Reimagining industrial water: From commodity to strategic asset

December 2025

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Executive summary

Key findings

To meet rising industrial water demand, the focus must shift from short-term water sourcing to long-term water resilience. By embedding water reuse into core infrastructure strategies, industries can future-proof their operations.

Rising industrial water demand: A strategic risk

- The combined effects of rapid industrialization, population growth, and climate variability are placing unprecedented stress on freshwater resources.
- The widening gap between water availability and industrial demand is evolving into a major operational and reputational risk, jeopardizing business continuity, compliance, and growth.

Water reuse as a strategic imperative

- Water reuse redefines industrial water management by reducing reliance on freshwater, enabling industries to scale without being constrained by freshwater limitations.
- By integrating advanced treatment technologies or contracting out reuse operations, industries can repurpose wastewater effectively, creating a resilient, circular water supply.

Technology is available, but underutilized

- Despite the proven efficacy and availability of reuse technologies, adoption remains limited. Barriers include fragmented infrastructure, lack of integrated planning, and insufficient funding.
- Driving adoption requires cross-sector collaboration and more affordable financing models like water management services, which outsources modular solutions and expertise to avoid plant redesigns.

Unlocking long-term value through reuse

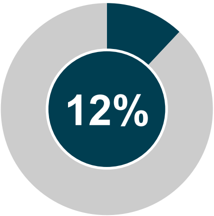
- Transitioning from linear to closed-loop water systems enhances regulatory readiness, supports ESG goals, and reduces risk of water disruptions caused by severe weather.
- In water-stressed regions, early investment in water reuse ensures operational continuity and offers a long-term strategic advantage, as water-supply resiliency becomes a key business differentiator.

Water: the foundation of industrial operations

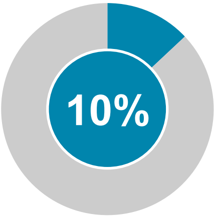
The industrial sector accounts for approximately **20% of global freshwater withdrawals,** rising above 40% in many developed countries and reaching 50–70% in North America and Europe.

Industrial water consumption

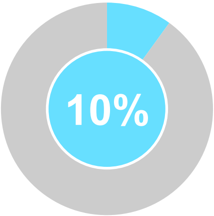
Figure 1. Global water use distribution by key industrial sectors from 2023-2024



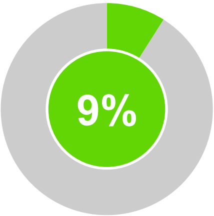
Textile & apparel



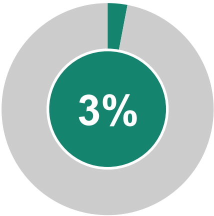
Power generation



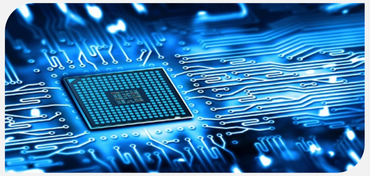
Chemical



Food & beverage



Semiconductor



https://www.fao.org/aquastat/en/overview/methodology/water-use/
https://thundersaidenergy.com/downloads/water-intensity-of-power-generation/

Escalating water demand and a shift toward water reuse

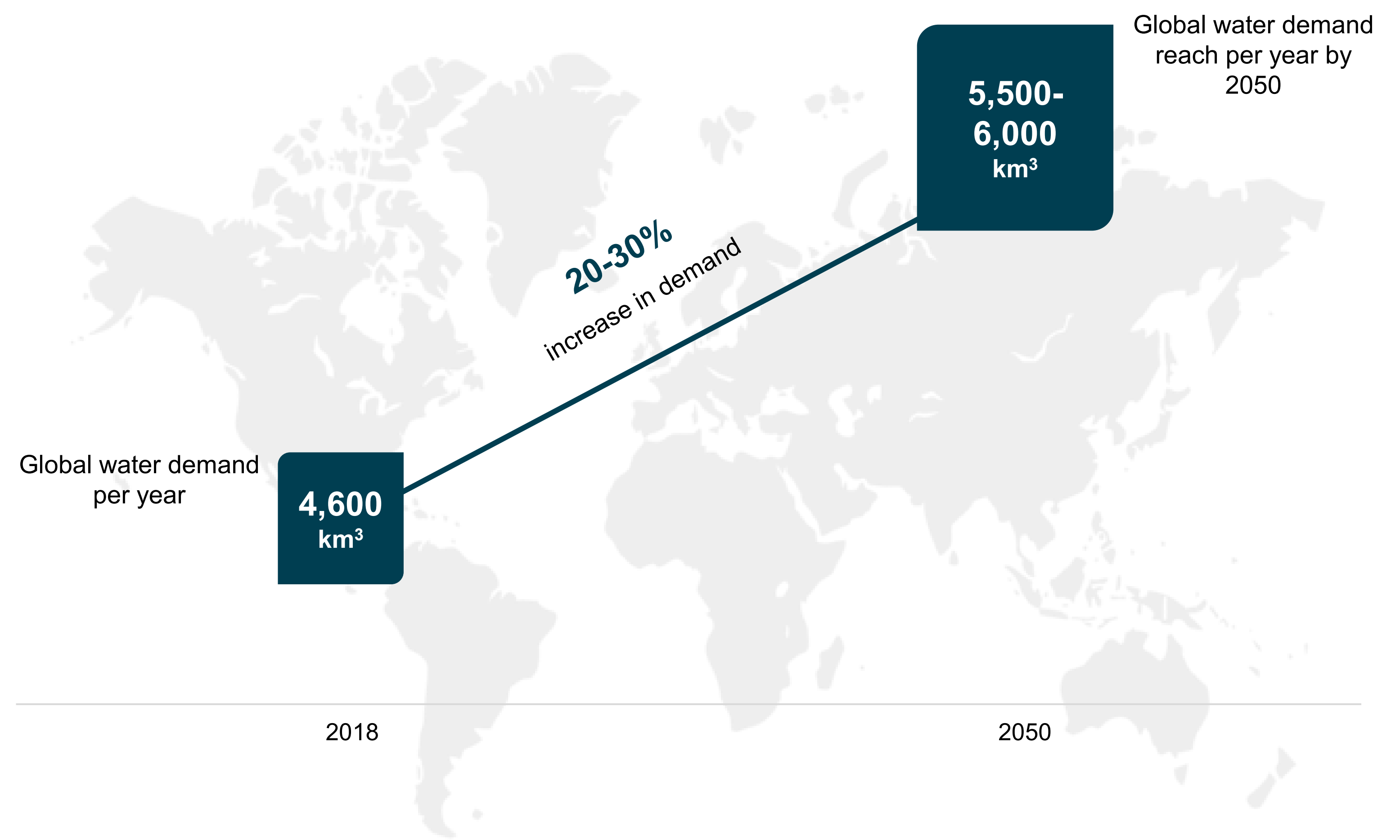
The industrial sector can win with a shift towards water reuse

By adopting water reuse technologies or water management services, industrials can cut freshwater dependence, meet regulations, and gain a competitive edge, advancing a circular, resilient water economy.

