operate the pumping station, including the energy consumed by the pump driver (electric motor or other), controls and all auxiliary services.

Energy costs can be a significant factor, depending on the type of application. For a stormwater pumping station running a few hundred hours every year, the energy cost is usually only a small part of the LCC. For a wastewater treatment plant intake station that runs continuously, however, energy costs account for the majority of its life-cycle cost.

It is anticipated that ever-higher demands for energy efficiency in legislation will make this factor an increasingly important part of the total formula.

C_o = Operational costs
Operational costs cover the labor costs for normal operation of the pumping system. This includes, for example, normal wear and tear, system supervision and keeping the station clean. Operational costs do not include costs attributable to energy or maintenance of the pump station.

By selecting a controller with cleaning functions, money can be saved on manual cleaning of the station. An LCC analysis can be a good tool to see how fast the investment in a new supervision system will pay back.

C_m = Maintenance and repair costs
Such costs relate directly to the cost of spare parts and the total number of hours spent on maintenance, including planned and unplanned maintenance. Costly unplanned maintenance can occur when pumps stop due to clogging or other malfunctions.

For small stations pumping raw sewage, maintenance can be a major component in the total LCC calculation. This is especially true if the pump is poorly matched to the pump system’s operating conditions.

C_s = Downtime costs
This category relates mainly to unexpected downtime but may also be due to loss of production or even loss of trust from a customer. The use of a standby pump limits this risk.

Downtime costs can be minimized by using maintenance contracts that ensure regular service to maximize uptime and shorten response time in the event of emergencies. Monitoring and control solutions can also create early warnings that help to prevent downtime.

C_{env} = Environmental costs
These include costs for dealing with spills, environmental inspections and contaminant disposal during the lifetime of the pumping system. Such costs are often set by local regulatory authorities and vary from country to country. The disposal of used parts and materials is also included.

Environmental costs are not only operational; they can also include substantial regulatory fines or mandated upgrades. For instance, a single sewer overflow event due to pump failure can cost a municipality upwards of $100,000 in penalties, environmental remediation, and reputational damage. Furthermore, tightening CO_2 emission reporting and carbon taxes are making energy-inefficient systems increasingly costly beyond just electricity bills.

C_d = Decommissioning costs
Decommissioning costs usually include the disposal of the pump and auxiliary equipment, as well as restoration of the local environment. The decommissioning costs seldom vary for similar solutions and are often excluded from an LCC calculation.

What to consider when conducting an LCC analysis

Different ways to use a life cycle calculation
An LCC analysis can be used to determine the total cost for the system over its lifetime. When conducting a complete analysis, it is necessary to gather and enter data for all eight categories in the formula.

An LCC analysis can also be used to examine how beneficial an investment can be, meaning that only factors that are of relevance for the analysis need to be included. The parts of the equation that matter the most will depend on the application, geographic location, labor costs and energy costs – factors that can vary significantly between markets. When comparing different systems, the relevant data should be entered for the same categories. Making two analyses – one with the investment and one without – and comparing the results will show the payback time for the investment.

Important factors for wastewater pumping systems
Since some factors don't vary much for wastewater pumping systems, they can often be excluded from the calculation. All factors are presented in this white paper but not discussed in depth. The focus here is on the three areas that vary the most: the initial investment, energy costs and maintenance costs.

Initial investment

Choosing the lowest purchase price can often mask far higher operational and maintenance expenses. Studies show that initial savings of just 5 to 10% in pump procurement are frequently offset by 20 to 40% higher energy and service costs within the first few years of operation. A lower upfront investment can lead to significantly higher total expenditures over the system's lifetime.

Flow rate

When designing a pump system and considering the initial investment, it is important to first optimize the system for the most common flow rate. One frequent mistake is to optimize the pump and station for the specified maximum inflow rate.

Inflow to a wastewater pump station often varies significantly, with a typical ratio of 1 to 15 between normal flow and peak flow. By using a diurnal flow diagram (Figure 1), it is possible to visualize and analyze these variations. The diurnal flow diagram shows the inflow over time as well as the maximum and minimum inflow to the station.

The vast majority of wastewater pumping stations are oversized relative to the most common incoming flow. This tends to increase the cost of pumping as well as the size of the station. Select a pump that can manage the maximum flow and head but also matches the best efficiency point (BEP) with the most frequent flow conditions. Avoid using an oversized pump since that will only increase the total costs – from the purchase price of the pump to the energy consumed by the pump to the station construction cost.

An easy way to deal with fluctuating inflow rates is to use either multiple pumps or pumps of different sizes in the station. A variable-speed drive can also be used to adapt to varying flow rates.

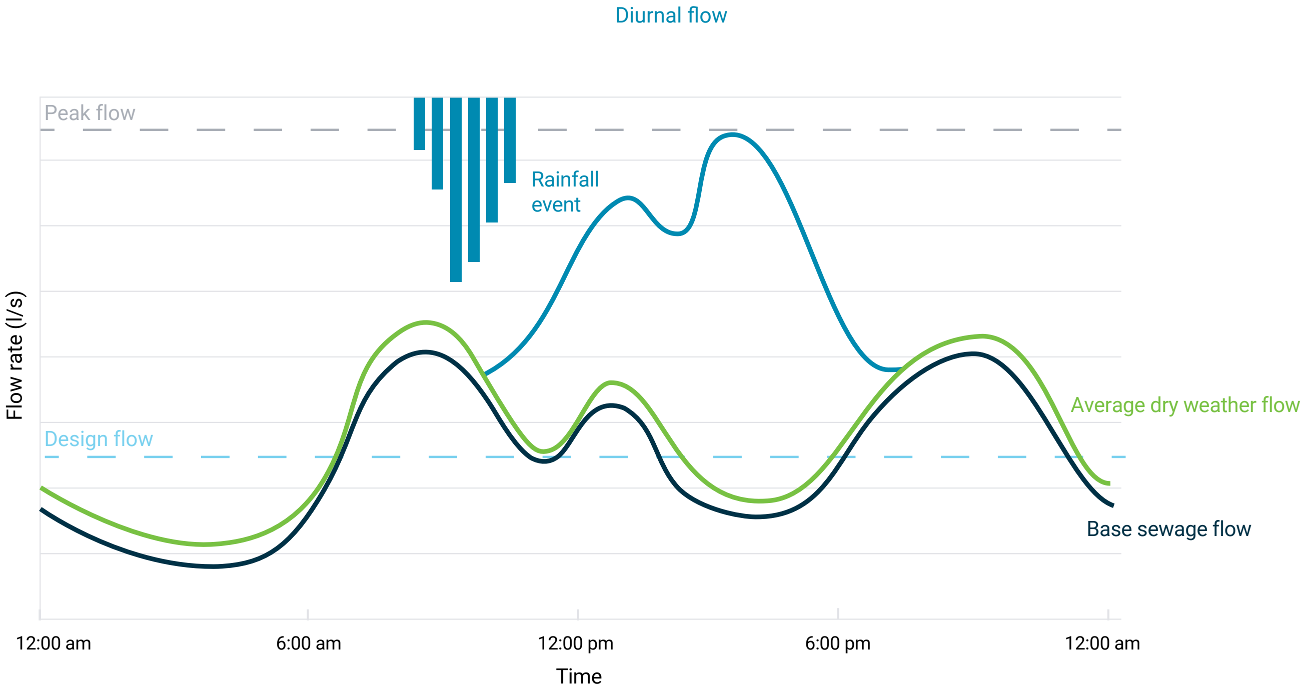


Figure 1: Duration curve of wastewater diurnal flow, showing typical fluctuation patterns and the impact of a rainfall event; key for pump sizing and station design optimization.

System design

The initial investment includes the cost of pumps as well as the construction of the pump station and piping. A larger station quickly increases the investment cost due to additional construction work as well as the added cost of materials. An oversized pump sump also creates less favorable working conditions for the pumps and allows more sedimentation in the sump.

