MIT Technology Review Insights

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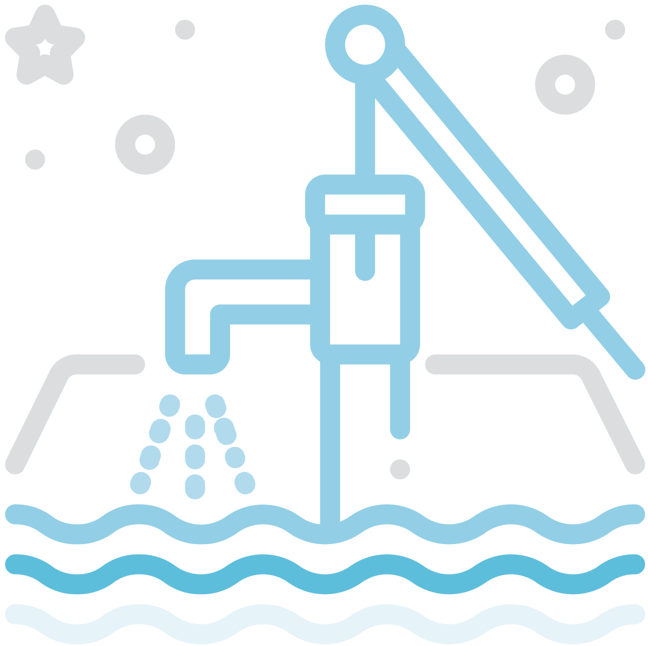
Schneider Electric

Water-intensive industries benefit from circularity, innovative investments, and data-driven technologies.

Driving sustainable water management



From semiconductor manufacturing to mining, water is an essential commodity for industry. It is also a precious and constrained resource. According to the UN, more than **2.3 billion people faced water stress** in 2022. Drought has cost the United States $249 billion in economic losses since 1980.

Climate change is expected to worsen water problems through drought, flooding, and water contamination caused by extreme weather events. "I can't think of a country on the planet that doesn't have a water scarcity issue," says Rob Simm, senior vice president at Stantec, an engineering consultancy focused on sustainability, energy solutions, and renewable resources.

Economic innovations, notably AI and electric vehicles, are also increasing industrial demand for water. "When you look at advanced manufacturing and the way technology is changing, we're requiring more, higher volumes of ultrapure water [UPW]. This is a big driver of the industrial water market," Simm says. AI, computing, and the electric vehicle industries all generate immense quantities of heat and require sophisticated cooling and cleaning. Manufacturing silicon wafers for semiconductor production involves intricate cleaning processes, requiring up to 5 million gallons of high-quality **UPW daily**. With rising demand for semiconductors, improvements in water treatment and reuse are imperative to prevent waste.

Key takeaways

1. **Climate change and water scarcity are driving innovation aimed at ensuring a plentiful and clean water supply. Water stress is a real threat to water-intensive industries like semiconductor manufacturing, mining, energy, chemicals, and consumer packaged goods.**

2. **The evolution of water filtration systems during the last century – from sand filters to membrane filtration technology – has boosted accessibility to clean water for both humans and industrial users. AI technology promises much more.**

3. **Digital technology – AI, machine learning, digital twins, sensors, cloud, and more – can work with water-intensive industries to root out waste, find opportunities for investment and circularity, and shape engineering processes for sustainable water management.**

Data-driven industrial water management technologies are revolutionizing how enterprises approach conservation and sustainability. They are harnessing the power of digital innovation by layering sensors, data, and cloud-based platforms to optimize physical water systems and allow industrial and human users to share water access. **Integration of AI**, machine learning (ML), data analytics, internet of things (IoT) and sensors, digital twins, and social media can enable not just quick data analysis, but also can allow manufacturers to minutely measure water quality, make predictions using demand forecasting, and meet sustainability goals.

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> Rob Simm, Senior Vice President, Stantec

The critical role of water in industry

Global companies move to prioritize water management in their sustainability efforts

Mining, minerals, and metals

Water's role
Extracting minerals, processing, cooling, and controlling dust.

Water challenges
Traditional lithium extraction pumps water beneath vast salt flats to mix with minerals below. The mix is pumped up and set out to evaporate until the lithium can be separated out in 12 to 18 months. Each ton of lithium extracted this way uses more than 500,000 gallons of water.

