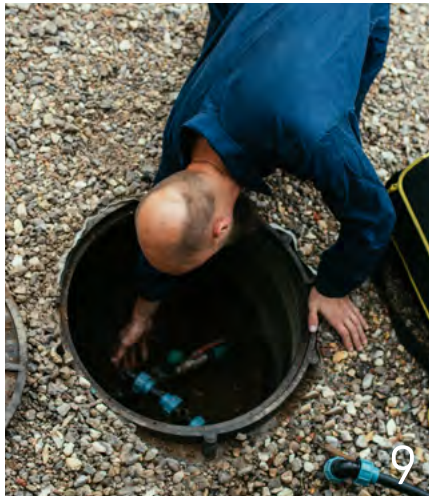
Urban Insight
By Sweco

Old pipes, new pressures

Transforming Europe's water infrastructure

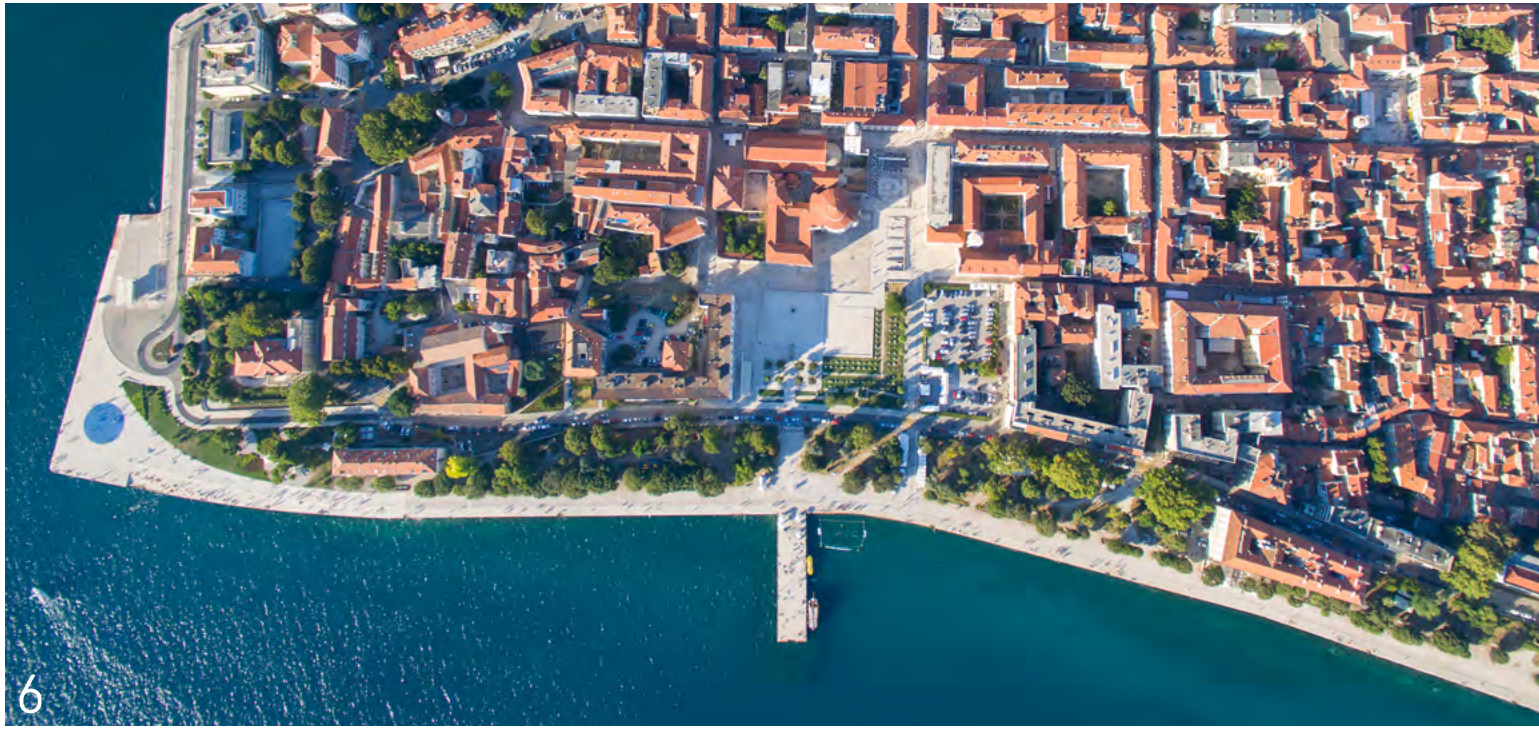
SWECO

Leakage reduction is one of the most cost-effective ways to strengthen resilience. Modern asset management uses digital tools to support whole life-cycle decisions, adaptive planning and sustainable service delivery.



If current renewal rates remain unchanged, many networks will continue to age faster than they are replaced.

There is a need for a different investment logic. How do we spend the money more wisely, delivering better value?



European water operators now see infrastructure renewal as their biggest challenge, and the real issue is not just how much is spent, but whether the right investments are made at the right time.

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Executive summary: Investing for resilience

Europe's water infrastructure is deteriorating faster than it is being renewed. At the same time, climate change, stricter regulation and rising expectations are placing increasing demands on water and wastewater systems. The European Commission estimates the annual investment gap in the EU water sector at around €23 billion. At today's investment rates, renewing Europe's water infrastructure can take centuries.

Sweco's analysis shows the scale of the challenge. Based on current investment rates, the implied time to replace drinking-water networks ranges from around 90 years in Belgium to 1,000 years in Finland. In Poland it rises to 250 years, while in several other European countries it is between 120 and 200 years. This creates a clear opportunity for a smarter investment logic.

This growing renewal gap is weakening the long-term performance of Europe's water infrastructure. Insufficient asset-renewal and prioritising emergency repairs and short-term needs over planned renewal can increase leakage, service disruptions, environmental risks and operating costs.

Europe therefore needs a new investment logic—one that moves beyond reactive replacement towards risk-based renewal and resilience. Investment decisions should reflect not only asset age, but also condition, criticality, performance and system-level risk.

Resilient water systems must also be prepared to withstand, respond to and recover from disruptions such as power outages, cyber incidents, contamination and extreme weather.

Europe cannot simply spend its way out of this challenge. It must invest more strategically:

- From reactive replacement to risk-based renewal
- From individual assets to interconnected systems
- From fixed investment plans to adaptive pathways
- From data collection to digital and AI-supported decision-making.

Introduction

Water and wastewater systems are among the foundations of everyday life. They protect public health, support economic activity, safeguard the environment and enable cities to function. Yet much of Europe's water infrastructure was built for a different era, when climate conditions were more predictable, demand patterns more stable and the need for renewal easier to defer. That context has changed.

Across Europe, recent crises have shown how quickly essential infrastructure can come under pressure. Severe droughts have pushed water resources to critical levels, while intense rainfall and flooding have overwhelmed drainage systems and damaged infrastructure. Energy shocks, cyber incidents and other disruptions have also highlighted how closely water services are connected to the resilience of wider society. What may once have been treated as isolated or temporary events are increasingly exposing vulnerabilities in systems that cities depend on every day.

The result is a growing gap between the performance society expects and what existing infrastructure can reliably deliver.

The question is,therefore, not simply whether Europe needs to invest more in water infrastructure. It does. The more important question is how available investment can deliver greater resilience, better service and long-term public value. Achieving this requires a more strategic approach to infrastructure investment.

20%

of Europe's land and

30%

of its population are affected by water stress every year.[1]

> The challenge facing Europe's water sector is not simply the scale of investment required, but how to make every investment count. The decisions we make today must create systems that are resilient, adaptable and able to deliver value over the long term.