For wastewater applications, the station design is of major importance to decreasing clogging and reducing the buildup of debris (Figure 2). This is obviously less crucial for clean water applications.

Recommendations regarding station design can be found in ANSI/HI 9.8 Rotodynamic Pumps for Pump Intake Design. Most manufacturers also provide pump sump design guidelines as well as station design tools. By using a pump station design tool, it is possible to achieve good inflow conditions to the pump with the smallest possible footprint while also lowering the investment cost considerably.

For retrofits or in special design cases where a standard design cannot be used, it may be necessary to use computational fluid dynamics (CFD) analysis or a scaled physical model test to ensure an optimal station design.

Selecting the optimal size of the force main is also important, especially for a system with a long force main. The size of the force main needs to be optimized in order to achieve the most favorable investment cost and energy cost and to reduce the risk of sedimentation. Although a smaller diameter pipe is less costly to buy and install, the velocity will increase and thus lead to higher pump and energy costs. A larger diameter pipe, on the other hand, leads to lower velocities in the pipe and can increase the risk of sedimentation during certain operating conditions.

System lifetime

The system design affects the investment cost to a high degree, but the factor that affects it most is the expected lifetime of the system. The longer the lifetime of a pumping system, the smaller the impact the initial cost will have since the investment cost becomes a smaller part of the total life-cycle cost. Experience from existing stations can be taken into account when estimating life length.

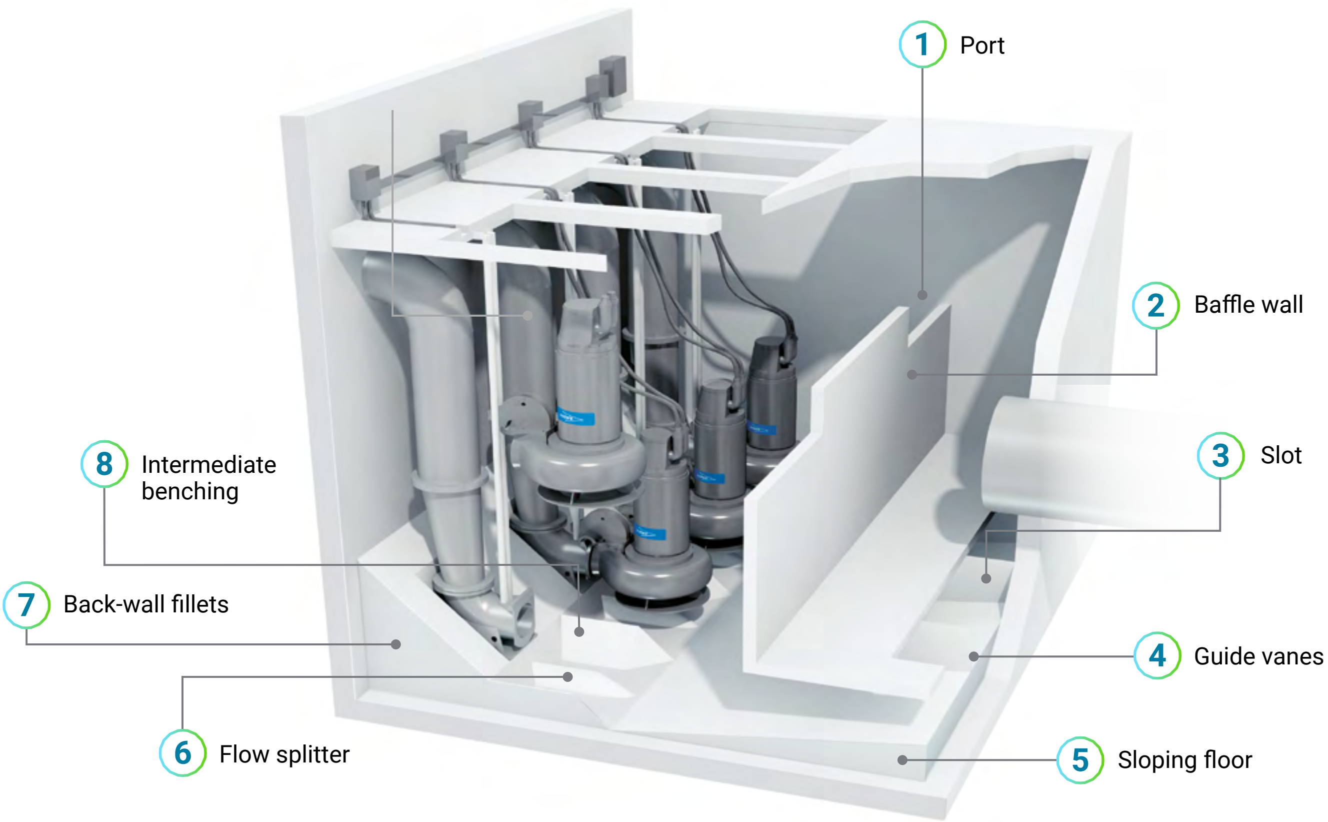


Figure 2: Example of an optimized pump station design.

Energy costs

Many factors affect the energy consumption of a pump system: the total head, the overall efficiency of the pumps (hydraulics, motors and drives) and the ability to sustain high efficiency over time. Maintaining a higher energy efficiency over time is a major concern for solids-handling pumps (see the Xylem white paper "Understanding sustained efficiency in non-clog pumps").

Specific energy

One method for selecting the wastewater pumping system with the lowest energy consumption is to use specific energy as a comparative measure.

Specific energy is the energy required to transport a volume of liquid in a specific pumping system. The solution with the lowest specific energy is the design that will need the least amount of energy to pump the media.

Specific energy is described according to this formula:

$$E_s = \frac{\text{Energy}}{\text{Volume}} = \frac{\text{P x time}}{\text{Q x time}}$$

The equation can be developed further:

$$E_s = \frac{\text{Energy}}{\text{Volume}} = \frac{\text{P x time}}{\text{Q x time}} = \frac{\rho gQH}{\eta_{tot}} \frac{1}{Q} = \frac{H}{\eta_{tot}} \rho g$$

Where,

P = power
Q = flow
H = head
g = acceleration of gravity
η_{tot} = total efficiency of the pumping system
ρ = density

As shown above, the specific energy can also be expressed as the head divided by the total efficiency and multiplied by a constant. Thus, specific energy can be reduced by minimizing the head or increasing the overall efficiency.

The specific energy for a certain pump system can be calculated using more comprehensive pump selection tools.

Pipe size selection

In solids-bearing fluids, the velocity of the fluid in the force main affects both the amount of sedimentation and the energy consumption (Figure 3). While operating with high velocities in the force main reduces the risk for sediment buildup, it also significantly increases energy usage. If the overall efficiency is constant, the energy consumed will increase by the square of the change in velocity.

In contrast, operating with low fluid velocities in the force main reduces energy consumption but increases the risk of sedimentation. Another risk is that if water travels slowly through the pipe it may result in the formation of a slime layer, leading to hydrogen sulfide (H_2S) problems. Pipe sizing is therefore important to consider when selecting suction, discharge and force main pipe sizes.

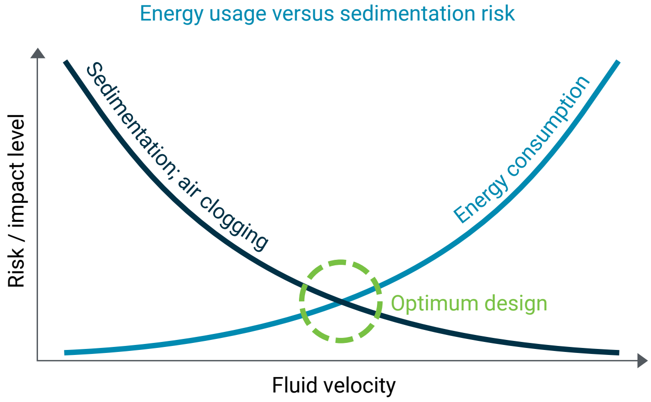


Figure 3: Relationship between fluid velocity, energy consumption, and sedimentation risk in force mains.