Industry solutions
Morocco's OCP Group, a state-owned phosphate rock miner producing phosphoric acid and fertilizer, is on track to use only sustainable water by 2028 and zero fresh water by 2030. Investment in desalinization helped create 25 billion liters of water for its operations. It uses recycled water for 80% of its phosphate enrichment process. Its plant in the city of Khouribga recycles 5 million cubic meters of wastewater from Moroccan cities each year.

Energy and chemicals

Water's role
Cooling machinery, steam to generate power, chemical processing, and extraction.

Water challenges
The machinery-intensive processes for refining chemicals and fossil fuel mean most water in these industries is used for cooling equipment. These machines can contain chemical reactions that produce heat. The U.S. electric power sector used 47.5 trillion gallons of water for cooling in 2020.

Industry solutions
The American Chemistry Council (ACC) is investing in broadening conservation efforts to find more efficiencies. ACC and The Water Council, a nonprofit focused on global water, are developing a measurement tool, the Water Body Risk Assessment, which seeks to help manufacturers consider factors such as climate change, nearby industries, and population growth.

Consumer packaged goods

Water's role
In-product use, processing, environmental controls, maintenance, packaging, and transportation.

Water challenges
The Water Footprint Calculator run by the nonprofit Grace Communications Foundation calculates the amount of hidden water used for CPGs, from raw materials to finished product. Producing one pair of denim jeans requires 2,866 gallons of water. The ubiquitous clear plastic water bottle serves up hidden water, too: For every liter of water it contains, the extraction, refining, and manufacturing of the plastic bottle takes up to 5.3 liters of water.

Industry solutions
CPG conglomerates such as Unilever, L'Oreal, and Procter & Gamble are looking to reduce water in consumer products by offering concentrated and solid versions. This not only conserves water, but saves on energy and transportation costs. Beverages, cleaning, and personal care products are current targets—liquid laundry detergent can be 60% to 90% water.

Semiconductor manufacturing

Water's role
Highly processed ultrapure water (UPW) for cleaning impurities, and machinery cooling.

Water challenges
Water scarcity where semiconductors are manufactured threatens global availability and pricing. Chips are used in everyday devices from lightbulbs to medical equipment. Each semiconductor chip requires thousands of gallons of UPW for production: Producing UPW is complex, expensive, and has a high carbon footprint. The more complex the chip, the more UPW it requires.

Industry solutions
The semiconductor world is concentrated among a few manufacturers. Most are directly impacted by water stress, and many set clear goals for conservation, such as reducing water use, increasing water recycling and reuse, using reclaimed water (wastewater), and water restoration (planting vegetation to hold water).

More integrated industrial water management solutions, including reuse, industrial symbiosis, and **zero liquid discharge** (ZLD), will all be crucial as greenfield industrial projects look toward water reuse. "Water is an input commodity for the industrial process, and wastewater gives you the opportunity to recycle that material back into the process," says Simm.

Treating a precious resource

Water filtration systems have evolved during the past century, especially in agriculture and industry. Processes such as low-pressure membrane filtration and reverse osmosis are **boosting** water access for both human and industrial users. **Membrane technologies**, which continue to evolve, have halved the cost of desalinated water during the past decade, for example. **New desalinization methods** run on green power and are dramatically increasing water output rates.

Advances in AI, data processing, and cloud computing could bring a new chapter in water access. The **automation this permits** allows for quicker and more precise decision-making. Automated, preset parameters let facilities operate at capacity with less risk. "Digital technology and data play a crucial role in developing technology for water innovations, enabling better management of resources, optimizing treatment processes, and improving efficiency in distribution," says Vincent Puisor, global business development director at Schneider Electric.

Puisor says his company uses sensors alongside cloud analytics and AI for a holistic approach to efficiency, providing the visibility to monitor processes and make predictions. "Previously, maintenance was scheduled at fixed intervals," he explains. "Now, instead of predefined schedules, we have become much more proactive. Systems can react in real time based on data insights. With more available data and AI models analyzing it, systems can adapt and predict the impact of actions."

Stantec helped New Zealand–based Wellington Water to build a predictive model of its operational performance, Simm says. The model used **pump data** to anticipate problems and detect failing pumps before service was affected. Simm says the model delivered an estimated 20% savings in electricity costs, translating to reduced emissions. And in another example, a wastewater treatment plant in Germany reduced its aeration energy use by 30% after implementing an **IoT-powered digital twin**, with sensors estimating aeration and chemical inputs.