Monica Welander, Chief Sustainability Officer, Sweco Group

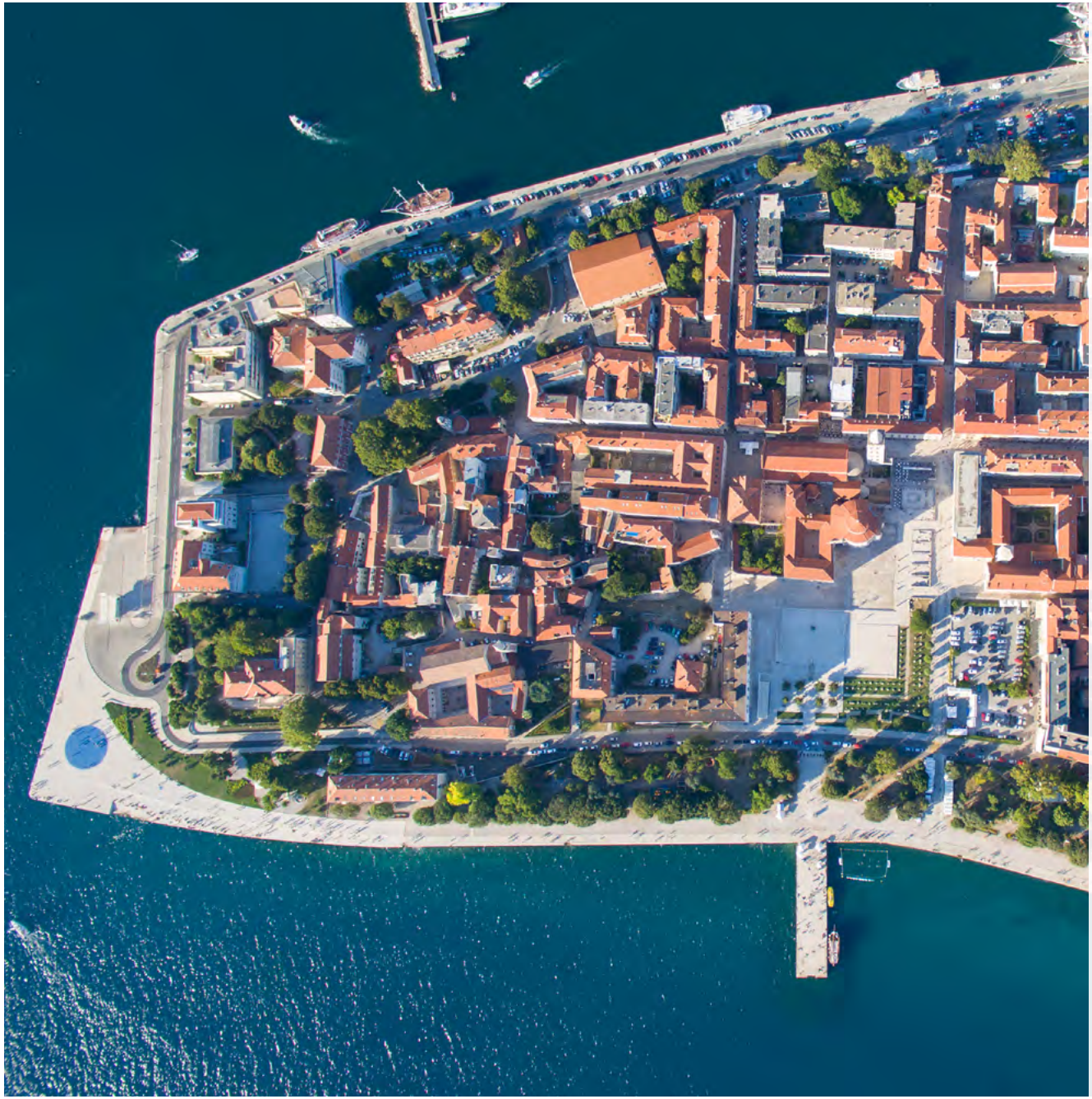
Image by Svenskt vatten

> Tomorrow's infrastructure decisions should be risk-based, lifecycle-driven and data-informed, with funding directed to the assets that deliver the greatest long-term resilience and value.

Pär Dalhielm, President, EurEau

This raises fundamental questions. Should renewal be driven by the age of individual assets or by the consequences of system failure? How can utilities avoid locking themselves into costly solutions designed for a future that might not materialise? And how can data, digitalisation and AI help decision-makers invest in the right place, at the right time, while protecting increasingly connected systems from cyber threats?

This report examines the scale of Europe's water infrastructure challenge and the changing conditions reshaping investment decisions. It shows why maintaining yesterday's systems is no longer enough. The aim is to support municipalities, utilities and policymakers in making investment choices that protect essential services today, while creating water systems that are robust, flexible and fit for the decades ahead.



Europe's ageing water and wastewater assets

Much of the continent's water and wastewater network was built decades ago, during periods of rapid urbanisation and under assumptions that no longer match current operational, climatic and regulatory realities.

High investment gap, persistent renewal pressure

Water service providers invest around €52.5 billion annually in drinking water and wastewater infrastructure in Europe. [2] Yet investment growth has not kept pace with the increasing demand, deterioriation of the sources as well as the inflation, and European water operators now identify infrastructure renewal as their biggest challenge.

€23 billion is the estimated annual investment gap identified by the European Commission needed to strengthen water resilience in Europe and implement existing EU water legislation. These investment needs are linked to the renewal of infrastructure, stricter requirements for drinking water and wastewater treatment, improved water quality and climate adaptation.[3]

Figure 1 compares average annual investment in drinking water and wastewater works per capita across selected European countries using a common EurEau dataset. Investment intensity ranges from around €37 per capita in Latvia to €335 in Norway, compared with an European average of €82. Investment figures are expressed in nominal euros and are not adjusted for differences in national construction costs.

The comparison nevertheless highlights an important point: high expenditure alone does not demonstrate that infrastructure is being renewed at a sustainable rate. Understanding the renewal challenge requires looking beyond total capital expenditure to the physical rate at which networks are being replaced — the focus of the following section.

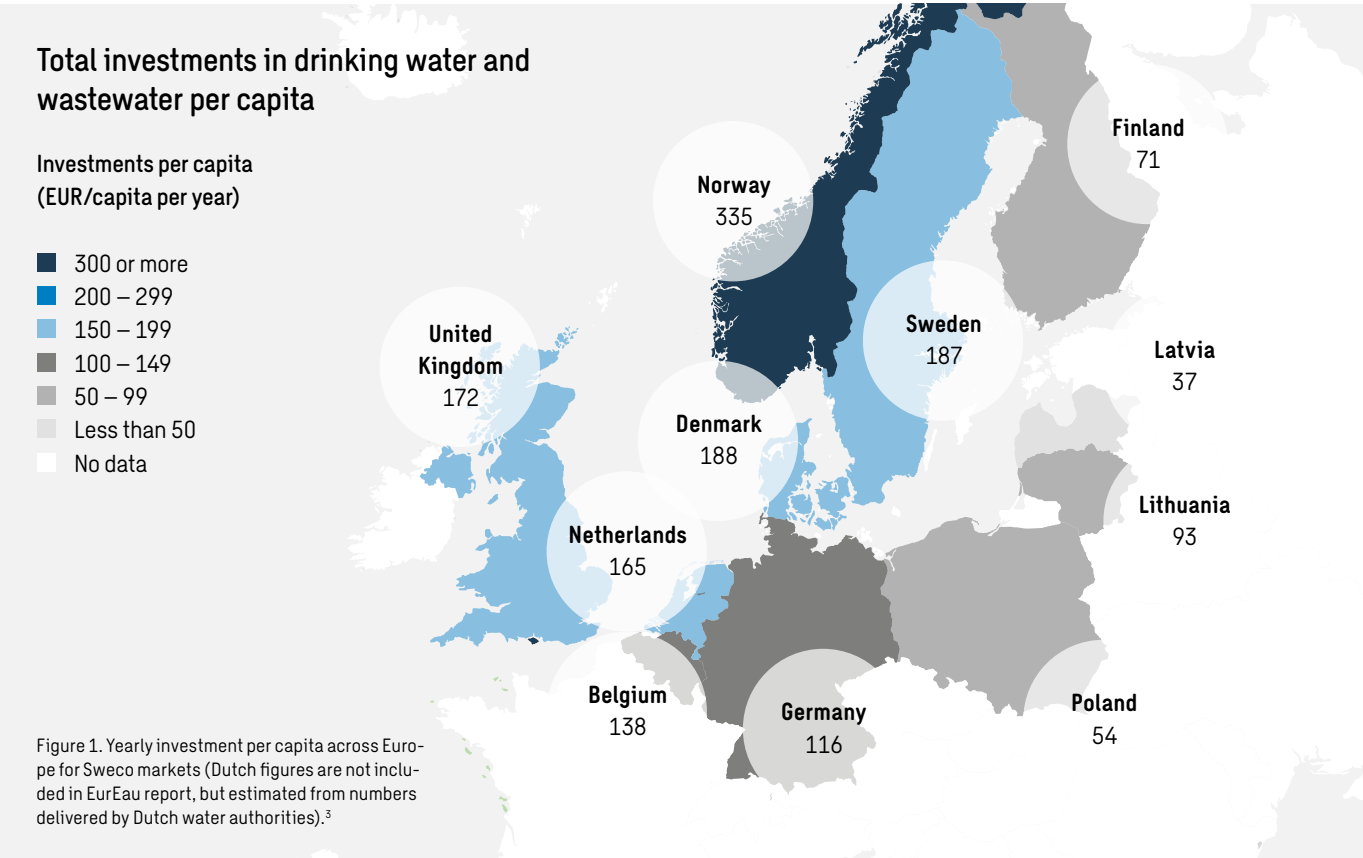


Figure 1. Yearly investment per capita across Europe for Sweco markets (Dutch figures are not included in EurEau report, but estimated from numbers delivered by Dutch water authorities).[3]