With variable-speed pumping, it is possible to reduce fluid velocity below the normally recommended 0.7 m/s (2.5 fps) for extended periods of time and flush the discharge line by increasing the fluid velocity during short periods of time. Depending on the type and concentration of heavy sediments and grease in the media, the sedimentation will differ: the higher the concentration of silt and sand, the higher the risk for sedimentation. The frequency of flushing depends on the system design, the degree and type of contaminants being pumped, and the minimum velocity required to maintain optimal operating conditions.

An alternative solution is to split the force main in two: One with a smaller diameter for low flow conditions and one with larger diameter for large flow conditions. This way, the optimal velocity is maintained at different flow rates while redundancy is also achieved.

Overall pump efficiency

The hydraulics, motor and drive all affect the overall efficiency of a pump, and thus the pump's power consumption and associated energy costs.

Overall efficiency – Hydraulics

The efficiency of a pump varies widely depending on the type of impeller. The efficiency specified by the manufacturer relates to clean-water performance. However, pump efficiency for some impeller types decreases dramatically in wastewater, often due to partial clogging of the impeller. Figure 4 shows the results from hydraulic comparison tests conducted in a laboratory environment with simulated wastewater.

Regardless of the impeller design, it is important to maintain the original efficiency. Wear and clogging are key factors that can reduce hydraulic efficiency.

When wastewater solids, such as stringy, fibrous material, enter the inlet of a conventional wastewater pump, they may get caught on the leading edges of the impeller and elsewhere in the pump. This buildup, referred to as a partial clog, often results in decreased flow, reduced efficiency, and increased energy use (Figure 5a).

If solids continue to build up in the pump, a complete clog may occur and the pump will stop – a situation that can result in costly unplanned service calls. If a conventional wastewater pump runs intermittently, the buildup is likely to be removed by the back-flushing. Back-flushing occurs when the pump shuts off at the end of an operating cycle. When the next cycle begins, the efficiency often has returned to its initial value since the pump is now free of buildup (Figure 5b).

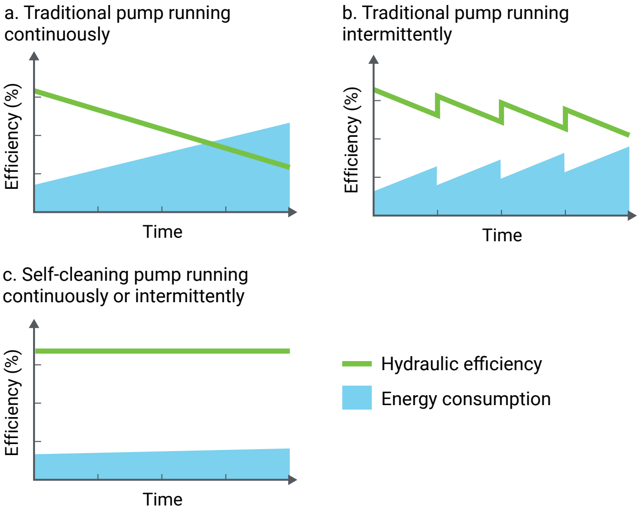


Figure 5a, b, and c: Energy efficiency is kept at a sustained high level when a self-cleaning impeller is used.

When using a variable-speed drive, the pump has longer operating cycles. This results in more potential buildup of stringy solids. Variable-speed drives with application-specific wastewater pump software can detect pump clogging and initiate a pump cleaning cycle that prevents the pump from clogging.

Sustained high efficiency can also be achieved by selecting a pump with self-cleaning hydraulics, such as an impeller with N-technology (Figure 5c). The reduction of unplanned service calls to an absolute minimum can be achieved by combining an impeller with self-cleaning hydraulics and a variable-speed drive that has clog detection and pump cleaning functions.

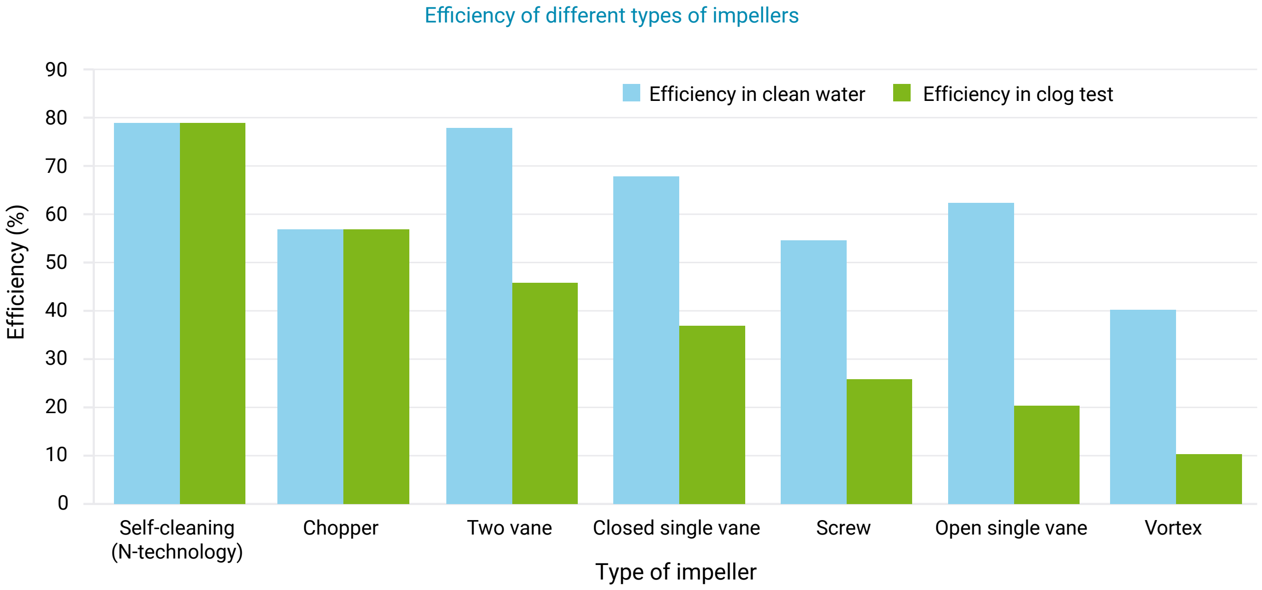


Figure 4: Laboratory-tested efficiency comparison of common wastewater pump impellers under clean water and clogging conditions.

Overall efficiency – Motors
Line-operated AC motors are classified based on their efficiency in accordance with the international standard IEC 60034-30-1. The IEC classification system currently includes designations ranging from IE1 to IE4, with IE4 representing the highest motor efficiency. As motor ratings increase, the minimum efficiency requirement also increases but the differences between efficiency classes decrease.

Figure 6 shows the differences in minimum efficiency between the IE levels according to current standards. The bigger the motor, the smaller the savings will be from a percentage point of view.

To determine whether an investment in a higher efficiency class motor is profitable or not, it is recommended to use an LCC analysis. The cost associated with selecting a higher efficiency class can have a relatively high impact on total costs. That is why the number of hours a motor is operated annually is a critical parameter and should be included in the analysis. Normal running time for a wastewater pumping station is approximately 1,500 hours per year.

Note: Submersible motors are currently excluded from the scope of IEC efficiency classes for line-operated AC motors, and the motor test standard (IEC 60034-2-1) does not provide a test method defining how to manage extra losses or deviation in test temperatures inherent to submersible motors. That means that submersible motor manufacturers may have different testing methods for motor efficiency, making claims difficult to verify and compare.