Global water demand is projected to outpace supply by 40% by 2030

This rising water demand is fueled by growing industrial consumption. In many regions, water treatment plants are near capacity, pushing industries to adopt non-potable water sources instead of potable ones.

Figure 4. Global water demand



https://www.verifiedmarketresearch.com/product/water-market/

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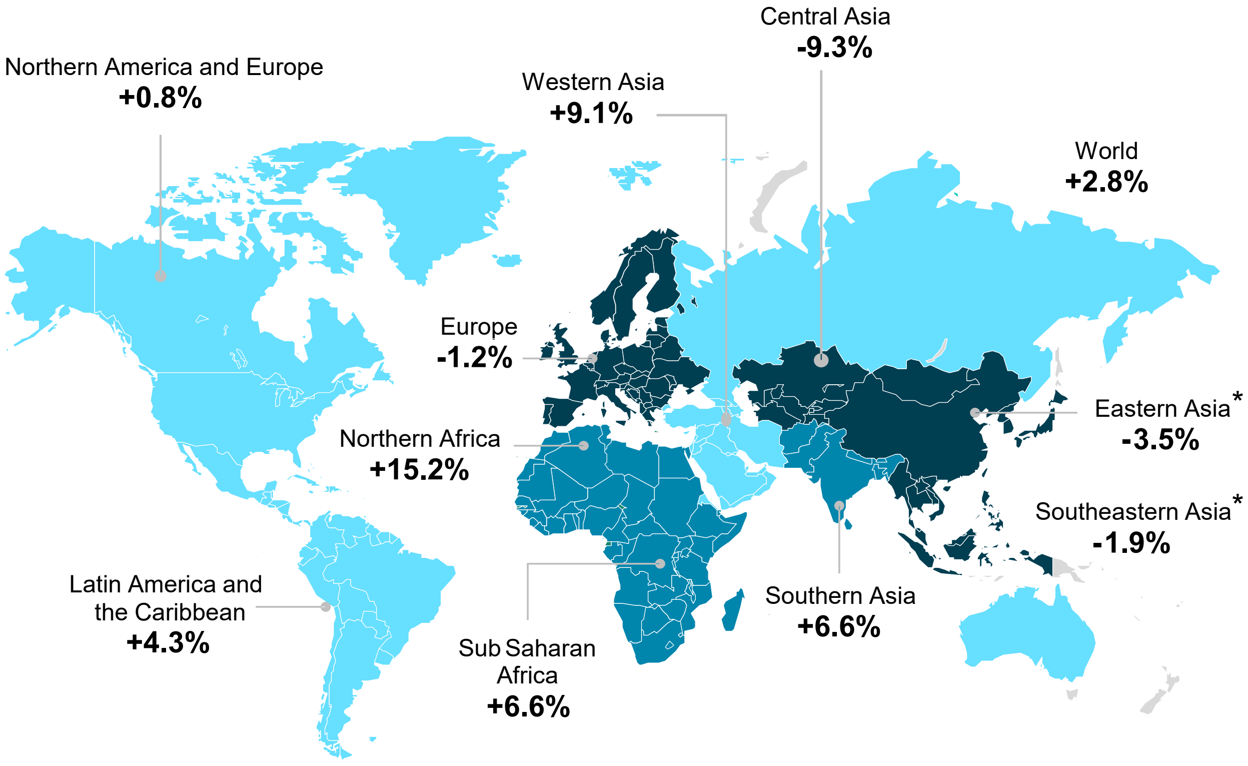
With limited freshwater, water security is now a top industrial priority

Water scarcity is here—and industries are feeling the pressure. Figure 3 shows how global water stress worsened from 2015 to 2021. In response, businesses are boosting efficiency and investing in resilient infrastructure. Eastern and Southeast Asia has eased water stress by treating freshwater as a finite, high-value resource and a strategic priority.

https://www.cdp.net/en/press-releases/internal-water-pricing-unlocks-resilience-and-long-term-growth
https://www.nature.com/articles/s41545-019-0039-9

Figure 3. Percentage change in water stress levels from 2015 to 2021



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Tightening regulations are making reuse a priority for industry

As global water regulations tighten, industries are facing mounting pressure to rethink their wastewater strategies, not just as a compliance necessity, but as a strategic imperative.

Zero Liquid Discharge (ZLD) and Minimum Liquid Discharge (MLD)

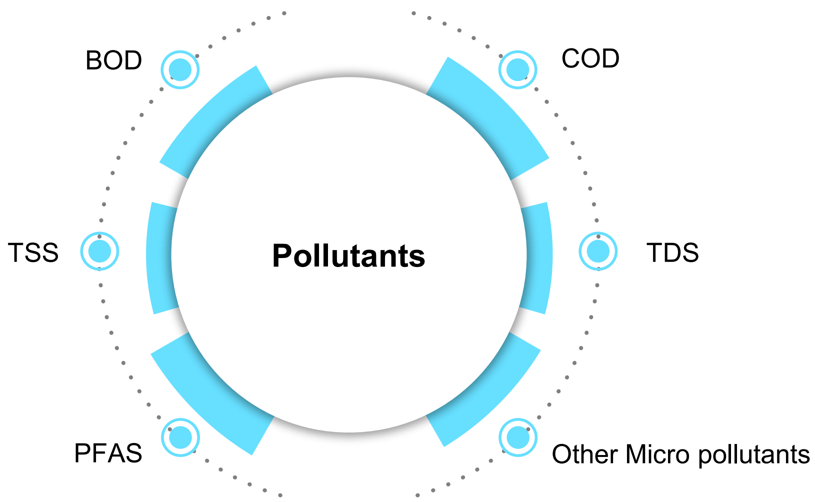
- In water-stressed regions and pollution-sensitive zones, authorities are mandating ZLD/MLD systems to curb untreated effluent discharge, protect freshwater bodies, and promote circular water management.
- Countries including India and China have already implemented sector-specific ZLD mandates, particularly for high-impact industries such as textiles, while others are moving toward similar frameworks.
- These requirements are forcing industries to invest in advanced treatment technologies that recover, recycle, and reuse water within the facility or at central effluent treatment plants, reducing dependency.

Regulatory bodies

- Fines for non-compliance are rising as regulatory bodies such as the U.S. Environmental Protection Agency (EPA), India's Central Pollution Control Board (CPCB), the European Commission (EC), UK's Water Services Regulation Authority (Ofwat), the Ministry of Environment, Water and Agriculture (MEWA) in the Saudi Arabia and the Middle East are tightening effluent discharge standards.
- These include stricter limits on parameters like Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Per- and Polyfluoroalkyl Substances (PFAS).