€23 billion

is the estimated annual investment gap identified by the European Commission to strengthen water resilience in Europe and implement existing EU water legislation.[3]

> Postponing investment does not reduce the cost — it simply pushes the bill into the future, where it becomes larger and harder to handle.
>
> Mattias Salomonsson, Research and development manager, water and wastewater, Sweco

The century-scale problem: addressing Europe's water network renewal cycle

The effects of underinvestment are especially visible in the water distribution network. In many countries, renewal rates remain far below what is needed to maintain the condition of assets over time. Using EurEau (2026) data on annual investment in drinking water networks and reported network length, Sweco analysed the implied replacement rate by calculating how many years it would take to renew the entire network at the current pace of investment. The results in Figure 2 show that, in several countries, the time required to replace the full network stretches far beyond conventional design lifetimes.

When planning for asset deterioration, a technical lifespan of when planning for asset deterioration, a technical lifespan of approximately 100 years is often required for ductile iron water mains, with refurbishment, such as relining, potentially extending service life by 30 to 50 years. Yet the replacement rates implied by current investment levels in many countries suggest that full network renewal would take far longer — in some cases centuries. This points to a structural mismatch between asset deterioration and the pace of reinvestment.

This mismatch is becoming more of a challenge. Wetter winters, hotter summers and more frequent extreme weather events affect soil moisture, groundwater levels and ground movement, all of which increase the likelihood of burst pipes, joint failures and other network damage. In drinking water systems, such failures increase leakage, levels of non-revenue water and cause service disruption. In wastewater networks, ageing assets and underinvestment contribute to infiltration, exfiltration, blockages, flooding and wastewater spills, with consequences for both system performance and environmental protection.

In other words, ageing is not only a matter of asset age. It is the result of long-term decisions about maintenance, investment, operating conditions and risk tolerance. Where renewal is delayed, deterioration accelerates and resilience gradually gives way to fragility.

Insufficient spending on asset renewal is already undermining the long-term performance of Europe's water and wastewater infrastructure. When investment is consistently directed toward emergency repairs, compliance pressures and short-term operational needs, ageing assets are allowed to deteriorate faster than they are replaced. The result is a widening renewal gap that increases leakage, infiltration, service disruptions and environmental risks, while ultimately making the system more expensive and less resilient to operate over time.

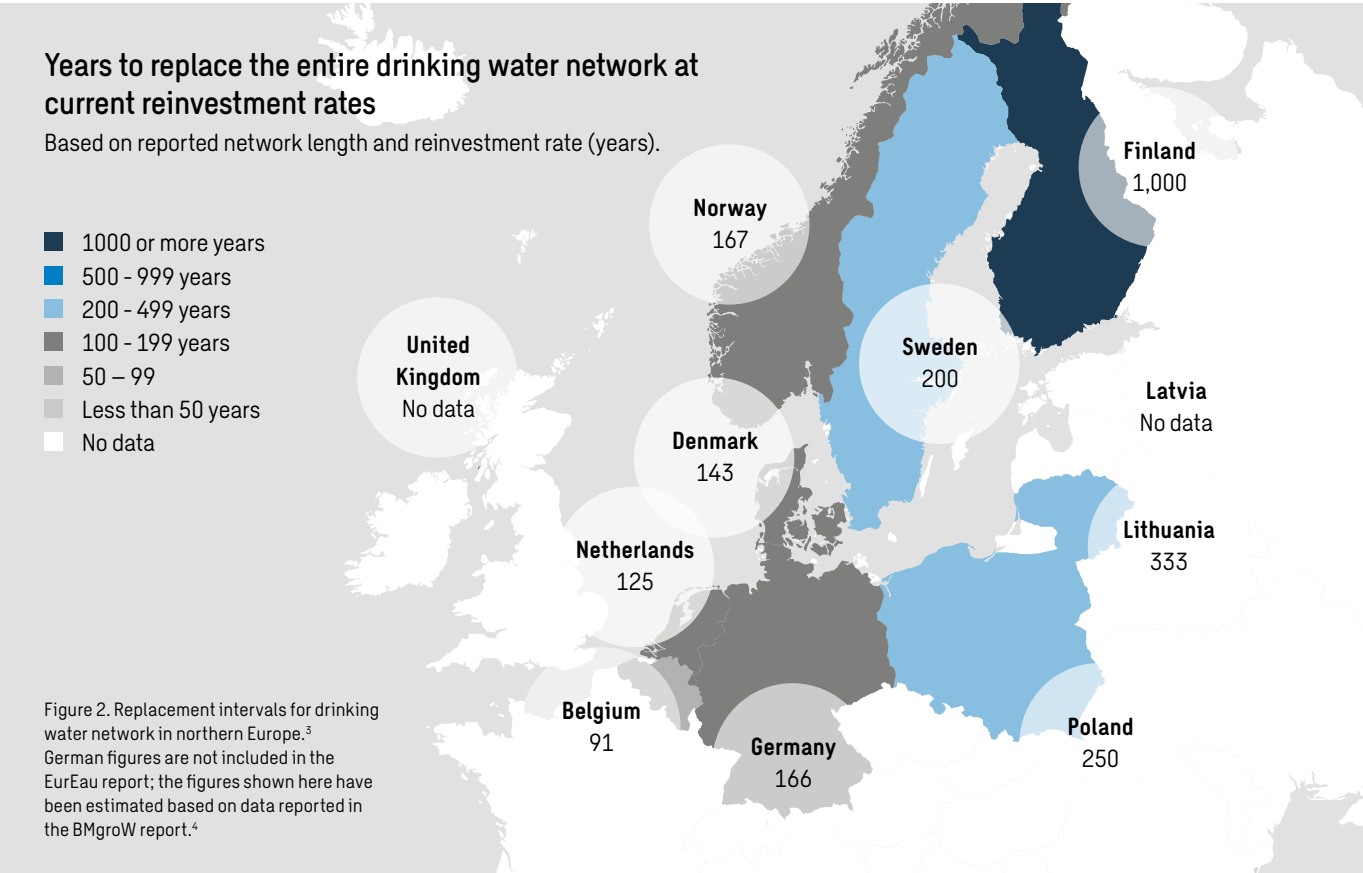


Figure 2. Replacement intervals for drinking water network in northern Europe.[3] German figures are not included in the EurEau report; the figures shown here have been estimated based on data reported in the BMgroW report.[4]

EU Water Directives

EU water directives shape Europe's water and wastewater infrastructure by raising requirements for treatment, leakage reduction, monitoring and risk-based asset management. Increasing attention to PFAS and other micropollutants is adding further technical and financial demands. Recent initiatives, including the EU Water Resilience Strategy and the European Green Deal, also link water infrastructure to climate resilience, energy efficiency and environmental protection.

Europe's water loss highlights underinvestment

Non-revenue water (NRW) is a widely used indicator of the performance of drinking water systems. This data shows the amount of water that is produced but does not generate revenue, revealing how much water is being lost and how efficiently the network is performing. The reasons for water being lost could be leakage, meter inaccuracies, unauthorised consumption, or authorised but unbilled uses.

Underinvestment in pipe networks leads to higher physical losses. Physical losses are expressed in cubic metres per kilometre of network per year. The differences are substantial: some countries experience leakage rates that are several times higher than others, indicating major variations in network condition, pressure management, pipe material, age and maintenance practice. High leakage levels point to lost water, higher operating costs and greater pressure on already scarce resources, making leakage reduction a key priority for improving both efficiency and resilience.

Leakage reduction is one of the most cost-effective ways to strengthen resilience. It is usually cheaper to reduce losses than to keep producing and treating additional water to compensate for them. Seen in this way, leakage is not just a technical oss, it is a signal of hidden system stress.