Overall efficiency – Drives
The specific energy for a given system varies with the pump speed. From an energy-savings perspective, the optimal speed is when the pump runs at the frequency corresponding to the minimum specific energy. The duty point will follow the system curve when the frequency is reduced. Figure 7 shows three different system curves – S1, S2 and S3.

Pump System S1: This system curve represents a lift system (the static head is larger than the friction losses). The energy-saving potential of variable-speed operation in lift systems, with the duty point to the left of best efficiency point, is small because the pump efficiency decreases faster than the total head decreases when the pump speed is reduced.

Pump System S2: This system has a better energy-saving potential than S1 because the total head decreases faster than the efficiency does when the pump speed is reduced. It is shown by applying the specific energy formula on System Curve S2.

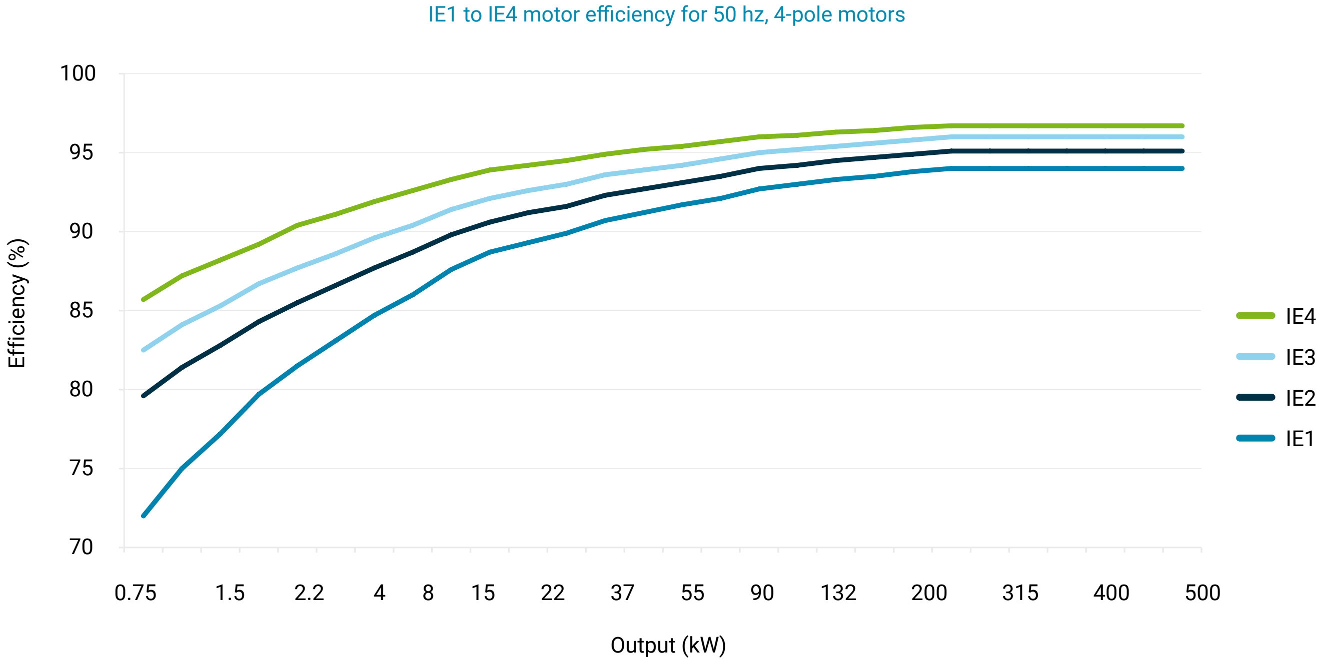


Figure 6: Efficiency for IE1to IE4 classifications for different size 50 hz, 4-pole motors.

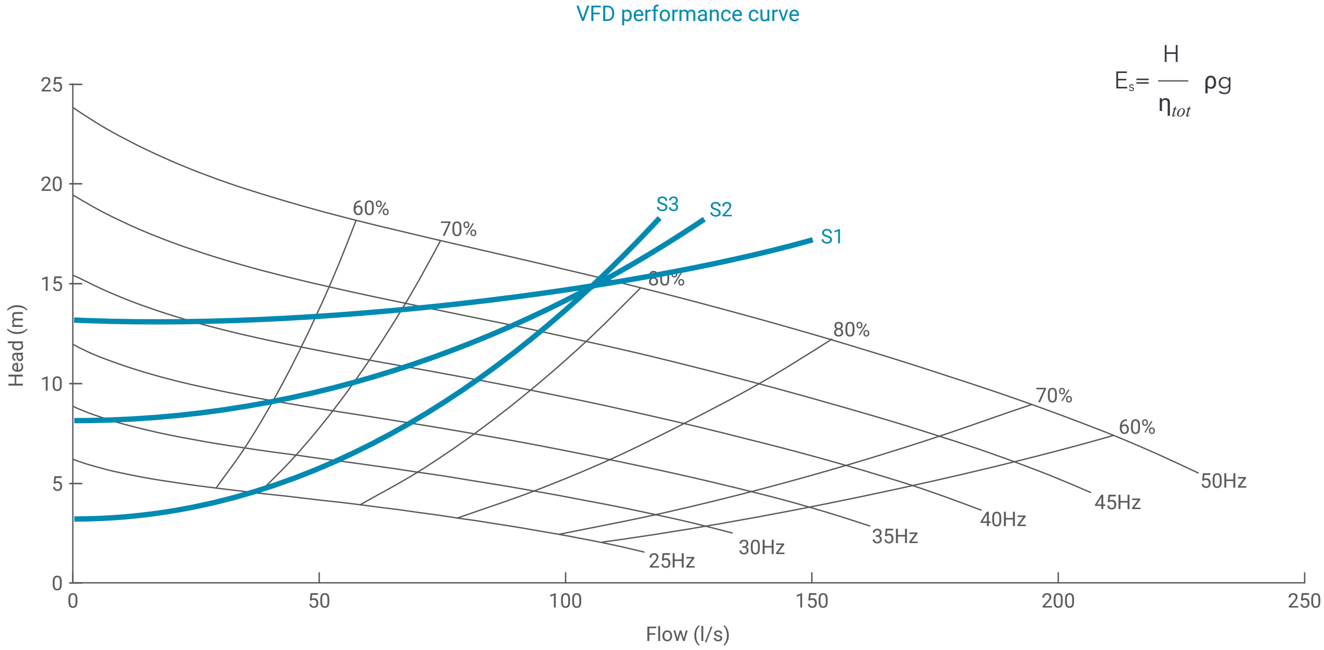


Figure 7: System curves for three different pump systems – S1, S2 and S3.

Pump System S3: This is primarily a circulation system (little or no static head). Here the potential for energy savings is the greatest because the pump efficiency is almost constant, while the total head decreases as the pump speed is reduced.

Figure 8 shows the specific energy for the three different system curves. Clearly, Pump System S3 has the highest potential for energy savings by using a variable frequency drive (VFD), with the optimal frequency for running a single pump being 23 Hz. That is the frequency where the lowest amount of energy will be used to transport the liquid in System S3.

Finding the “energy-optimal” frequency when operating a pump at variable speed presents challenges. One method for identifying the optimal speed is through the use of algorithms. Some intelligent pump controls have algorithms that provide automatic optimization of speed to minimize energy usage. They use an iterative process to determine the optimal speed and adapt for system changes such as varying inflow, varying head or reduced pump performance. Conducting a theoretical study of the pump system is another method for identifying the optimal frequency. However, there are drawbacks to this approach, including the possibility that changes to the system can occur at any given time.