US EPA | EC | MEWA | CPCB | Others

Regulatory bodies are tightening discharge limits



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US snapshot: Industrial water reuse tax credits

A proposed federal bill would establish a 30% investment tax credit for industrial and commercial water users implementing qualifying water reuse projects—supporting business development, robust local economies and sustainable water management

The Advancing Water Reuse Act (H.R. 2940)

- The proposed Advancing Water Reuse Act, would provide a 30% credit for industrial sectors such as data centers and food & beverage who invest in onsite reuse systems or connect to municipal reuse systems that reduce water withdrawals.
- The credit applies to new construction, retrofits, and municipal expansions supporting industrial reuse and is effective for projects beginning before 2033
- Federal incentives like this recognize the ongoing shift from conservation to circularity—positioning water reuse as a core enabler of industrial innovation, resilience, and sustainable growth in the U.S.

https://www.congress.gov/bill/119th-congress/house-bill/2940

On-site water reuse builds resilience amid supply and regulatory pressures

Industries are adopting on-site reuse to turn wastewater into a safe, reliable resource and maintain operations. As municipalities face growing demand, unpredictable supply, and rising costs, reuse offers businesses greater reliability, cost control, and independence from shifting water prices and regulations.

Publicly owned treatment works (POTWs)

Evolving wastewater management

Changing external treatment rules and costs impact planning and budgets. To gain consistency and control, many businesses are moving toward on-site treatment solutions.

Rising water costs and supply constraints

Regional disparities in potable water pricing and supply are prompting industries to rethink water management, as public systems can't always meet industrial demand. In one case, a Virginia refinery's cost projections in 2000 found that adopting reclaimed water now would be more cost-effective than relying on potable supplies 20 years into the future.

Figure 5. Variable municipal water costs across the United States

Municipal Water Rates, United States ($ per 1000 gallons)

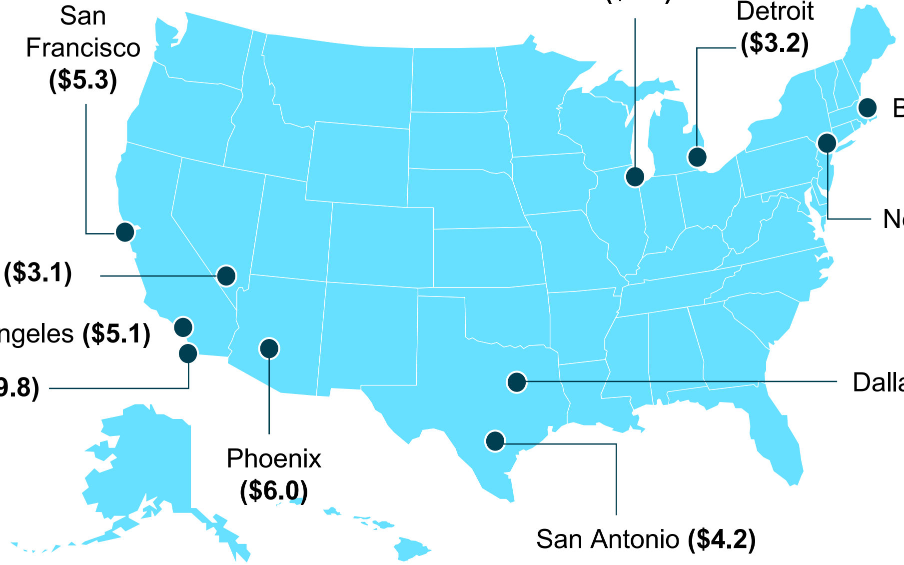


Figure does not include sewer costs

https://www.researchgate.net/publication/221920835_Economic_Principles_for_Water_Conservation_Tariffs_and_Incentives
https://watereuse.org/wp-content/uploads/2015/10/WRA-101.pdf

Building operational security

Seasonal demand spikes and unplanned disruptions drive water-intensive industries toward reuse. To counter these risks, companies are pivoting toward adaptive strategies that prioritize water reuse, shared municipal–industrial investments, and on-site treatment solutions. This evolution signals a wider move toward closed-loop systems designed to optimize costs, secure a reliable supply, and unlock sustainable long-term value.

Operational fluctuations

Operational fluctuations, such as seasonal production spikes or unexpected shutdowns, lead to inconsistent water needs.

Food & Beverage: The food and beverage industry experiences a 20-30% increase in water use during peak seasons (e.g., summer for beverage production). Industries are motivated to embrace water reuse not just for sustainability, but to ensure long-term operational continuity and cost control.

Adaptive industrial strategies

Industries are incorporating adaptive business models that consider both cost and supply risks, including shifting from potable to non-potable or reclaimed sources, co-investing in municipal-to-industrial reuse partnerships, or building on-site treatment capacity.

Data Centers: Limited potable water at publicly owned treatment works (POTWs) is accelerating municipal-to-industrial reuse in regions like Columbus, Chicago (with quantum computing demands up to 150 MGD), and Arizona, where 100+ data centers are planned.

https://divertinc.com/divert-inc-data-shows-30-increase-in-wasted-food-during-the-summer-months/

Benefits of water reuse

Wastewater treatment systems can enhance business resiliency and efficiency, unlock new revenue streams, and position companies as leaders in sustainability and innovation. Businesses with robust reuse systems can scale production without fear of impacting community water supplies or exceeding regulatory discharge limits.

Operational security

- On-site reuse boosts resilience: less dependence on municipal water, lower costs, higher efficiency, uptime, and equipment life.
- Integrating treatment into production, like solvent recycling, cuts waste and disposal, creating leaner workflows.

Turning waste into profit

- Reuse turns wastewater into assets, driving circular economy and ESG goals.
- Advanced treatment recovers nutrients, metals, and energy—phosphorus to lithium, biogas to hydrogen—unlocking ROI. Byproducts become fertilizers; recovered metals feed raw material streams.

Reducing regulatory risks and increasing trust

- Industrial reuse reduces compliance risk and costly penalties while strengthening brand credibility with regulators, investors, and communities.
- Lower discharge means less pollution and strain on municipal systems.

Transforming wastewater management into real savings

Industries embracing water reuse and smart wastewater management are securing a competitive edge. As global demand rises and supplies become less certain, success depends on integrating digital technologies into system design, monitoring, and operations.

Process optimization

Operational efficiency is the most immediate and controllable driver of ROI in wastewater treatment systems. A systemwide optimization approach targeting process design, equipment performance, and control logic can yield substantial reductions in operational expenditure (OpEx) while maintaining effluent quality.

Smarter systems, stronger ROI

Integrating smart automation, IoT-enabled sensors, predictive analytics, and digital twins into wastewater systems enables real-time visibility and control across treatment operations. By optimizing system performance, smart monitoring reduces OpEx, lowers compliance risks, and accelerates return on infrastructure investment.