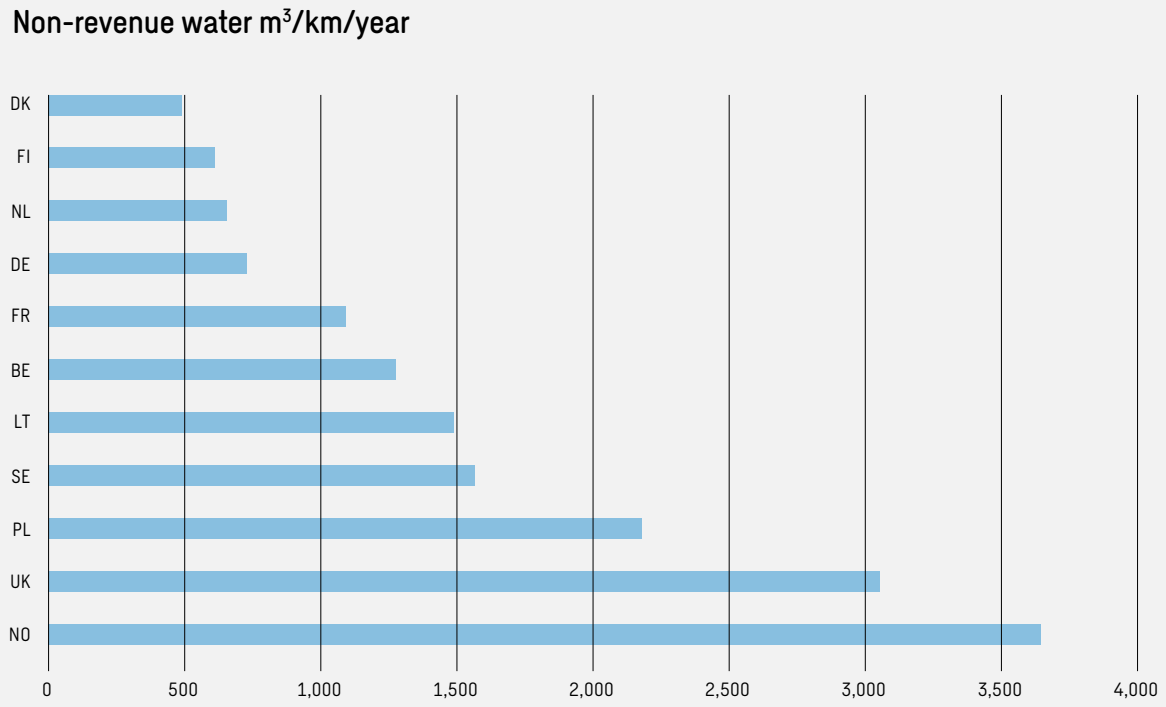


Figure 3. Leakage levels across selected European countries, in m³/km/year.[3]

> We have a choice: identify risks early, anticipate what may happen and prioritise investment accordingly—or wait for failures to dictate where and how money is spent. When investment is insufficient, failures rather than priorities determine where the money goes.
>
> Demet Antakyali, Team leader in environmental business consulting

Too much water: the infiltration challenge

The same logic applies to wastewater infrastructure, where under-investment is often less visible but equally consequential. Ageing networks can suffer from infiltration, structural deterioration and reduced hydraulic capacity, all of which increase the likelihood of flooding, overflows and untreated discharges. In many countries, wastewater spills and urban flooding are becoming more frequent symptoms of an infrastructure base that is no longer aligned with current loading, rainfall intensity, or maintenance requirements.

Infiltration is particularly important because it creates both operational and environmental costs. Excess groundwater entering wastewater systems increases treatment volumes, raises pumping and transport costs and can overload networks and treatment plants during wet periods. Like leakage in drinking water systems, infiltration is not only a sign of deterioration but also a direct driver of inefficiency and environmental risk.

Improving asset management: best practice examples

Renovation of wastewater treatment facilities to secure future treatment capacity: Spijkenisse Wastewater Treatment Plant, the Netherlands

Waterschap Hollandse Delta (Dutch Water Authority) used asset lifecycle management to assess the condition and future requirements of its wastewater treatment assets. The analysis showed that six wastewater treatment plants in the southern part of the region required renovation. Sweco is involved in the renovation of the Spijkenisse Wastewater Treatment Plant (WWTP), providing support in both programme-level project control and the technical design of the upgrade.

The project will replace ageing components and renew critical systems while retaining the parts of the treatment plants that remain in good condition. The design is aligned with expected wastewater flows for 2030 and allows for potential additional inflow from a nearby treatment plant, making the facility more future proof. The project is currently in the realisation phase and will improve reliability, operational continuity and long-term wastewater treatment performance for the Spijkenisse area.

Future concept at the Setterich Wastewater Treatment Plant, Germany

The Setterich Wastewater Treatment Plant is currently operating close to its hydraulic and biological capacity limits, while substantial future population growth is forecasted. Sweco was commissioned to assess short-term measures for increasing treatment capacity and to develop options for the projected influent loads using mathematical process simulation models. In contrast to conventional static approaches, which are typically based on multi-year average data, these models enable dynamic, high-resolution simulation and, therefore, a more accurate representation of the underlying biological processes. They also allow the isolated assessment of individual interventions, such as the addition of storage tanks or pipeline extensions.

Following the evaluation of various short-term measures, it was demonstrated that the installation of additional sensors and the adaptation of the control strategy could significantly improve treatment performance, particularly with regard to ammonia peak handling, while requiring only limited investment. In addition, the model can be readily parameterised with projected influent scenarios, supporting a model-based decision-making process to decide whether it is necessary to expand the WWTP or divert treatment to an alternative facility.

Photo by Dirk Kurz, Sweco

New boundary conditions for water infra-structure

Europe's water infrastructure is facing changing boundary conditions: climate change, urban growth, demographic shifts, stricter regulation and growing pressure on resources. These interconnected factors make future needs harder to predict. This chapter explores why resilience now depends on moving beyond static design assumptions toward more adaptive system planning.

Climate change and system resilience

Infrastructure based on historical data is increasingly misaligned with future realities. Climate change is amplifying existing vulnerabilities in water and wastewater systems, affecting both service delivery and the physical resilience of infrastructure.

Longer and more frequent drought periods reduce the availability of raw water for drinking water production and can place additional stress on source protection and supply reliability. At the same time, higher temperatures and lower river flows affect water quality and reduce dilution of treated wastewater. Intense rainfall and rising sea levels increase the risk of flooding, sewer surcharge and combined sewer overflows, disrupting operations and threatening service continuity.

Climate change is no longer a long-term planning issue. It is reshaping the conditions under which water infrastructure must operate, emphasising the importance of resilience, flexibility and adaptive planning.

To respond to these changing conditions, water utilities and infrastructure owners need a broader set of action perspectives. These might include diversifying water sources, adopting alternative treatment technologies and integrating nature-based solutions such as retention, infiltration and blue-green infrastructure. Such measures can increase flexibility, reduce vulnerability and support a more adaptive and resilient water systems that will cope better with future climate and environmental pressures.

€822 billion

in economic losses were caused by weather- and climate-related extremes in the European Union between 1980 and 2024, including over EUR 208 billion (25%) between 2021 and 2024.[6]

Securing the future drinking water supply in South Holland, the Netherlands

To secure the future drinking water supply in western South Holland, Dunea, a water supply company and Sweco explored new raw water sources and treatment options as the existing dune-based storage and natural purification capacity was no longer considered sufficient to meet growing demand and declining raw water quality.

The study assessed alternatives including brackish groundwater, seawater, additional river abstraction and existing surface water sources. Sweco worked in close collaboration with Dunea's integrated project management team and regional stakeholders. A multidisciplinary Sweco team supported technical development, risk reduction, environmental coordination and design work. The work helped Dunea build a robust basis for decision-making on a future-proof drinking water system and contributed to the selection of a preferred solution combining a new source with membrane filtration. The resulting approach is intended to strengthen resilience, reliability and long-term supply security for 1.4 million people in South Holland.

The project addressed future drinking water security including climate change, salinisation and PFAS. It is a good example of strategic source planning, asset and system modernisation and long-term investment prioritisation.

Flood and erosion protection measures, Norway

Sweco is supporting the Norwegian Water Resources and Energy Directorate (NVE). The projects are aimed at reducing the risks associated with flooding, riverbank erosion, landslides and other water-related ground movements.