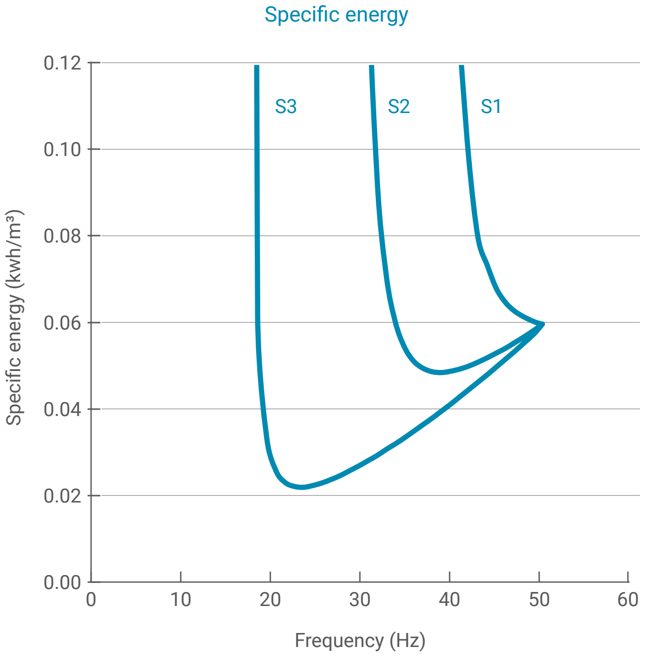


Figure 8: Specific energy curves for different system types (S1, S2, S3) highlighting the greatest potential for energy savings under variable frequency operation.

Of note, the drive will consume energy, resulting in an approximately 3 to 4% efficiency reduction. The energy savings achieved by running at optimal frequency must therefore exceed this – otherwise there will be no savings achieved using a drive with a variable-speed function.

Potential in investment to decrease energy usage

A typical distribution of energy usage in a sewage lift station is shown in Figure 9. This distribution also shows the potential savings that can be achieved when considering an investment to decrease energy usage.

A major difference between individual pump stations is the distribution between the energy needed to overcome the static head (actual lifting work done by the pump) and dynamic head (the friction losses in the system and force main). For pump systems with long force mains, the losses in the pipe will be the major part, but for pure lift stations (for example in most propeller pump applications) the static head is the major part of the total head.

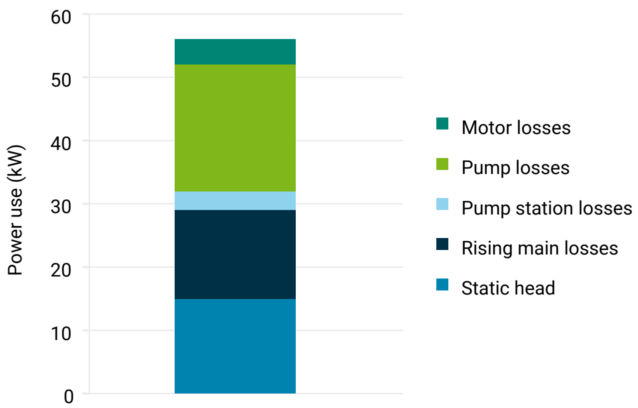


Figure 9: Distribution of power usage for a typical wastewater pumping system.

When investing in a drive with an energy-minimizing function, the energy consumption can be reduced by 20 to 50% or more in systems with long force mains. This can have a major impact on the total energy usage. In contrast, investments in a motor with higher efficiency will not save nearly as much.

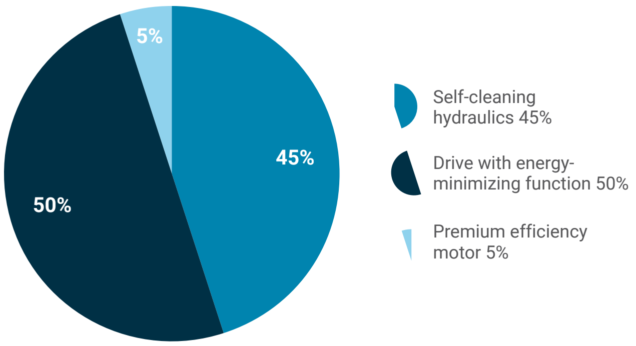


Figure 10: Distribution between the potential energy savings enabled by smart investments in the right drives, motors and hydraulics.

Drives, motors and hydraulics are the three key investments that can lead to a decrease in energy consumption over time (Figure 10). A typical distribution of the potential savings is 50% due to the use of a drive with an energy-minimizing function, 5% due to the use of a premium efficiency motor and 45% due to the use of a self-cleaning impeller.

Upgrading to a premium efficiency motor in wastewater lift systems will lower the total energy usage only to a limited degree, but it may be specified in the requirements due to carbon restrictions, tax benefits or legal requirements.

An LCC analysis is an excellent tool for calculating the payback time and thus an excellent guide when selecting the appropriate investment.

Energy cost over time

The cost of energy is increasing in most parts of the world and is expected to continue to rise. A study titled World Energy Outlook 2014 (WEO-2014), published by the International Energy Agency (IEA), shows the estimated energy cost for different regions by 2040 (Figure 11). This estimated increase in energy cost can be included in most LCC calculation tools.

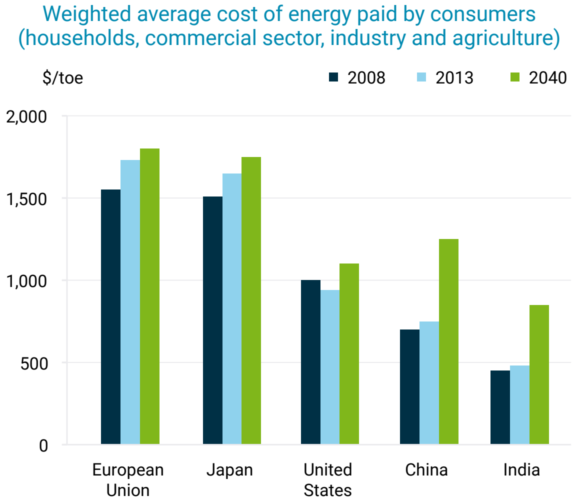


Figure 11: Economies face higher costs, but the pace of change varies: China is overtaking the US, costs will double in India and remain high in the European Union and Japan.

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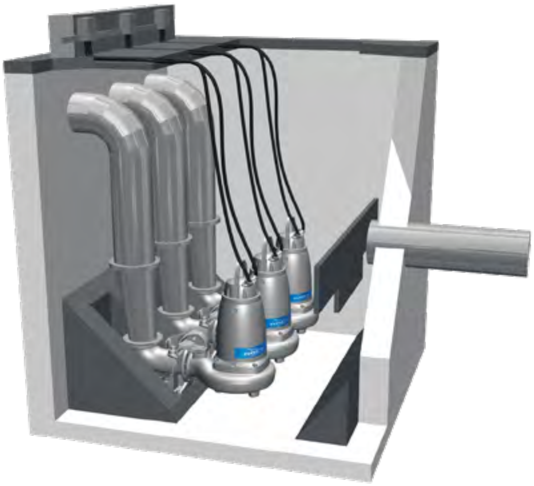
In areas where the cost of energy is very low, or for pump stations with very limited annual operational time, the cost of energy is sometimes excluded from the LCC calculation. Some countries have legal requirements to decrease energy usage. In such cases, an LCC analysis can be extremely useful in determining the optimal solution with the lowest energy usage.

Example 1: How to decrease energy consumption in a pumping system

Type of station: Raw water intake station
Media: Clean water
Running time: 5,000 hours/year (per pump)
Expected lifetime: 25 years
Pumps: Three NP 3301 LT 55 kW (one is standby)
System A: Constant speed pumps
System B: Pumps equipped with a VFD with energy-minimizing function

In this example, an LCC analysis is used to determine whether investing in a drive with energy-minimizing functions makes financial sense. In the calculation, only the affected factors are taken into account. Costs associated with installation, decommissioning and downtime are assumed to be equal.