Unlocking ROI through industrial symbiosis

Cross-sector collaboration transforms wastewater treatment from an isolated challenge into a shared value opportunity. By integrating effluent streams where one industry's waste becomes another’s input, companies can reduce treatment loads, monetize by-products, and maximize asset efficiency, lowering OpEx and enhancing ROI.

How modular design and smart financing boost results

Industries can unlock significant ROI by aligning modular wastewater technology with smart funding strategies. This approach minimizes capital risks and ensures faster execution, improved resource use, and steady long-term returns.

Future-proofing infrastructure through modular, scalable solutions

Prefabricated, scalable wastewater treatment systems deliver long term value by avoiding costly retrofits and downtime.

These turnkey solutions minimize future integration challenges when production expands, effluent characteristics shift, or regulations evolve.

Leverage innovative financing models to accelerate returns

Innovative financing strategies like water management services, green bonds, performance-based O&M contracts, and Public-Private Partnerships (PPP) help reduce capital risk and improve cash flow.

These approaches give industrials access to expert partners who can who can deliver faster, more accountable performance and stronger ROI.

Industrial wastewater complexity

Effluent informs the approach

Industrial effluent poses unique treatment challenges due to its complex composition including solids, organics, heavy metals, and emerging pollutants like PFAS.

Treatment choices depend on contaminant profile and reuse goals whether for cooling, process water, cleaning, or discharge compliance. See Table 2 for technologies matched to contaminant classes.

Table 2. Technology effectiveness by contaminant type

Technology	BOD/ COD	TDS	TSS	Nutrients	Pathogens	Heavy metals	PFAS	Other micro pollutants
Biological treatment	●	○	◐	●	○	○	○	◐
Membrane technologies	●	●	●	●	●	●	◐	◐
AOPs	◐	○	○	○	●	○	◐	●
Adsorption	◐	◐	○	●	○	●	●	●
Disinfection systems	○	○	○	○	●	○	○	○

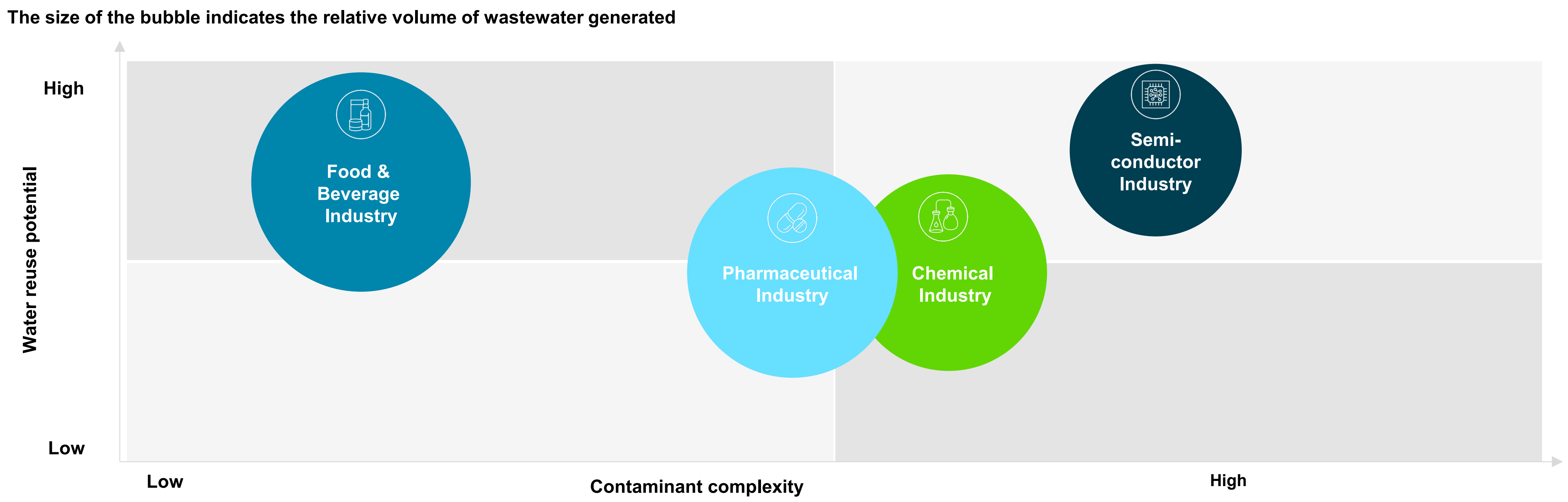
● **Very effective** ◐ **Moderately effective** ○ **Not effective**

- *"Moderately effective" statement is true for the adsorption technique if the amount of organics is relatively low*
- *BOD – Biological oxygen demand; COD – Chemical oxygen demand; TDS – Total dissolved solids; TSS – Total suspended solids; PFAS – Per and polyfluoroalkyl substances; AOP – Advanced oxidation process*

Industrial wastewater complexity

Industrial manufacturing adoption of water treatment technologies

Figure 8. Industrial manufacturing wastewater complexity



The water treatment landscape is evolving fast with innovations in biological processes, membranes, AOPs, adsorption, disinfection, and real-time digital controls. Global industries now blend conventional, advanced, and digital solutions.

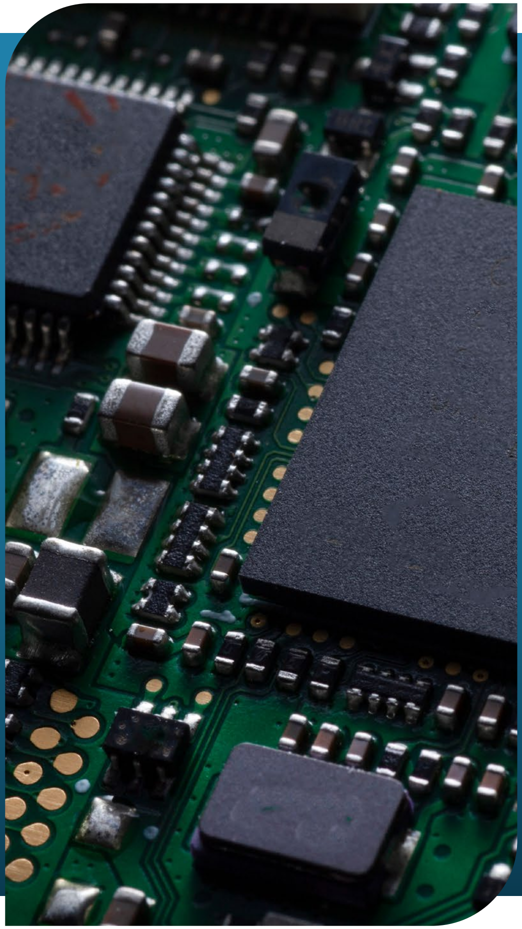
Success hinges on understanding contaminants, choosing the right tech, and assessing reuse potential for sustainable operations and compliance. See Figure 8 for industrial manufacturing adoption trends.