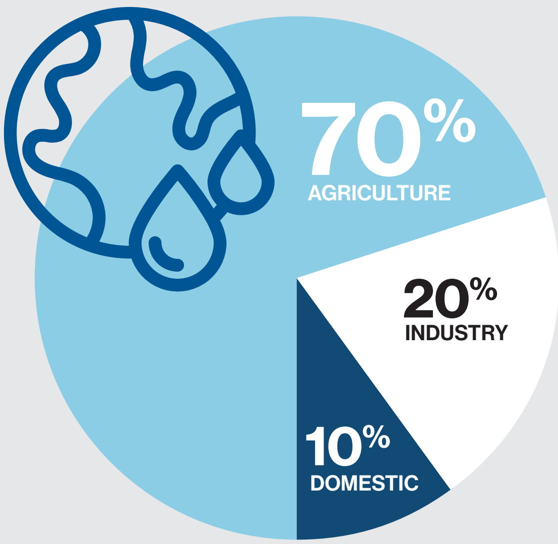
Prediction capabilities will be more important in a changing climate. **Scottish Canals**, for example, created a digital twin that simulates water conditions and weather data along the canal, allowing the organization to automate lock operations and control water levels ahead of potential flooding events.

Creating a data-driven circular water economy

Aquapolo is the largest project for production of reused water in South America, and it is one of the largest water reuse companies in the world, processing more than 250 gallons of reused water per second. It primarily serves industrial clients like Italian tiremaker Pirelli, Norwegian aluminum company Hydro, and petrochemical companies. Founded in response to climate change, Aquapolo counts GS Inima Industrial and São Paulo municipal sanitation company Sabesp as its partners. Aquapolo supplies recycled wastewater for industry in São Paulo.

Global fresh water use

Consumption of fresh water has been increasing about 1% each year.



Source: Compiled by MIT Technology Review Insights with data from "The United Nations World Water Development Report 2024: Water for prosperity and peace," UNESCO, 2024

Water-scarce São Paulo, with more than 20 million residents, relies on the surrounding region's resources. Urbanization created water availability conflicts in former industrial areas where residents sought new housing opportunities. "We have to use water rationally and efficiently," says Aquapolo CEO Marcio da Silva Jose, as most of Brazil's population lives in the southeast, far from the Amazon's freshwater.

To create potable water, Aquapolo conducts tertiary treatment by acquiring wastewater from Sabesp, using a **biological reactor**, ultrafiltration, and reverse osmosis. The heart of the process is the biological reactor, which is a tank with a colony of bacteria that feeds on nitrogen, phosphorus, and organic material. Membrane filtration and selective reverse osmosis for high mineral content ensure that the water is safe for consumption and industrial use.

Data is also advancing Aquapolo's efforts to create a circular economy. The company uses AI tools to help optimize decision-making, with automation and remote monitoring built into its processes. Its data repository stores all data from the company's operations, including parameters such as the water's ammonia content, conductivity, and pH levels. "With this remote monitoring system, we can operate the entire plant from one control room," says Jose.

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Unlocking sustainable mining

German supplier of pumps and pump systems Wilo has put sustainable water management at the forefront of its business, using data-powered technologies to optimize water consumption. As the quantities of water in mining vary greatly across regions, technology is key to ensuring that operators properly manage limited resources and avert dangerous flooding. "Much mining infrastructure is really obsolete," says Tushar Sheel, market management and business development manager at Wilo. "Data from our equipment and the surrounding environment can provide better systems control and allow us to predict issues before they happen."

Wilo uses Schneider Electric's integrated IoT platform for monitoring and managing machines and operations. IoT-enabled sensors detect water levels and energy consumption, as well as identifying any potential flaws or malfunctions in the equipment. The ability to monitor equipment located up to 50 kilometers away enables remote oversight from one central location. "It's important that the pumps never stop, so if something goes wrong, the workers need to be on-site immediately to repair the pumps," says Sheel. "With analytics, they can know how much time is left for the pump to run, and they can automatically order spare parts or check their stocks in advance. They can know beforehand if there will be a failure, and they can mitigate it."