The drive with the energy-minimizing function will automatically find the frequency with the lowest specific energy – meaning that the energy used to transport the media will be as low as possible. For this system the frequency will be 32 Hz, as shown in Figure 12. An overview of the system curve, pump curve and duty point is provided in Figure 13.



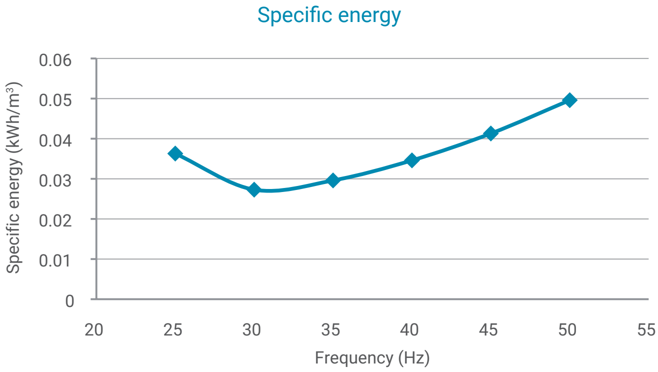


Figure 12: Specific energy is lowest at 32Hz.

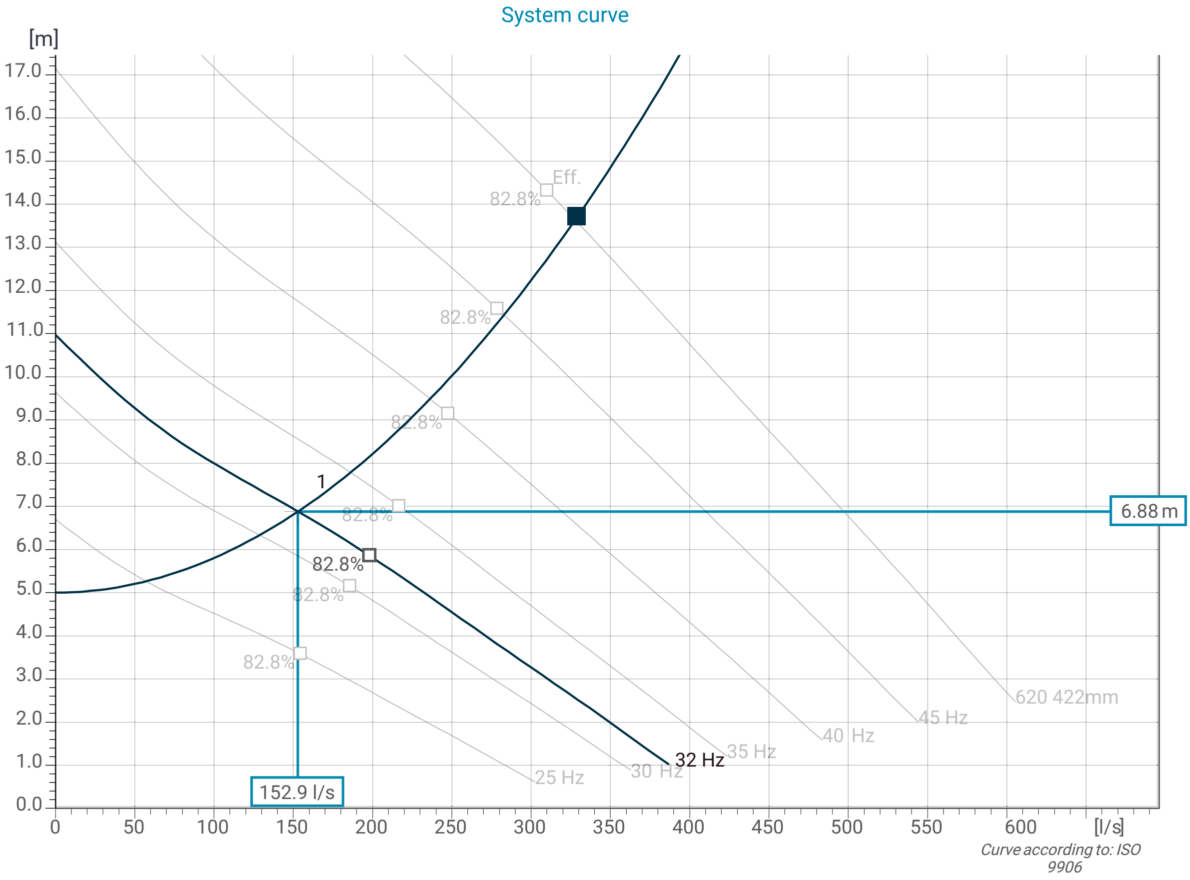


Figure 13: Overview of system curve, pump curve and duty point.

As shown in Figure 14, the total cost of the pumping system – including the initial investment cost, energy consumption, maintenance, environmental costs and operational costs – is $1,620,000 for System A and $1,215,000 for System B. Although the initial purchase price for System B is more expensive, the lower energy consumption reduces the payback time for that investment to approximately a year and a half (Figure 15).

An LCC analysis provides a clear view of energy consumption and thus, indirectly, CO_2 emissions. With many countries enacting legislation to decrease emissions, there is increasing pressure on municipalities and governments to show greater leadership in reducing global warming.

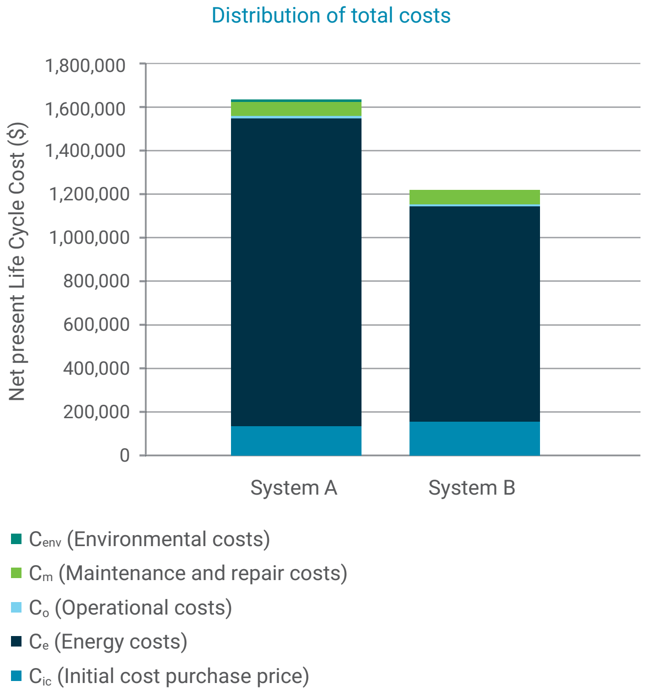


Figure 14: System B delivers a lower total cost over the lifetime of the pump system due to a reduction in energy costs.