Silfex recycles 80% of wastewater with membrane technology

Industrials are turning to advanced membranes to hit tougher water and sustainability targets with less effort. Next-gen nanocomposite, ceramic, and high-flux membranes deliver higher durability, better selectivity, and stronger fouling resistance—helping operators reclaim more process water, cut discharge, and shrink freshwater demand. Silfex is a strong example: by recovering RO reject and cleanroom wastewater with high-efficiency membranes, they're recycling high-purity water, reducing use, and strengthening long-term sustainability performance.

Microelectronics/Case Study:

Driving sustainable outcomes using advanced membrane systems



Challenges

Given the semiconductor industry's dependence on ultrapure water (UPW), Silfex implemented an advanced water reuse and recycling program to mitigate growing water-related risks.

With cleanroom operations generating significant wastewater and reliance on municipal supplies posing long-term risks, Silfex needed to identify efficient ways to reduce water consumption and increase internal water reuse.

Solution

Silfex initiated a comprehensive assessment of its water treatment systems, analyzing the volume and chemical characteristics of individual waste streams.

The facility then implemented a brine recovery reverse osmosis (RO) system to capture and reuse RO reject water and overflow from precision cleaning processes.

Springfield, Ohio, USA

Silfex

Impact

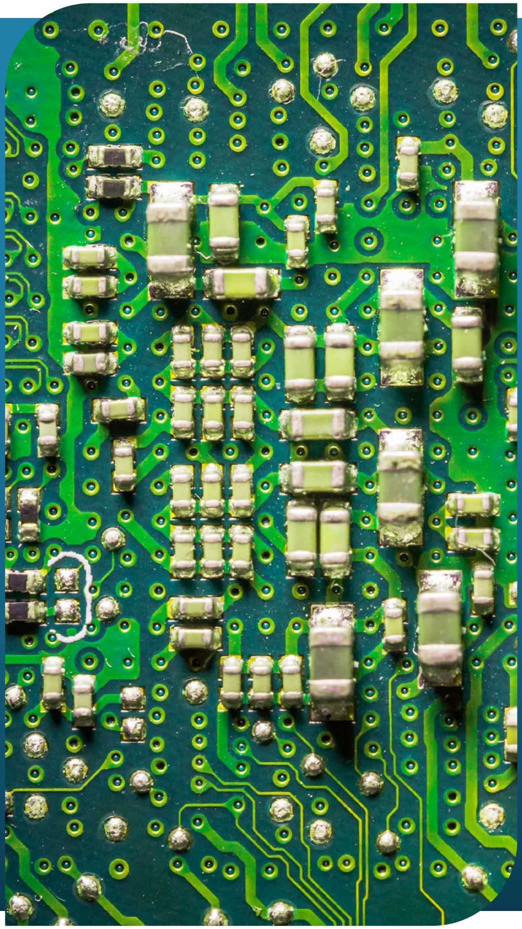
- Achieved a 15% reduction in ultrapure water system waste through early recovery efforts.
- Enabled recycling and reuse of up to 80% of cleanroom wastewater.
- Reduced dependence on municipal water significantly, building operational resilience and avoiding the cost of expensive treatment chemicals.
- Projected to save millions of gallons of water annually and futureproof plant from public water supply disruptions.

Texas microelectronics facility secures water reliability through water management services

Innovative facilities are increasingly embracing water management service models, leveraging temporary, third-party-operated systems to meet immediate needs during construction or expansion. By adopting this approach, facilities can maintain high water quality and operational continuity while avoiding the capital and operational challenges of traditional ownership.

Microelectronics/Case Study:

Accelerating semiconductor production with Build-Own-Operate water solutions



Challenges

A new microelectronics facility in Sherman, Texas, required immediate access to high-purity rinse water to commission new tooling while permanent infrastructure was still under design.

Traditional construction timelines and complex permitting made it difficult to meet startup schedules without temporary water treatment capabilities.

Solution

Rapid Deployment: Xylem AQUA pros mobilized three containerized treatment systems—including pretreatment, reverse osmosis, and ultrapure polishing—each installed in roughly two weeks.

Flexible Water Management Services Model: Delivered as a turnkey Build-Own-Operate agreement, Xylem owned and operated the temporary systems, ensuring compliance, uptime, and water quality without customer capital expenditure.

Operational Support:

- Continuous service from on-site AQUA Pro experts
- Remote system monitoring and optimization
- Modular design enabling staged startup and scalability

Sherman, Texas

Impact

The temporary water management systems kept production on track and exceeded performance expectations regarding water quality and quantity, leading the customer to extend all three contracts.

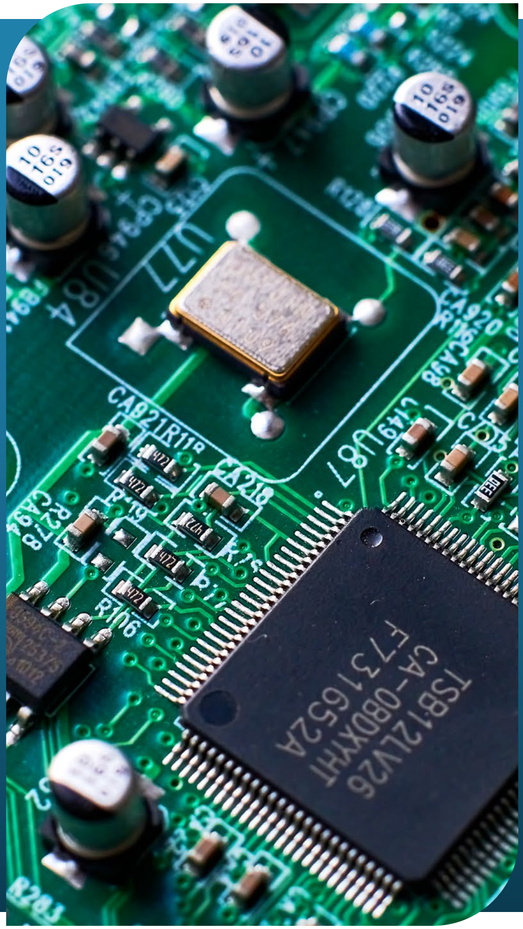
The success of the temporary systems has provided a blueprint to guide the facility’s permanent wastewater treatment and reuse system.

Printed circuit board manufacturer recovers wastewater with ion-exchange services

Advances in ion exchange resins are giving industries more precise, efficient, and durable wastewater treatment. Modern resins offer higher capacity, easier regeneration, and stronger fouling resistance, letting companies recover valuable metals and reuse water at high purity. This turns ion exchange from a routine treatment step into a strategic tool for circular water management and sustainable operations.