Norway has experienced a series of severe weather events in recent years, including Storm Hans in 2023 and Storm Ingunn in 2024, which have highlighted the growing need for resilient infrastructure and strengthened national preparedness to address climate-related risks.

The scope also includes climate adaptation measures designed to protect people, communities, property and critical infrastructure.

€78 billion

a year is estimated to be needed for investment in Europe's water infrastructure, up from around €55 billion today, to address climate change, water scarcity and stricter environmental requirements.[5]

Energy, carbon and resource efficiency

Water systems require substantial energy for pumping, treatment and distribution, and can, therefore, represent a meaningful/substantial proportion of municipal emissions. At the same time, they represent untapped potential for energy recovery, nutrient re-use and circular resource flows.

Water and energy are closely linked, and the way they interact can determine whether carbon footprints rise or fall.

At the same time, wastewater infrastructure can become a resource through measures such as biogas production from sludge digestion, reducing both energy use and emissions.

For engineering design, the nexus has clear practical implications. Measures such as leak reduction can simultaneously decrease water losses, the energy needed for pumping and carbon emissions. Conversely, energy-intensive treatment technologies can increase a treatment plant's carbon footprint unless the electricity supply is low-carbon. As carbon pricing through the EU Emissions Trading System (ETS) increasingly rewards energy efficiency and lower emissions, water infrastructure must be planned with both energy and carbon performance in mind to remain resilient and future-proof.

Renewal of the aeration equipment in wastewater treatment plants, Germany

The Monheim Wastewater Treatment Plant has been treating wastewater from the cities of Monheim am Rhein and Langenfeld, while the Ratingen plant serves the city of Ratingen and parts of Düsseldorf. Both facilities use biological treatment for nitrogen removal. The incoming wastewater is predominantly domestic, with only a minor contribution from industrial sources.

After reaching the end of their economic service life, the aeration systems at both plants require replacement and upgrades. The goal is to improve energy efficiency, modernise the biological treatment stages and bring both plants in line with current technical standards.

Sweco has been commissioned to plan the new aeration systems across all key design and engineering phases. The scope of the work includes:

- replacing the air compressors
- including all associated electrical installations
- adapting pipework and fittings
- installing new aeration elements
- selecting the most effective aeration strategy based on a review of several technical options.

Going forward, aeration at both plants will be demand-driven, supported by modern measurement and monitoring technology, and is expected to deliver significant energy savings. Alongside the renewal of the aeration equipment, full process redesigns of the biological treatment stages are being carried out at both facilities.

As an additional service, Sweco GmbH also prepared funding applications on behalf of both clients under the German National Climate Protection Initiative (Kommunalrichtlinie) administered by the Federal Ministry for Economic Affairs and Climate Action.

Spatial and geopolitical challenges

Urban densification places additional pressure on legacy systems that were not designed for today's population density or land-use patterns. As cities become more compact, the physical space available for new pipelines, storage, treatment upgrades and construction work becomes increasingly limited. This makes traditional expansion and renewal more difficult, disruptive and costly.

At the same time, spatial constraints affect how infrastructure can be renewed, adapted and made more resilient. In dense urban areas, utilities often need to work around existing buildings, underground utilities, transport corridors and other critical infrastructure. This increases technical complexity, prolongs delivery times and highlights the importance of coordination across sectors and disciplines.

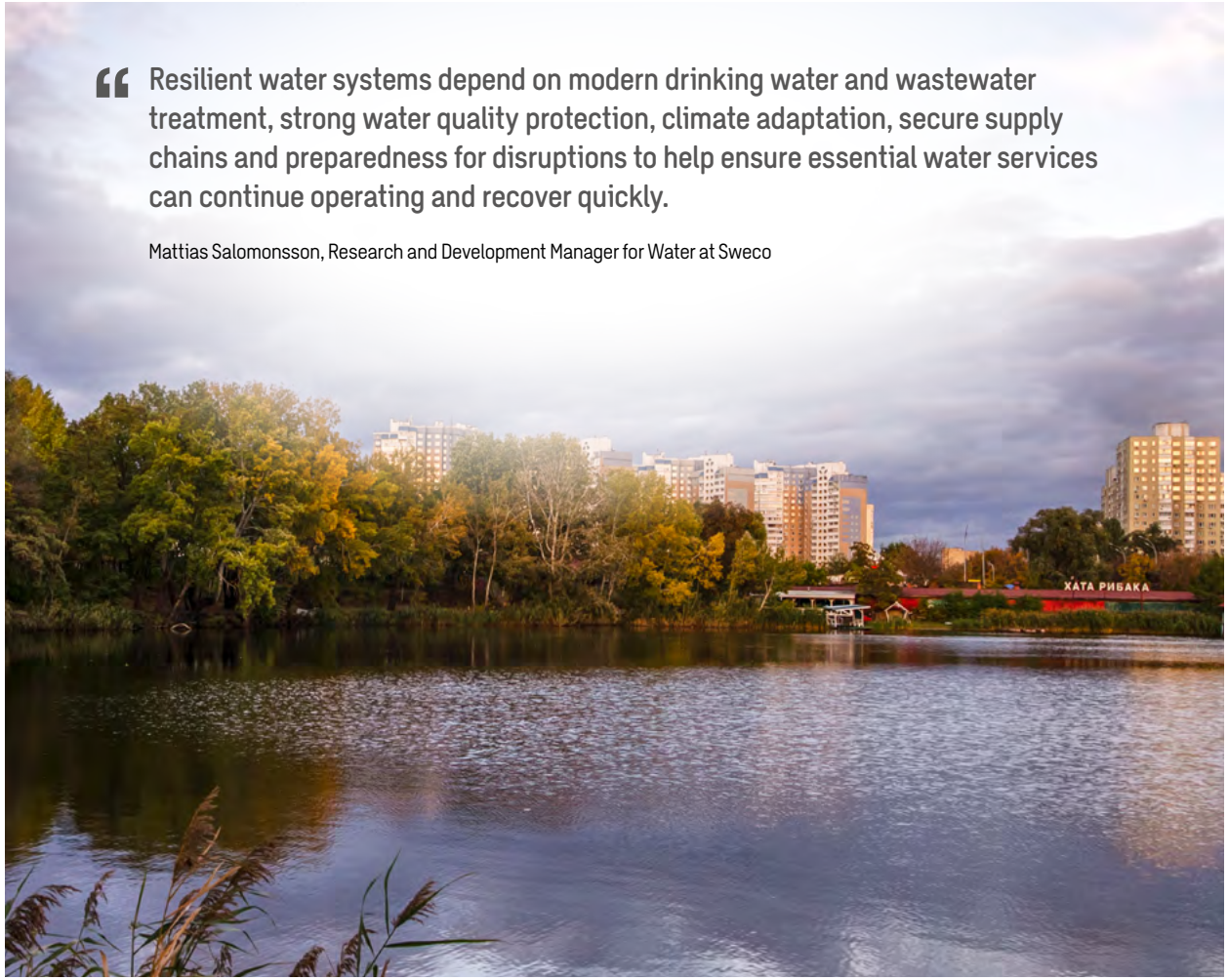
These constraints also make preparedness essential. Utilities need to plan for disruptions during construction and operation, including power outages, flooding, contamination and failures in interconnected systems. Measures such as redundancy, emergency access, temporary capacity and alternative supply routes can help ensure that essential services continue operating and recover quickly when disruptions occur.

Modernising water and wastewater management systems, Ukraine

Sweco has extensive experience supporting Ukrainian municipalities in strategically important water supply and wastewater projects, working together with our local partners. Our services cover the full project cycle, including feasibility studies, preliminary and conceptual design and integrated assessments of technical, environmental, social, economic and financial aspects.

Through assignments in Chornomorsk, Kobleve, Dobroslav and Kremenchuk, we have helped define practical development pathways, prioritise investments and establish a sound analytical basis for informed decision-making.

The teams collaborative approach and understanding of local conditions enable us to develop solutions that are robust, well prepared and ready for implementation throughout the project life cycle. For example, Sweco was selected to plan and design water and wastewater systems in Kobleve and Dobroslav. This important preparatory phase was financed by Sweden through Swedfund. The projects secured investment financing from Nefco and entered the implementation stage, using funds that included grant proceeds from the Swedish International Development Cooperation Agency (Sida). Sweco was selected by Nefco to support the municipalities and their project implementation units (PIUs), providing assistance with procurement, contract management and construction supervision. This support helps ensure efficient implementation, high-quality delivery and a successful transition to operations.