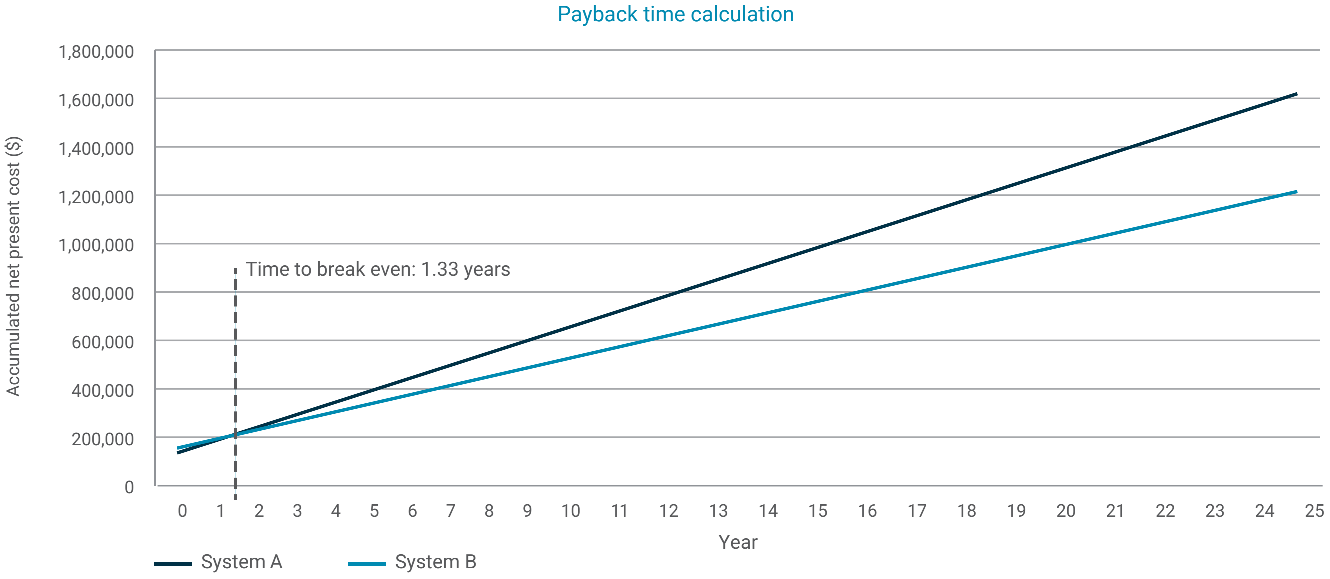


Figure 15: The payback time for System B is approximately a year and a half.

Maintenance

The maintenance of a pumping station, which typically accounts for about a quarter of life-cycle costs, can be divided into two parts: planned maintenance and unplanned maintenance.

Planned maintenance

Planned maintenance is the maintenance that the operator has planned to perform. It should be based on the recommendations provided by the equipment manufacturer.

The time between major overhauls differs from manufacturer to manufacturer and will impact the LCC results. The cost of spare parts, labor and transportation also needs to be included.

Recommendations on major overhaul intervals can often be found in the Installation, Operation and Maintenance (IOM) guide from the manufacturer.

Unplanned maintenance

Unplanned maintenance is more difficult to estimate. If the operator has knowledge from earlier experience with the station, or experience from other similar pump stations, that information can be used to estimate the costs for unplanned maintenance.

In addition to the service call-out itself, the cost of unplanned maintenance can extend to downtime costs while awaiting service and, in a worst case scenario, capital expenses for a spare pump.

Clogging is a common reason for unplanned maintenance. The number of times a pump clogs in a pump station can vary widely, with the most common factors being as follows:

- Type of pump hydraulics
- Type of pumped media
- How far the pump is running from its best efficiency point
- Length of pump cycles
- Size of pump
- Motor torque
- Performance of routine maintenance

Estimation of the number of clogging instances

Xylem's pump hydraulic experts, engineers, laboratory staff and field service personnel have undertaken work to estimate the probability of pump clogging in wastewater pumping applications. Physical tests in full scale, as well as field measurements and wastewater application experience, have provided valuable input to the results presented below.

To estimate the number of instances of pump clogging in a year of operation, first find the clogging coefficient from Table 16. The clogging coefficient is dependent on the type of pump hydraulics and the type of pumped media (clean water, fine screened sewage or unscreened sewage). The clogging sensitivity also depends on the pump size. Values are given for three ranges of pump sizes: 1.5 to 7.4 kW, 7.5 to 22 kW and 22.1 to 105 kW.

Note: The numbers shown in the table can vary depending on the type of pumped media. Local circumstances should be taken into consideration and the values can be adjusted accordingly.

Clogging coefficient by impeller and media type

	Clean water			Fine screened sewage*			Unscreened raw sewage		
Power (kW)	1.5 – 7.4	7.5 – 22	22.1 – 105	1.5 – 7.4	7.5 – 22	22.1 – 105	1.5 – 7.4	7.5 – 22	22.1 – 105
Open single vane		0		0.375	0.375	0.25	0.75	0.75	0.5
Closed single vane				0.375	0.375	0.25	0.75	0.75	0.5
Closed two vane				0.5	0.5	0.375	1	1	0.75
Screw				0.375	0.375	0.25	0.75	0.75	0.5
Vortex				0.25	0.25	0.125	0.5	0.5	0.25
N-technology				0.125	0.125	0	0.25	0.25	0

*The clogging coefficient for fine screened sewage is half that of the unscreened raw sewage.

Table 16: Clogging coefficient for impellers in different types of media with on/off pump control. The coefficient for a closed two vane impeller in unscreened raw sewage is set to one as a baseline.

Since the number of running hours is correlated to the number of clogging instances, this is also factored into the calculation for number of clogs per year. The total equation is a percentage of the time the pump is running multiplied by the clogging coefficient from Table 16, multiplied by a factor of 10, as shown in this formula:

$$\text{Cloggings per year} = \frac{\text{Running hours}}{8760} \text{ x Clogging coefficient x } 10$$

The estimation for the factor is based on the assumption that the pump is running at its best efficiency point. If a conventional pump is operating away from BEP, the likelihood of clogging will increase.

If the pump is equipped with a self-cleaning impeller and a drive using a cleaning cycle, the likelihood of clogging will be close to zero.

Examples of LCC distribution for different stations

The bar charts to the right show examples of a how life cycle costs are distributed for different pump sizes.

Figure 17 shows the cost distribution for a pump station with zero call-outs due to clogged pumps. Clearly, energy cost is the dominant cost here, regardless of motor size. The energy cost percentage increases only marginally with a larger motor size.

Figure 18 shows what happens when two unplanned call-outs due to pump clogging are added to the same calculation. The cost for these call-outs equals or exceeds the cost of the pumps. This is a fairly common situation for a typical smaller wastewater pump station.

Lastly, in Figure 19 is the cost distribution for a troublesome pump station with 10 call-outs per year. In this situation, the unplanned maintenance costs will far exceed the other costs for stations using smaller pumps. For large pumps, the energy cost is still the main consideration.

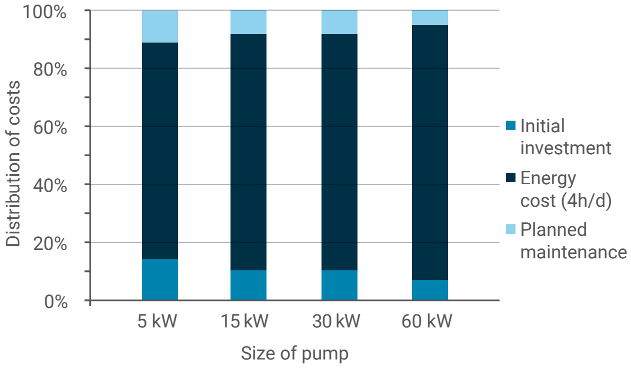


Figure 17: Cost distribution for a pumping station without any call-outs.

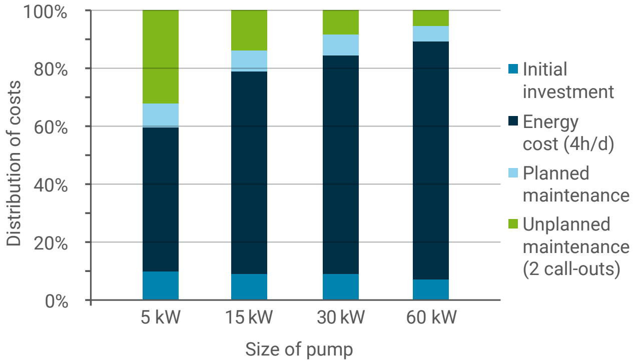


Figure 18: Cost distribution for a pumping station with two call-outs.