Microelectronics/Case Study:

Enhancing water security with advanced ion exchange



Challenges

The PCB manufacturing process at the facility involves multiple rinse and wash stages, particularly during board population and soldering. These steps generate wastewater containing surfactants and heavy metals like copper, lead, and tin, making treatment complex and necessary before reuse.

Solution

To address the challenges, the plant adopted a wastewater ion exchange system, which uses ion exchange resins and tailored media to selectively remove dissolved ionic contaminants from process water.

This technology operates using modular, DOT-compliant vessels filled with mixed-bed resin.

The integration of ion exchange resin to purify processed water proved to be a robust and future-ready solution for complex industrial effluents. The system not only ensures regulatory compliance, it also positions the facility for sustainable water reuse and long-term operational resilience by reducing dependency on municipal water.

West Coast, United States

Impact

- Enabled 90% water recovery.
- Reduced reliance on municipal water by increasing circularity.
- Maintained full production capacity.
- Recovered hazardous metals such as copper, lead, and tin.
- Streamlined regulatory compliance by reducing hazardous materials discharge.

 https://www.xylem.com/en-us/resources/case-studies/recycling-waste-rinsewater-meets-production-needs-during-water-shortage/

New Belgium Brewing transforms wastewater into green energy

Biological treatment systems help industries tackle high-organic-load wastewater efficiently. Innovations like anaerobic membrane bioreactors, aerobic granular sludge, and microbial-electrochemical systems deliver compact, energy-generating, high-performance treatment—helping companies meet regulations while advancing circular economy and sustainability goals.

Food & Beverage/Case Study:

Anaerobic membrane reactor for high-organic load wastewater

Challenges

The brewery faced the dual challenge of managing high-strength wastewater from its brewing operations, while adhering to stringent discharge standards. Limited space for upgrades also limited New Belgium Brewing’s options to more traditional treatment systems.

Solution

To address the challenges, New Belgium Brewing adopted the AnMBR, a hybrid system that incorporates:

- Anaerobic digestion to break down organic matter and produce methane-rich biogas.
- Ultrafiltration membranes to retain biomass and deliver a high-quality effluent.

The system is uniquely suited for industries generating high-organic-load wastewater and needing efficient energy and water reuse solutions in space-constrained settings.

Asheville, North Carolina, USA

Impact

- Achieved strict BOD and TSS limit, making water suitable for reuse or compliance discharge.
- Converted organic waste into methane-rich biogas, helping offset energy costs.
- Ensured high-performance treatment in a limited plant footprint through a compact design of AnMBR
- It can treat up to 142,000 gallons of wastewater/ day.

 https://www.xylem.com/en-us/resources/case-studies/brewery-achieves-sustainability-objectives-with-adi-anmbr-solution/

Gulf Coast chemical plant invests in ZLD and achieves major cost and water savings

By upgrading from a legacy demineralizer to a modern water treatment system, the plant turned an operational burden into ROI through reduced costs, higher water reuse, and improved safety – advancing zero liquid discharge goals and long-term sustainability

Chemical/Case Study:

How a chemical plant reduced costs, minimized risk, and advanced ZLD

Challenges

A Gulf Coast chemical facility aimed to expand its boiler feedwater capacity while achieving a zero liquid discharge (ZLD) target. However, high TDS levels in a proposed well-water source threatened to increase regeneration frequency of the aging demineralizer system, leading to excessive chemical use, increased wastewater volumes, and operational inefficiencies.

Solution

To address these challenges, the facility replaced its unreliable demineralizer with a modular water treatment solution. Key components included:

- A 300-gpm expandable reverse osmosis (RO) system with mobile cation softening as pretreatment
- Off-site regeneration to eliminate hazardous chemical storage
- Integration of RO concentrate reuse for cooling tower makeup
- Remote monitoring for performance tracking and uptime assurance

The system was deployed under a water management services agreement, reducing capital burden and ensuring water quality at a predictable cost.

Chemical plant, Gulf Coast, United States

Impact

- Reduced 22 million gallons/year of wastewater.
- Achieved $300,000 savings by eliminating emergency mobile demineralizer use.
- Reused 2.2 million gallons/month of RO concentrate for cooling tower makeup.
- Improved workplace safety by eliminating on-site hazardous chemical handling.
- Redirected capital and manpower toward core operations.

 https://www.xylem.com/en-us/resources/case-studies/turnkey-solution-to-meet-zero-liquid-discharge-goals

US Medical Manufacturer expands production while meeting discharge limits with reuse

By implementing a high-efficiency nanofiltration system, the manufacturer achieved regulatory compliance, enabled production expansion, and secured long-term water cost savings. This smart reuse solution strengthened the facility's operational resilience and ROI, while advancing its sustainability goals.

Healthcare/Case Study:

A recovery system projected to save millions and eliminate feedwater dependency

Challenges

A U.S.-based medical device manufacturer faced production growth limitations due to strict municipal water discharge limits and a mandated 10% reduction in industrial water consumption. The facility also aimed to minimize raw water usage and reduce disposal costs while improving effluent quality. At the time, the plant generated a 375 GPM waste stream contaminated with organic and inorganic by-products, posing compliance and operational challenges.

Solution

To meet water reuse, quality, and production goals, a nanofiltration (NF) system was deployed with:

- Activated carbon for chlorine and organic removal
- Nanofiltration unit for selective rejection of organics while retaining required inorganics
- Ozonation and sanitization for microbial control
- On-site storage and distribution system for reuse integration

The system was piloted and optimized to ensure minimal fouling, reduced cleaning, and reliable long-term operation.

United States

Impact

- Recovered 80% of the 375 GPM waste stream (300 GPM reused).
- Saved over 52 million gallons/year of feed water.
- Projected to save $3.36 million over 10 years.
- Superior water quality achieved, exceeding feedwater standards and reducing organics and bacteria to target thresholds.
- No re-injection of key inorganics required, reducing chemical costs.