> Resilient water systems depend on modern drinking water and wastewater treatment, strong water quality protection, climate adaptation, secure supply chains and preparedness for disruptions to help ensure essential water services can continue operating and recover quickly.
>
> Mattias Salomonsson, Research and Development Manager for Water at Sweco

From sewage canal to natural flowing water: new construction of the Emscher wastewater sewer, Germany

Since the beginning of the industrial development of the Ruhr area, the river Emscher has been consistently used for wastewater disposal. After the extensive cessation of mining activities in the Ruhr area, the plan is to return the river to natural flowing water again. The heart of this task is the Emscher sewer, an underground sewer of the Emschergenossenschaft of approx. 51 km in length, which went into operation in 2021.

Challenging geology and active corrosion protection
The somewhat complicated geology at the boundary layer of the Emscher marl and the predominant location of the route in the conurbation of the cities were taken into account through intensive consultation and planning activities. In addition, innovative materials were used in this construction project which, in combination with active building ventilation, counteracted the increased risk of corrosion.

Sweco services: Proportional planning optimisation - planning and tendering, technology, site management and construction supervision.

Photos by Dirk Kurz, Sweco

New requirements for resource protection

Water infrastructure is increasingly expected to do more than simply collect, treat and convey water and wastewater. New regulatory, environmental and societal expectations are placing additional demands on utilities, especially in relation to water quality, circularity and resource efficiency.

One of the most significant developments is the growing need to address micropollutants and other emerging contaminants. Substances such as pharmaceuticals, hormones, industrial chemicals and pesticides can occur in very low concentrations, but still pose risks to ecosystems and, in some cases, human health. PFAS are a particularly challenging group because they are persistent, mobile and difficult to remove with conventional treatment processes. As awareness and regulation increase, utilities face growing pressure to improve monitoring, treatment performance and source control.

Demand for water reuse and recycling is also increasing, particularly in regions facing water scarcity, drought risk, or competing demands on freshwater resources. Reuse can help reduce pressure on drinking water sources and improve resilience, but it requires high and reliable treatment standards, strong public acceptance and careful management of health and environmental risks. In many cases, it also calls for separate distribution systems, advanced monitoring and clearer frameworks for quality assurance.

Taken together, these developments mean that future water infrastructure must be designed not only for quantity and capacity, but also for quality, circularity and adaptability. Meeting these new requirements will be a key part of the broader transition from traditional asset renewal to system transformation.

Modernisation of wastewater treatment plant to increase treatment capacity, the Netherlands

Waterboard Zuiderzeeland is preparing a large-scale expansion and modernisation of the wastewater treatment plant in Almere. It's the largest facility in Flevoland. Construction started in 2025 and is expected to be completed by the beginning of 2027. The plant will remain operational throughout the work.

The expansion is driven by continued growth in Almere, which is causing increased amounts of wastewater. The upgrade will increase treatment capacity by approximately 30%, enabling around 40,000 additional homes to be connected to the sewer network.

Key elements of the project include a new pre-settling tank with odour treatment, the use of powdered activated carbon to remove pharmaceutical residues and other micropollutants, a second Ephyra® sludge digestion installation for biogas production and a third sludge centrifuge for further sludge dewatering.

With these measures, the facility is being developed into an energy and resource recovery plant. Through digesting sludge to the maximum extent possible, biogas will be produced, upgraded and fed into the gas grid. This will allow energy to be recovered from sludge, materials to be reused and the plant's CO_2 emissions to be reduced significantly.

Sweco prepared the designs and tender documents for capacity expansion and system conversion. The project is highly multidisciplinary, with energy and sustainability as central themes.

System transformation, not just renewal

Utilities must consider how infrastructure can work differently—through adaptive planning, system-level solutions and digital tools that improve efficiency, resilience and resource use.

A holistic, risk-based approach to adaptive planning

Modern asset management frameworks focus on long-term value creation rather than short-term cost minimisation. In practice, this means managing infrastructure as part of a broader system, where technical performance, service delivery and financial planning are aligned across the full asset lifecycle.

Age-based renewal and static 'snapshot' models are increasingly being replaced by adaptive planning approaches. Climate change, shifting regulatory expectations, urban growth, demographic change and pressure on resources all affect what future systems need to deliver. Investment decisions must, therefore, consider not only an asset's condition, but also its performance, its role in the system and its ability to meet future needs.

This requires a more holistic and adaptive approach. Rather than replacing assets like for like, utilities should assess which intervention creates the greatest overall value and the least risk over time. Operational data can support this shift by showing where intervention is truly needed and where systems are still performing well. The aim is to move from reactive renewal to strategic, risk-based planning that keeps water infrastructure fit for changing future conditions.

Adaptive planning builds on lifecycle management and risk-based decision-making by considering multiple future scenarios and investment pathways. Throughout a lifecycle, predictive maintenance and portfolio-based asset management enable continuous performance optimisation by comparing similar assets, identifying underperformance and targeting interventions. In many cases, existing operational data, such as pump run hours or treatment inflow and quality metrics, already provide a sufficient basis for this more proactive approach.

Identifying and managing system-wide risks through integrated modelling: Jersey's Liquid Waste Strategy

Integrated modelling for Jersey's Liquid Waste Strategy. Sweco supports the Government of Jersey in developing and maintaining its Liquid Waste Strategy. Using an integrated, risk-based model of wastewater and surface water infrastructure, Sweco has helped identify operational, environmental and capacity risks and supports long-term planning for growth, climate change, pollution control and public health.

The model has become Jersey's primary digital tool for assessing infrastructure needs, climate change impacts and informing investment decisions. It has helped optimise major infrastructure upgrades, mitigate overflow risks and demonstrate a potential 90% reduction in untreated discharges to St Aubin's Bay.

As growth and climate pressures increase, the model continues to support integrated planning across wastewater, surface water and tidal systems, enabling resilient and evidence-based decision-making.

Key outcomes

- System-wide risk identification across wastewater and surface water networks
- 90% reduction of untreated discharges to St Aubin's Bay demonstrated through modelling
- Digital decision-support tool used continuously for over 15 years
- Improved climate resilience through the integrated assessment of rainfall, tides and growth
- Informed delivery of 8,000 new homes while protecting environmental and public health outcomes
- Foundation of the formal Surface Water Management Plan.

There is not always a single way

Replacing assets one-to-one is rarely sufficient. In many cases, utilities need to look beyond traditional renewal and consider system-level solutions such as decentralised treatment, nature-based solutions and more flexible network design.

Most water systems still follow a centralised model: water or wastewater is collected, conveyed to a central point, treated in large facilities and then distributed or discharged. This approach can be efficient, especially in dense networks, where the cost per unit of treated water or wastewater might be lower. However, adaptive planning increasingly shows the value of considering tailored solutions that complement conventional infrastructure.

Decentralised treatment

Decentralised treatment is one such alternative. Treating water or wastewater closer to the source can reduce transport needs and allows treatment to be better adapted to local conditions and pollutant loads. A clear example is decentralised treatment in hospitals, where specific micropollutants and antimicrobial resistance risks can be addressed directly at source before they enter the wider water system. Decentralised solutions can also support resource recovery, for example, by enabling the recovery of phosphorus, nitrogen, or energy from concentrated streams.

Nature-based solutions

Nature-based solutions offer another important option. These approaches use natural processes and ecosystem functions to support water treatment, stormwater management, infiltration and pollution control. Compared with conventional infrastructure, which is often energy-intensive and maintenance-heavy, nature-based solutions can reduce infrastructure demand, lower energy use and provide additional benefits such as improved water retention, biodiversity and climate resilience.

Nature-based solutions are not a direct replacement for conventional infrastructure in all cases, and their technical applicability is limited in some settings. However, when combined with conventional systems, they can reduce costs, lower operational demands and improve adaptability to changing conditions.

In practice, there is no reason why centralised and decentralised solutions, or conventional and nature-based approaches, should not be combined in urban areas as hybrid systems. The choice should not be based solely on a simple capex-opex comparison, but on a broader risk-based assessment that considers performance, resilience, local conditions and long-term value.

Exploring the future of decentralised wastewater treatment, Sweden

Sweco supported Vivab (Vatten och Miljö i Väst AB) in exploring the future of Okome and Köinge wastewater plants over a 50-year horizon. The study focused on a decentralised solution, where both facilities would continue to serve their respective catchments rather than be replaced by a fully centralised system. This approach was assessed alongside the option of a transfer pipeline and a shared plant in Köinge. A decentralised setup was chosen because of the need to renew both plants while keeping treatment close to the source.