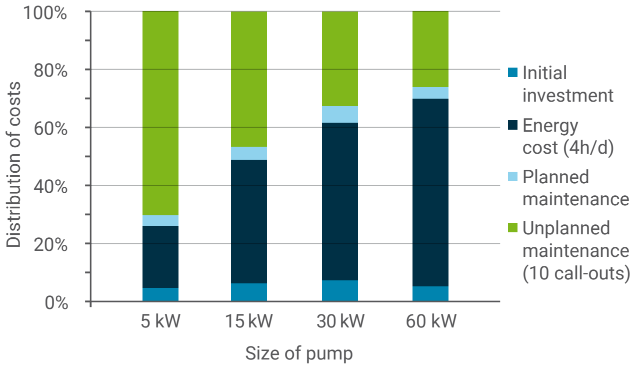


Figure 19 : Cost distribution for a pumping station with 10 call-outs.

Maintenance contracts

For applications where process interruptions are particularly detrimental to the operation, a maintenance contract ensuring regular scheduled maintenance is a way to improve pump station reliability. Maintenance contracts typically include one to four planned inspection visits per year. These visits help to prevent unplanned downtime and costly emergency repairs that can occur if preventive maintenance is not done. By contracting the service out, operations personnel are able to utilize their time elsewhere. Maintenance contracts can also include prioritized service benefits, leading to less downtime.

As a complement to maintenance contracts, supervision monitoring services may be available. Such systems can provide notifications when corrective actions are needed, before a pump is out of service. Warnings and alarms can be forwarded to on-call service staff and additional data logging functions can help troubleshoot the pump at a distance to prevent further unplanned outages. Systems can be set up to give early warnings to minimize downtime and enable staff to act quickly before serious problems occur.

Example 2: How to decrease unplanned maintenance in a pumping system

Type of station: Wastewater pumping station
Media: Unscreened raw sewage
Running time: 1,500 hours/year
Expected lifetime: 15 years
Call-outs per year with existing system: 26
System A: Existing system; two 30 kW pumps with closed two-channel impellers (one is standby)
System B: Upgrade; two NP 3202 30 kW pumps with N-technology impellers (one is standby)

In this example, a medium-sized pumping station is experiencing problems with pump clogging, leading to unplanned service calls. The station has two 30 kW pumps and clogs every second week on average. An LCC analysis is made to evaluate whether a retrofit using two new pumps with N-technology to replace the existing pumps with closed two-channel impellers will be a good investment. Installing two pumps with N-technology will decrease the number of clogging instances to zero.

The cost for unplanned maintenance often adds up, with labor cost, spare parts and travel cost included. In this example, the cost per man hour is $100/h while every maintenance call-out takes two hours. No spare parts are needed in this case.

Since this example is for a retrofit, it means the only relevant factors for the LCC analysis are the initial cost of the pump, installation and commissioning costs, energy costs, operational costs and maintenance costs. The LCC analysis (Figure 20) shows that System A has a cost of $146,000 over a 15-year period, while System B costs $93,000 – a difference of $53,000.

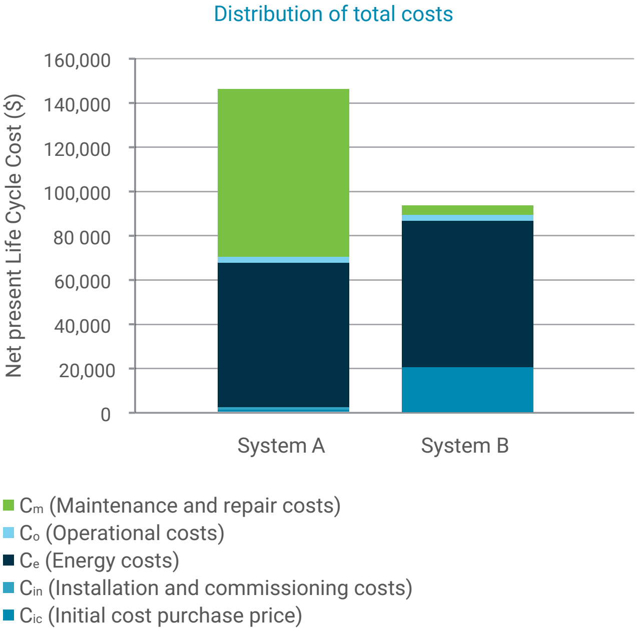


Figure 20: System B achieves a lower total life cycle cost by reducing unplanned maintenance with pumps featuring self-cleaning N-technology.

The up-front cost for the new pumps with N-technology has a payback time of less than 4 years (Figure 21), as the initial investment in the new pump significantly decreases maintenance costs due to fewer call-outs. It also prolongs the lifetime of the system.

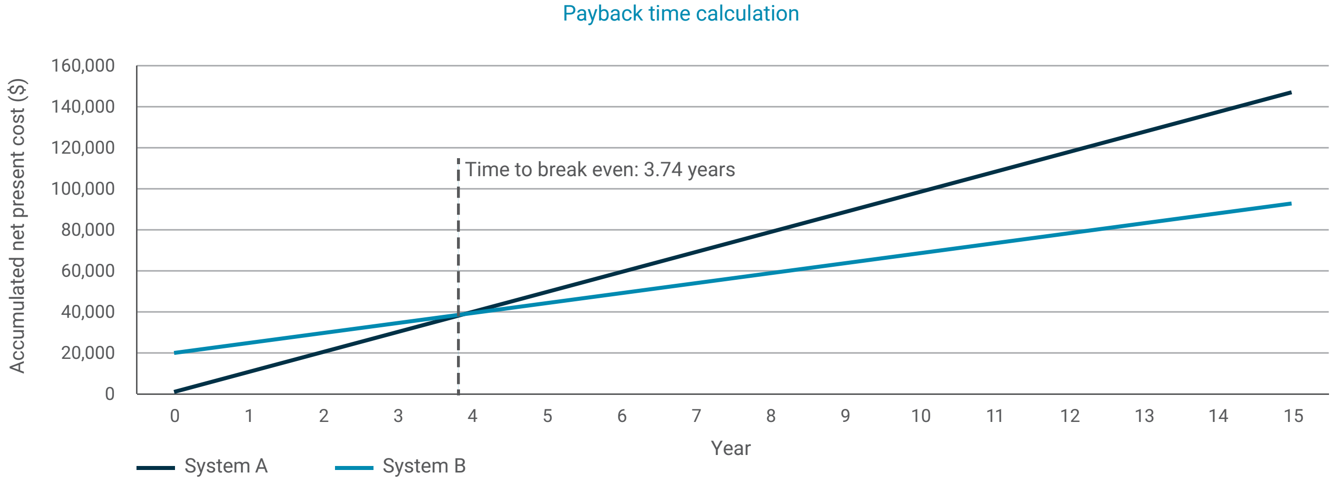


Figure 21: The payback time for System B is less than 4 years.

Conclusion

When faced with an investment decision for wastewater pumping systems, the use of a life cycle cost (LCC) calculation is a valuable tool for evaluating all costs, including important energy and maintenance costs. The recommended formula allows for variations in specific system requirements or geographic differences, which can and should be factored into the total cost calculation.

The LCC analysis gives municipalities, consultants and others a relevant overview of all the key factors required for making the best decision to lower the cost over the total lifetime of a pump system. It also avoids the all-too-common fixation on up-front investment costs (often less than 10% of the total costs).

In conclusion, when evaluating investments aimed at lowering the total life cycle costs, use an LCC analysis to calculate the payback time and select the preferred option. It is also recommended that an LCC analysis is included in the pump system specifications to ensure that the station with the lowest life cycle cost is selected.

Best practices for limiting life cycle cost surprises

- Perform an LCC analysis including energy, maintenance, and environmental costs
- Optimize station design to avoid overdimensioning and sedimentation
- Select solids-handling pumps tested for sustained efficiency
- Invest in monitoring systems to enable preventive maintenance and early clog detection
- Factor in environmental compliance and future energy cost escalation in decision-making

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