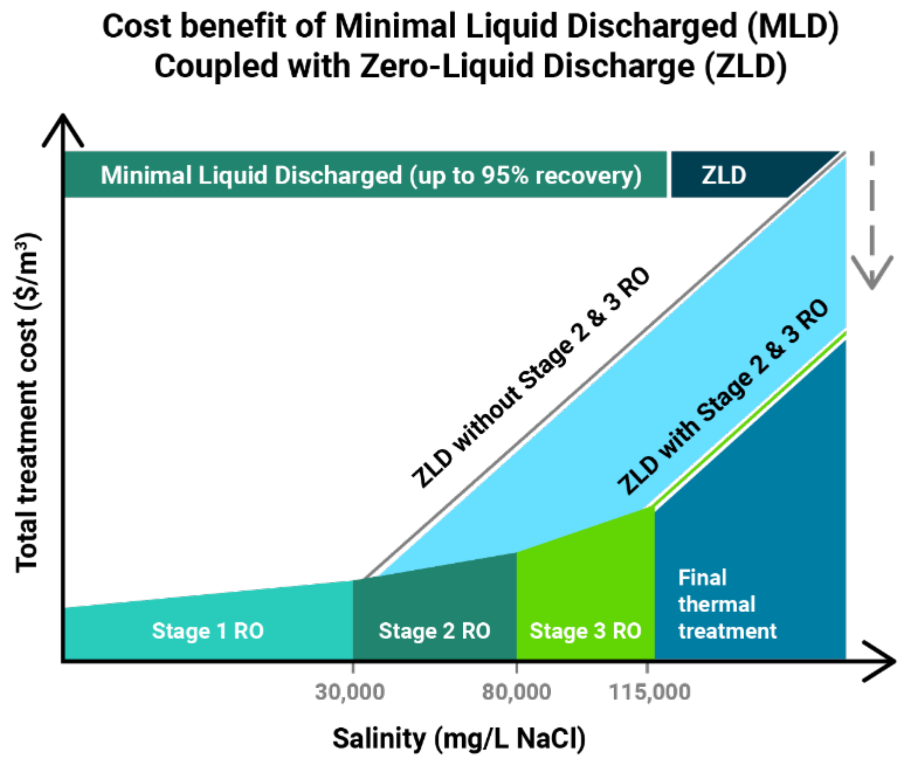
MLD and ZLD: building blocks of industrial water resilience

Growing focus on responsible water practices has made minimum liquid discharge (MLD) and zero liquid discharge (ZLD) essential, complementary approaches in industrial water management. Table 1 highlights the strategic differences between the two. ZLD always requires a thermal stage, figure 7 demonstrates how using membrane technologies upfront reduces the load on that final step and lowers overall costs.

Table 1. MLD vs ZLD

	MLD: Tactical agility	ZLD: Visionary endpoint
Purpose	Accelerates water recovery while optimizing cost and energy	Enables full water loop closure, aligns with ESG leadership and compliance
Best For	Industries seeking cost-effective, high-recovery systems with manageable CapEx	Regions with water scarcity, high discharge penalties, or regulatory mandates
Value proposition	Fast ROI, scalable implementation, adaptable across sectors	Environmental credibility, resource recovery (salts, nutrients), long-term autonomy
Strategic message	“Build resilience and efficiency now”	“Future-proof your operations for zero-waste compliance”
Regulatory use case	Ideal for voluntary or cost-driven reuse	Often mandated in water-scarce or highly regulated areas
Role in circularity	Mid-point enabler of reuse culture and infrastructure	Final milestone in industrial water circularity

Figure 7. Cost comparison for MLD and ZLD systems



 https://www.sciencedirect.com/science/article/abs/pii/S2213343720307673

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Minimum Liquid Discharge (MLD) and Zero Liquid Discharge (ZLD)

Rather than choosing between MLD and ZLD, companies should view them **as complementary milestones on the same journey, toward closed-loop, circular water systems that align with economic, environmental, and regulatory objectives.**

Phasing the future: from MLD today to ZLD tomorrow

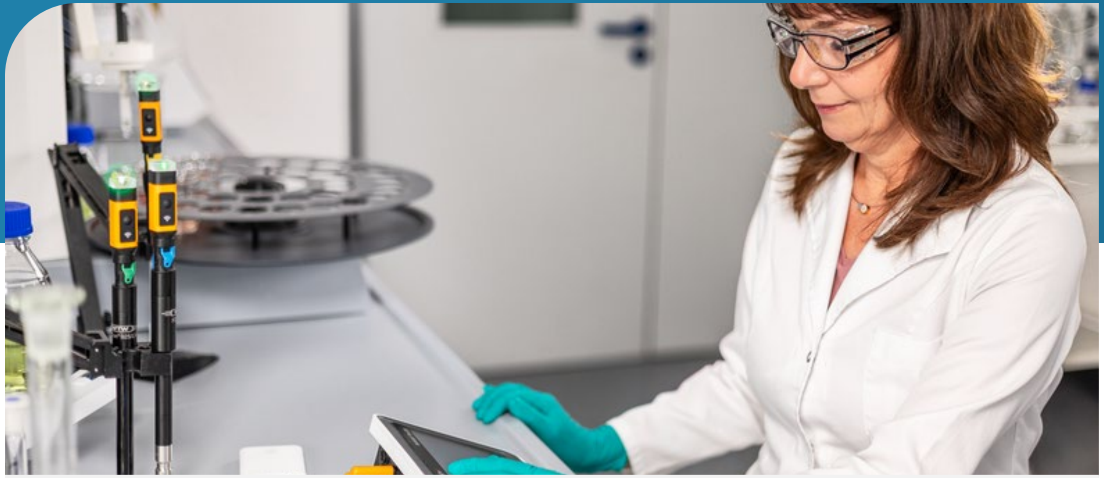
MLD provides the tactical flexibility to respond to today's water challenges, while ZLD offers a visionary endpoint aligned with circular economy principles.

01	Industrial leaders must adopt a phased approach to sustainable water management.
02	MLD should be prioritized as a near-term, scalable solution that delivers immediate benefits, regulatory compliance, reduced freshwater intake, and lower operational costs. It serves as a pragmatic starting point, especially in regions with moderate water stress or evolving discharge norms.
03	However, forward-looking organizations should simultaneously chart a path toward ZLD as a long-term objective. ZLD ensures complete elimination of liquid waste and enables resource recovery, aligning operations with future environmental mandates, circular economy principles, and investor expectations around ESG performance.
04	Adopting this dual-track strategy positions organizations to stay ahead of tightening regulations while future-proofing operations against escalating water and environmental risks.

Industry	Preferred approach
Food and Beverage industry	MLD supports the recovery of valuable by-products (e.g., proteins from whey), while ZLD's thermal processes may degrade organics.
Pharmaceutical Industry	ZLD prevents the discharge of bioactive and other harmful substances into the environment.
Semiconductor Industry	ZLD prevents the release of the industry's complex and hazardous effluents into the environment.

The table outlines preferred approaches tailored to each industry's specific needs. However, globally, ZLD is more commonly adopted due to legal mandates than as a routine industry practice.

The future of industrial reuse: hybrid systems & membrane innovation



Hybrid systems improve flexibility and performance

Hybrid systems that combine key treatment technologies will ease adoption and help industrials make the most of their reuse potential.

By integrating physical, chemical, biological, and thermal processes with advanced digital solutions, commercial water users can:

- improve contaminant removal
- reduce energy consumption and operational costs
- adapt to treat complex and varied wastewater streams, and
- strengthen system resiliency.

Membrane innovations reduce downtime and costs

Membrane filtration technologies will continue to advance, reducing system maintenance and downtime, improving efficiencies, and unlocking cost-savings and revenue opportunities.