At the time of the study, Okome operated with biodams and lime dosing, while Köinge relied on a temporary biological stage but struggled with ageing infrastructure. Sweco compared process alternatives for each plant, taking site conditions, receiving waters and future discharge requirements into account. The result gave Vivab a clear basis for choosing a long-term solution that is technically robust, cost-effective and adapted to a decentralised structure.

> Adaptive planning means thinking differently, decentralisation can be part of the approach. Treating pollutants at source, for example at hospitals or industrial sites, can improve control, prevent their spread and increase treatment efficiency.
>
> Mark Narbrough, Technical Director in Sweco's Asset Management Business Unit.

Not without digital tools

The water sector's transformation cannot rely on renewal alone. It also depends on digital tools that help utilities use existing assets more intelligently. The question is no longer whether to digitalise, but how to do it in a way that reflects real operational needs.

Unlike standard IT rollouts, digitalisation in water and wastewater must be grounded in how treatment processes actually work: how aeration responds to incoming load variations, how permit conditions define critical parameters and how real-time operational data from systems such as Supervisory Control and Data Acquisition (SCADA), laboratory results and operational logs are combined into decision support that operators can use in practice.

When designed well, digital tools do not replace operational expertise, they strengthen it, helping staff act faster, with greater confidence and on the basis of better information.

+30,300

urban wastewater treatment plants in EU[7] represent a major opportunity for digital optimisation, monitoring and automation.

Data-driven energy performance monitoring of pump stations using Smart Water Home, Sweden

Värnamo municipalilty has implemented Sweco's Smart Water Home platform to enable continuous, data-driven monitoring of pump station performance. By integrating operational data, flow rates, water levels and energy consumption, with data from energy suppliers, the platform calculates key performance indicators such as kWh/m³. For stations lacking flow meters, an innovative proxy metric (kWh/m of pumped head per day) was developed to enable performance benchmarking across the entire asset base. Combined with several years of historical data, the solution enables both anomaly detection and long-term trend analysis. The initiative has already identified several pumping stations with significantly lower energy efficiency than comparable assets, enabling targeted maintenance and investment prioritisation. The solution also supports environmental reporting requirements.

Sweco uses the widely adopted standard ISO 27001, which describes how to set up an information security management system (ISMS) to ensure confidentiality, integrity and availability across the organisation. It covers not only digital information, but also physical access to buildings, risk assessments, supplier management, role management and business continuity.

A major enabler of this shift is better data in near real time. Water utilities already have experience with sensors and operational systems, but legacy infrastructure, poor data quality and ageing networks remain major barriers. At the same time, the sector faces the loss of tacit operational knowledge as experienced staff retire. This makes digital asset management increasingly important, not only for monitoring assets today, but for anticipating what they will need tomorrow. Digital twins and AI can support this shift by improving process visibility, forecasting risks, detecting anomalies and enabling more proactive maintenance and investment planning. However, these tools depend on reliable sensors, calibration routines, validated data pipelines and strong domain expertise to avoid misleading outputs.

Cybersecurity: the precondition for digital water utilities

Cybersecurity is a precondition for this digital transition. As legacy systems, operational technology and new digital solutions become more interconnected, utilities must protect service continuity while enabling innovation. This is especially important under tighter regulatory frameworks and the growing use of AI and connected devices. At the same time, the digital transition brings its own resource footprint: AI and data centres require significant energy and water. In water-stressed regions, this creates a paradox that reinforces the need for efficient, transparent and carefully planned digitalisation. Used well, digital tools can improve resilience, resource efficiency and decision-making, but only if they are built on robust data, secure systems and a clear understanding of the sector's operational reality.

5.5 TWh/year

Improving inefficient European wastewater treatment plants could save over 5.5 TWh of electricity annually[8]—roughly the annual household electricity use of one million Swedish homes. Digital monitoring, process control and optimisation can help unlock this potential

Flood safety in a complex setting, the Netherlands

The Zuidelijke Waaldijk Oost project covers 35.5 km of dike reinforcement along the River Waal and plays a key role in strengthening flood resilience in the region. What makes the project particularly notable is its complex setting, where flood protection measures must be carefully balanced with Natura 2000 protected areas, cultural heritage values and the interests of nearby residents. Sweco has been appointed by Waterboard Rivierenland, the regional Dutch water authority, to support the exploration phase of the project.

Sweco will provide integrated advisory and engineering services, including safety assessments and design development, supported by advanced digital tools and drone-based inspections to enhance data quality and safety.

The aim is a future-proof, climate-resilient solution.

Data-driven water management, Belgium

A water level decree (peilbesluit) is used to establish legally binding agreements regarding surface water levels in specific areas. The agreed water levels are explicitly based on measured water level data collected in the area and are supported by ongoing monitoring, allowing water managers to adjust operations to meet the defined objectives.

Within the framework of the 'Hydrological restoration of the Kleine Nete valley near De Zegge and Olens Broek', Sweco is assisting the Province of Antwerp and the Flemish Environmental Agency (VMM), as water managers, in preparing the orientation note, the draft water level decree and the accompanying environmental assessment report (plan-MER) for the priority area of De Zegge.

The decree will bring together the needs of nature, agriculture and safety, while also providing a solution for the unpermitted dewatering pumps in the polder area. The policy aims to retain water for longer, reduce drought and flood risks and support nature restoration, while providing legal clarity and predictability for land users and water managers. Now that work on the orientation note is finalised, we are currently working on the draft decree.[9]

Designing water systems for resilience

Resilience requires a shift in how water infrastructure is planned, designed and managed. Rather than simply replacing ageing assets, utilities need to consider how entire systems can withstand disruption, adapt to changing conditions and maintain essential services over time.

Conclusion: the need for a different investment logic

If current renewal rates remain unchanged, many networks will continue to age faster than they are replaced. Over time, this increases the share of assets operating beyond their intended service life and narrows the margin for operational flexibility. The result is a water and wastewater sector that spends more on emergency response, while achieving less in long-term resilience.

Addressing this challenge requires a different investment logic. Rather than focusing only on immediate repair needs, decision-making should account for whole-life performance, service continuity and system-level risk. Renewal priorities must be based not only on the age of an asset, but also on its criticality, failure consequences, condition and role in the wider network.

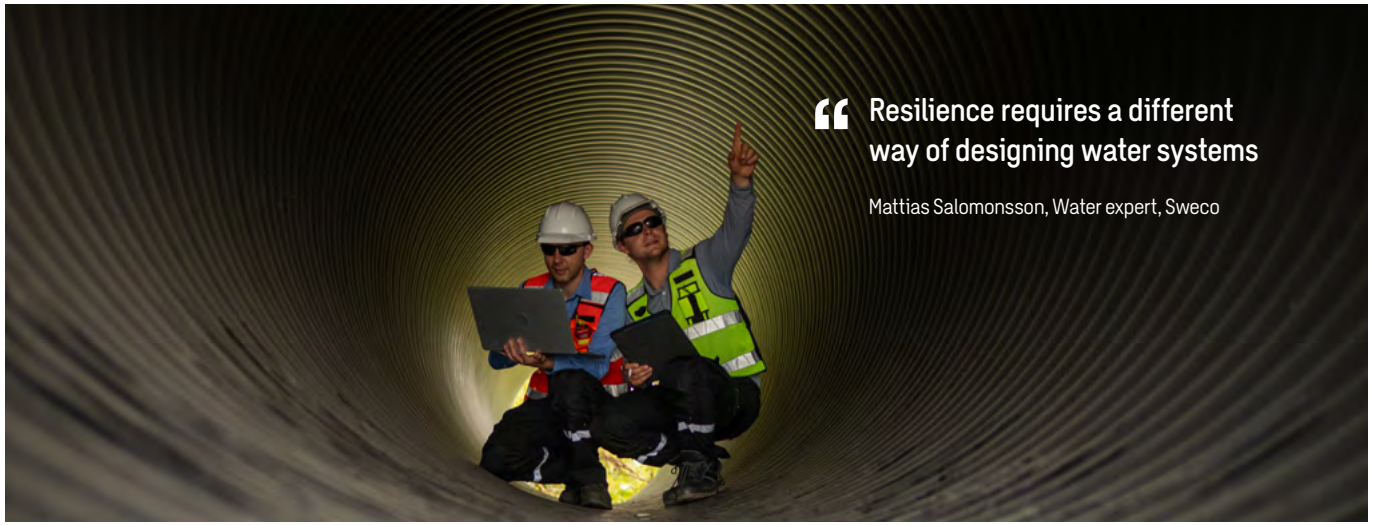
Why better-designed water systems now are critical
Europe does not only need more investment in water infrastructure. It needs better-timed, better-targeted and better-designed investment.