Matthias Pantze, group director of strategic business development at Wilo, says that predictive capability is significant. "When we notice early if there is something we need to change in the system, it reduces our risk by allowing us to intervene earlier o prevent bigger damages to the equipment."

This data archive is helpful in understanding São Paulo's seasonal patterns, with its pronounced rainy and dry seasons, and their effects on the city's environmental conditions. Data analytics provides insight and identifies trends tailored to meteorological needs. "We can analyze what happens to different parameters each month and correlate that data to predict chemical consumption, optimal membrane cleaning times, and so on," says Jose. "Digital and data solutions provide amazing help for us to predict scenarios, measure impacts in real time, and make comparisons."

Data is also invaluable for managing toxic pollutants that may impact the biological reactor's bacteria levels. Aquapolo takes preemptive measures by temporarily shutting off the wastewater inflow when analytics anticipate excess pollutants. "By measuring these parameters, we're able to predict what may happen in the future; we shut off the supply of wastewater when we detect a potentially dangerous level of pollutants, and replace it with a supply of clean water, so the system can keep operating without becoming contaminated," says Jose.

Highlighting Aquapolo's success in using digital solutions for water processing, Jose says their production is high enough that industry no longer competes with the local population for water resources. This success is a model for water-intensive industries around the globe.

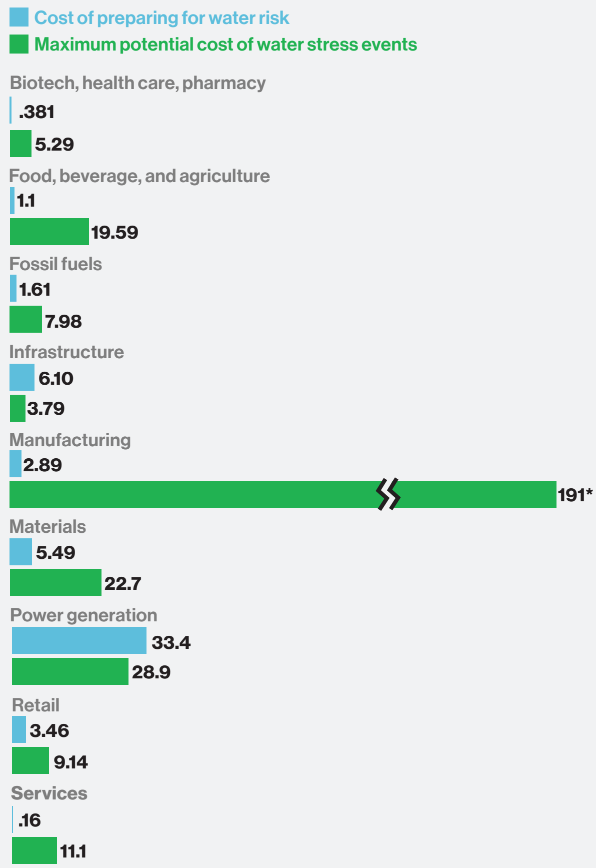
Environmental data shows that the **factors that increase water stress continue to rise**: the **global urban population** is slated to grow by a factor of 1.5, reaching 6 billion people; **worldwide water demand** is expected to increase 55% by 2050. Some studies say **global water use for energy** will increase 20% over 2010 figures by 2035, and by **85% by 2050**. Water, Jose says, "is a very important and finite resource we have. So, we must take better care and change the way we deal with it. We can stop wasting water right now, and that's a must."

The cost of water emergencies

The Carbon Disclosure Project (CDP) is a global nonprofit that gathers and standardizes environmental data from more than 23,000 companies and 1,100 government entities.

CDP data from 2020 data shows that the maximum potential cost of water emergencies to industry is more than five times higher than the cost of preparing for them.

"Water emergencies" include flooding, water scarcity, regulatory restrictions, drought, severe weather, and damage to water quality.



*This figure is high in part due to the large number of manufacturing respondents and two significant figures exceeding $50 billion: one linked to flooding, and another linked to reputational risk associated with pollution.

Source: Compiled by MIT Technology Review Insights with data from the "CDP Global Water Report for 2020," 2024.

"Digital and data solutions provide amazing help for us to predict scenarios, measure impacts in real time, and make comparisons."

Marcio da Silva Jose, CEO, Aquapolo

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