- Innovative coatings to prevent fouling and more durable materials will extend membrane life and enable reuse systems to tackle high-salinity and chemically aggressive wastewater streams.
- RO, ED (electrodialysis), and MD (membrane distillation) processes will evolve to optimize brine concentration and enhance resource recovery.

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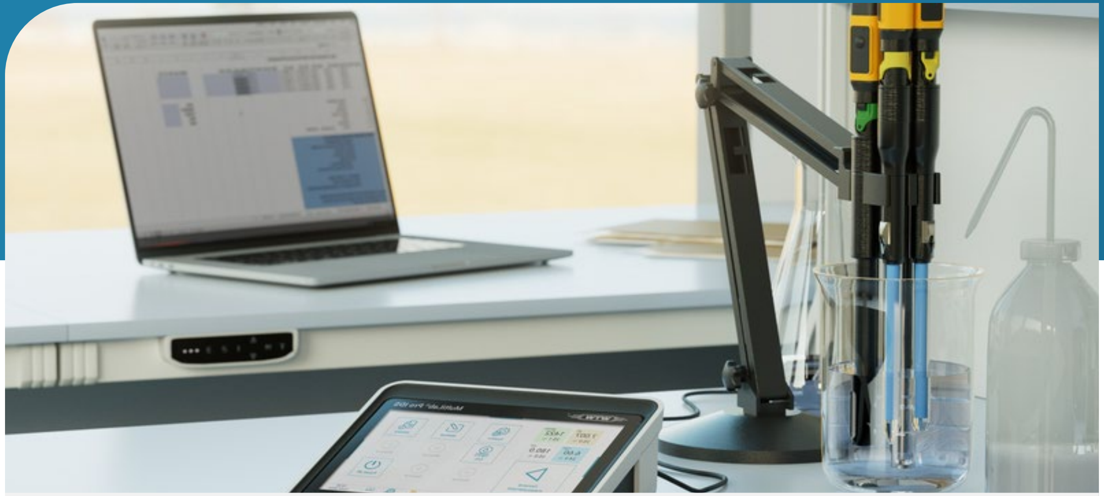
The future of industrial reuse: AI-driven intelligence and innovative business models



AI-driven intelligence strengthens water reuse performance

Real-time monitoring, integrated digital platforms, and AI-powered analytics are transforming how industrials manage water. Unified data from sensors, treatment systems, and water sources helps operators optimize existing infrastructure, automate treatment processes, and anticipate issues before they escalate.

Centralized dashboards and collaborative interfaces strengthen decision-making, improve responsiveness to regulatory or operational changes, and enhance system reliability while reducing energy use and costs.

Innovative business models drive project implementation

Traditional approaches like EPC (Engineering, Procurement, Construction) and BOT (Build, Operate, Transfer) are evolving. New models—such as temporary leasing of water treatment systems with options for later purchase, or outsourcing water services for process and wastewater—are gaining traction.

These alternatives reduce upfront CAPEX and allow industrial users to stay focused on their core operations while leaving water management to specialized experts

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Key insights

A proactive, systems-wide approach powered by innovation, investment, and institutional alignment is key to realizing the full potential of industrial water reuse

Strengthen business resiliency through on-site reuse

Reduce reliance on municipal treatment systems to mitigate business risks from supply disruptions, surcharge variability, and policy shifts to improve business and community water security.

Redesign water infrastructure for circularity

Transform water systems from isolated treatment points to integrated reuse networks to create a new and reliable supply of affordable, clean water and accelerate circular economy goals.

Unlock resource recovery as a secondary revenue stream

Deploy systems to extract nutrients (e.g., phosphorus, nitrogen), metals (e.g., lithium, copper), and energy (e.g., biogas, hydrogen) from wastewater, converting liabilities into financial assets.

Innovative financing mechanisms

Mobilize capital through green bonds, water purchase agreements, and performance-based incentives that recognize long-term savings and risk mitigation associated with reuse investments.

Treat regulation as an innovation catalyst

Anticipate tightening global water and wastewater standards and turn compliance into a competitive advantage by setting the pace on adopting advanced reuse solutions.

Deploy advanced modular, scalable technologies

Harness integrated systems or outsourced water management service solutions and expertise to make transitioning to reuse easier, more affordable, and more scalable.

Leverage digital transformation for real-time optimization

Invest in AI-powered systems, digital twins, and predictive diagnostics to dynamically monitor and respond to influent variability, treatment performance, and compliance thresholds.

A scalable path from MLD to ZLD

Adopt MLD as a near-term, scalable solution to achieve regulatory compliance, reduce costs, and optimize water recovery. Plan for ZLD as the long-term goal, enabling total effluent elimination, resource recovery, and future regulatory compliance.

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Let's Solve Water

Thank you

Key questions and methodology

The goal of this whitepaper is to explore how industrial water reuse is evolving from an optional practice into a critical component of sustainable water management. This white paper aimed to address the key drivers compelling industries to adopt water reuse, what strategic actions industries can take to overcome water reuse challenges and to future-proof their operations, and how advanced treatment technologies can enable a shift toward circular, resilient water systems. To deliver a clear, insightful, and evidence-based narrative, we followed a multi-layered approach.

1. Literature review and industry reports

- To ensure a holistic understanding of the drivers, challenges, and opportunities surrounding industrial water reuse, we conducted an extensive review of diverse knowledge sources.
- This included global and regional policy documents, regulatory guidelines (e.g., EPA), international frameworks (e.g., UN, World Bank), corporate sustainability reports, peer-reviewed academic publications, and thought leadership from technology providers.

2. Expert insights

- To supplement insights from the literature review and ensure the findings reflect on-ground realities, we engaged with industry experts through in-depth interviews.
- These included water engineers, environmental compliance officers, and sustainability leads across industrial sectors such as power generation, F&B, microelectronics, and pharmaceuticals.
- We further enriched the analysis with perspectives from technology innovators and sectoral thought leadership to validate key themes and uncover operational and systemic challenges.

3. Emerging technologies driving industrial water reuse

- To understand how industrial water reuse can be made more viable and future-ready, we assessed a range of enabling technologies. This included a review of advanced treatment systems, such as membrane-based filtration, biological processes, adsorption systems, advanced oxidation techniques, and digital innovations like AI, IoT, and automation.
- The objective was to identify how these technologies are shaping industrial wastewater management and how digital tools enhance efficiency and cost-effectiveness through real-time monitoring and predictive maintenance.

4. Case study analysis

- To ground the analysis in real-world applications, we provided a series of case studies across industries such as semiconductors, manufacturing, food & beverage, and others. These cases were selected to examine how advanced water reuse technologies are being deployed in diverse operational contexts.
- This methodology allowed us to blend technical depth with practical relevance, informing the development of a strategic framework that guides stakeholders in implementing effective, scalable, and sustainable water reuse solutions.