Across Europe, water and wastewater systems are under growing pressure. Networks are ageing, renewal backlogs are increasing and climate risks are intensifying. At the same time, municipalities and utilities are expected to deliver reliable services, meet stricter environmental requirements and keep costs affordable.

This is no longer simply an infrastructure challenge. It is a governance, financing and timing challenge.

Preparing water systems for greater uncertainty
A resilient water system cannot be built with yesterday's planning logic. Much of Europe's infrastructure was designed for relatively stable conditions: predictable demand, known regulatory requirements and climate patterns that could be used as a baseline for engineering design. That context no longer exists.

Today, water systems must perform under greater uncertainty — from drought, flooding and cloudbursts to energy volatility, population shifts, tighter regulation and rising expectations for circularity and sustainability. In this context, resilience is not simply about making existing assets last longer. It requires a different way of designing water systems in the first place.



> Resilience requires a different way of designing water systems
>
> Mattias Salomonsson, Water expert, Sweco

For Sweco, this new context can be understood through four transitions shaping the future water system

- **from renewal to resilience**
  not only replacing ageing assets, but strengthening the ability of the system to withstand, adapt to and recover from disruption;

- **from assets to systems**
  not only optimising individual pipes, pumps or treatment plants, but understanding how they function together across the full water cycle and urban environment;

- **from fixed solutions to adaptive solutions**
  not only building for one forecast, but creating flexible investment pathways that can respond to uncertain future conditions;

- **from data to digitalisation and AI for better decisions — with cybersecurity built in**
  not only collecting information, but using digital tools, analytics and AI to improve timing, prioritisation and performance, while safeguarding critical infrastructure from cyber threats.

These four transitions redefine what smarter investment means. They move the conversation from replacing what is worn out to building systems that are robust, flexible and fit for a more uncertain future.

Seven actions for smarter, better-timed investment in water systems

The four transitions set the direction. These seven actions translate that direction into practical steps for building more resilient water systems.

1 Stop replacing, start predicting

For decades, investment decisions in water infrastructure have often followed a simple pattern: repair what fails, replace what is old and respond to regulation when required. That approach is no longer enough.

A resilience-based investment logic starts from a broader question: which interventions create the greatest long-term value for the system and for society?

This means moving beyond age-based replacement. Investment priorities should be shaped by condition, criticality, failure consequences, climate exposure and the role an asset plays in the wider network. An older asset is not always the highest priority; in many cases, a newer but more critical asset might represent greater system risk. For municipalities, utilities and political leaders, this shift is essential to ensure that limited capital is directed to the investments that create the greatest long-term public value, while providing a stronger basis for deciding what to do now, what to phase and how to target resources where they will have the greatest effect.

2 Think in systems, not silos

Resilience is not created asset by asset. It emerges from how the system works as a whole.

A pipe failure is not only a pipe failure if it disrupts treatment performance, overwhelms stormwater capacity or compromises public health. Likewise, wastewater treatment is not only about compliance at the end of the pipe. It is also connected to energy use, nutrient recovery, water reuse and the wider urban system.

This is why future water management must move from an asset perspective to a systems perspective. Utilities and municipalities need to understand interdependencies across networks, treatment processes, energy systems, digital infrastructure and urban planning. Looking at assets in isolation can lead to sub-optimised investment. Looking at the system as a whole creates better opportunities to reduce risk, unlock co-benefits and strengthen long-term resilience.

3 Prioritise where the consequences are greatest

Across Europe, investment needs exceed available funding. In this reality, prioritisation is not optimal, it is the core of effective asset management.

The key question is not which assets are oldest, but which failures would have the greatest consequences for service continuity, public health, environmental compliance or public trust. A risk-based approach helps decision-makers focus first on the interventions that matter most, rather than spreading limited budgets too thinly.

This also makes investment decisions more transparent and easier to communicate. For municipalities and policymakers, clearer prioritisation provides a stronger basis for explaining why some investments must happen now, why others can be sequenced over time and how affordability can be balanced with resilience.

4 Plan adaptively

Traditional infrastructure planning has often assumed that future conditions can be predicted with sufficient certainty to justify large, fixed investments. That assumption is becoming increasingly weak. Climate change, shifting demand, technological development and regulatory change all mean that future conditions are less certain than before. Under these circumstances, rigid planning can create expensive lock-in. Systems may be oversized, undersized or simply insufficiently flexible when conditions change.

Adaptive planning offers a stronger alternative. By phasing investments and linking them to decision points, utilities and municipalities can respond to new information over time. This helps preserve flexibility, reduce regret and align investment timing with actual need.

Adaptive solutions do not mean postponing action. They mean designing infrastructure pathways that can evolve, technically, financially and operationally, as future conditions become clearer.

5 Use digitalisation, AI and cybersecurity to make better decisions

One of the biggest barriers to smarter investment is not a lack of ambition, but a lack of decision-ready information. Many organisations still struggle with incomplete asset registers, limited condition data and weak connections between operational insight and capital planning.

This is where digitalisation becomes transformative. Sensors, real-time operational data, geographic information systems, hydraulic modelling, leakage monitoring, predictive analytics and AI can provide better visibility into network performance, deterioration patterns and intervention timing. The value is not digitalisation for its own sake, but digitalisation that supports better decisions.

In a capital-constrained environment, timing is critical. Acting too late increases emergency costs and risk. Acting too early can lock up capital unnecessarily. Better digital insight helps organisations invest in the right place, at the right time and for the right reason.

As water systems become more connected, cyber security must be treated as a core part of resilience, not as a separate IT issue.

6 Maximise value across the full lifecycle

A resilient water system cannot be delivered through short-term budgeting alone. Investment decisions that appear cost-efficient upfront might lead to higher operating costs, greater maintenance needs and more frequent failures over time.

A lifecycle perspective changes the decision framework. It connects design, operation, maintenance, rehabilitation and replacement, making it possible to evaluate investments based on long-term value rather than initial cost alone. This supports better choices around rehabilitation, treatment upgrades, energy-efficient equipment, nature-based solutions and digital systems.

The smartest investment is not always the largest one. Often, it is the intervention that best improves long-term performance, preserves flexibility and reduces future risk.

7 Invest when the timing is right

The challenge is not simply to spend more, but to invest with greater precision.

That means shifting from renewal to resilience, from assets to systems, from fixed solutions to adaptive solutions and from data collection to digitalisation and AI for better decisions — with cyber security built in from the start.

In a time of mounting pressure, resilience will depend less on how much capital is available than on how intelligently it is deployed.

Smarter investment is ultimately not only about infrastructure. It is about protecting essential services, supporting sustainable and liveable cities and ensuring that every investment creates the greatest possible public value, now and over the decades ahead.

About the authors

Feel free to contact us with your questions and thoughts. E-mail: urbaninsight@swecogroup.com

Mattias Salomonsson is Research and Development Manager for Water at Sweco. He holds a MSc in Water and Environmental Engineering. He had ten years of experience working at a water and wastewater utility before joining Sweco as a consultant. Mattias works across the entire water and wastewater sector. In recent years, his work has focused heavily on climate adaptation measures and strategic water and wastewater issues. He has been responsible for the development of several national policy documents and guidelines related to climate adaptation in Sweden and is a well-known speaker and moderator at conferences within the water sector.

Noémi Van Bogaert is a Project Manager at Sweco with a strong interest in the interplay between nature, agriculture and society and with particular expertise in water. After completing her MSc in Environmental Sanitation and Management, she pursued a PhD at the Faculty of Bioscience Engineering at Ghent University. Following her doctoral studies, she further honed her expertise by conducting post-doctoral research on aquatic viruses in the United States. As a scientific advisor for the Belgian agri-food industry, Noémi tackled various environmental challenges, emphasising the enhancement of water quality and availability through sustainable farming practices. At Sweco, she leverages her extensive experience to promote the development of a sustainable and resilient society.

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Urban Insight

By Sweco

Urban Insight is Sweco's international knowledge platform, where experts come together to develop and share insights, facts and solutions about how to plan and design sustainable cities and the societies of the future. Global and local initiatives will be organised throughout the year to inspire and open up discussions about sustainable urban planning.

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