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Let's Solve Water

NET Zero
THE RACE
WE ALL WIN

Mapping the route to water utility decarbonization

NET THE RACE WE ALL WIN Zero

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Foreword

The effects of climate change are now plain to see. Every day, headlines bring news of another community suffering from severe storm events, flooding, or drought. This is the reality of a warming world.

For water and wastewater utilities, these impacts come on top of other, more familiar challenges: aging networks, rising populations, shrinking fresh water supplies, evolving regulations, and tightening budgets. Utilities do an exceptional job providing essential services to their communities – but climate change is making that job harder.

But I am optimistic. We can mitigate climate change. Water utilities around the world can make a real and lasting difference.

The task of reducing greenhouse gas emissions presents a rare opportunity to rethink how we do business. New approaches and affordable technologies can kick-start network optimization, enabling utilities to both decarbonize and serve their communities more effectively.

This paper captures some of the bold, practical steps utilities are already taking toward resilient, zero-carbon operations and a leaner, smarter future.

I have seen first-hand the thoughtful, community-centered approaches utilities are taking to decarbonize. And they're not alone. The broader water ecosystem is getting behind them – from regulation to financing – to remove hurdles and give them the space to do what they do best: deliver for their community.

Rapid decarbonization of the water sector is eminently achievable. This paper outlines some of the ways to get it done. The time to act, the time to make a difference, is now.

Patrick Decker
President and Chief Executive Officer of Xylem

Executive summary

The race to net-zero emissions is on. Since the Paris Agreement of 2016, more than 70 countries, accounting for 76 percent of all greenhouse gas (GHG) emissions, have pledged to meet ambitious net-zero goals.[1] Most have committed to a 45 percent cut in GHG emissions by 2030, and net zero by 2050.[2]

That's a challenge for water utilities. Water and wastewater infrastructure is a major GHG contributor – making up approximately 2% of global GHG emissions, on par with the global shipping industry.[3]

Utilities are not just required to deliver on financial metrics. They must also meet their communities' need for safe, affordable water and sanitation, and comply with regulatory requirements. Those imperatives don't pause for emissions reduction.

And they don't have to. Utilities can reduce emissions quickly and affordably. With the right approaches and proven technologies, net zero is possible.

The strategies in this paper enable water utilities to hit net zero and still meet their community and regulatory obligations. More than that, these approaches can optimize utility operations to deliver better sustainability and business outcomes, hand-in-hand.

Net zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed by the atmosphere, such as by oceans and forests.[4]

Net zero: creating smarter utilities and a healthier planet

Worldwide, water and wastewater infrastructure make up approximately 2% of GHG emissions.[5] A medium-size water utility offering both clean water and wastewater services can produce the equivalent of 42,000 tons of CO_2 emissions annually from energy usage only – the same as 150 commercial flights from Paris to New York City.[6] This is before the impact of process emissions such as methane or nitrous oxide, which can be more damaging than CO_2, are considered.

Simultaneously, demand for services continues to grow. Two billion people have no access to safe drinking water. Almost four billion don't have proper sanitation facilities.[7] As more people connect to water utilities, emissions will rise unless we make operations more carbon efficient and, ultimately, carbon neutral.

Population growth isn't the only challenge. Extreme weather events place added pressure on aging infrastructure. Contaminants such as poly-fluorinated alkyl substances (PFAS) – "forever chemicals" – require more energy-intensive treatment processes.

Every day, utilities walk a fine line. The industry must meet the growing demand for quality water services. They must deliver these services at a cost communities can bear. And they must meet their net-zero targets.

The UN wants everyone to have access to clean water and sanitation by 2030.[8] Can water utilities achieve this and cut their carbon footprint?

Research by Xylem and partners shows that wastewater utilities could cut electricity-related GHG emissions – up to three-quarters of total sector emissions[9] – in half using existing technologies.[10] Around 95 percent of this impact can be achieved at zero or negative cost.

Net-zero strategies can kick-start comprehensive network optimization.

The industry's rapid progress towards resilient, zero-carbon operations does more than lower emissions. It helps cut energy use and reduce water losses – dramatically lowering costs. It also makes operations and processes safer and more stable.

While this paper focuses on some of the practical actions that utilities can take, it does not address two of the key elements of delivery – financing and contracts. These are points that require dedicated discussions and will be addressed by Xylem in future contributions.

NET Zero THE RACE WE ALL WIN

Any water utility can start, today, and make rapid progress towards optimized operations, by:

- **Setting net-zero targets**
- **Optimizing energy use across existing assets**
- **Embedding net-zero strategies into capital planning**
- **Transforming from treatment to resource recovery**

Process emissions – a unique challenge and opportunity

GHG reduction strategies often focus on energy savings. This approach can neglect process emissions, particularly methane (CH_4) and nitrous oxide (N_2O), derived from sewage treatment.

According to Xylem research, N_2O emissions can make up between 25-75 percent of total plant emissions, depending on process and electricity mix. While methane usually represents a lower proportion of total emissions, it can be up to 50 percent of total emissions in cases where anaerobic treatment byproducts are not captured, or leakages occur.

A better understanding of process emissions is needed not only for utilities to reach their own GHG goals, but also to establish a firm baseline for total water-sector emissions.

Managing process emissions, particularly nitrous oxide and methane, begins with accurately measuring them. Reliable measurement solutions are in their infancy, but the industry is gathering pace in developing accurate and affordable systems.

At Xylem, we have targeted partnerships with renowned institutions, such as Massachusetts Institute of Technologies (MIT) and Isle Utilities, which have led to active investment in start-up technologies and services. This will accelerate the technical and commercial readiness of fresh solutions that can make a real difference – such as sensors enabling the measurement of gas emissions. Digital twin models use this data for real-time optimization of existing processes and minimization of nitrous oxide emissions.

On the starting line: developing a net-zero strategy

As of April 2022, Global Water Intelligence has counted more than 80 water and wastewater utilities with explicit net-zero and climate-neutrality targets. Of these, 26 have joined the UN Race to Zero. [11] Alongside this, a much larger number of utilities are working closely with their communities and governments to achieve net-zero targets.

Emission scopes explained:

- **Scope 1**: direct emissions from sources controlled or owned by an organization. This includes emissions from fuel combustion – for instance, diesel dewatering pumps. Process emissions such as N_2O also fall within Scope 1.[12]
- **Scope 2**: indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling. Although scope 2 emissions happen elsewhere, they are accounted for in an organization's GHG inventory because they are a result of the organization's energy use.
- **Scope 3**: emissions from assets not owned or controlled by the organization, but that the organization indirectly affects through its value chain.[13]

Creating a net-zero strategy

As water utilities accelerate their journey to net zero, these six considerations for shaping emissions reduction targets can help keep them on track.

Based on frameworks from major international and national industry bodies, these points are not meant to be prescriptive. Instead, they look at some best practices across industries to help utilities shape their net-zero strategies.

1. **Align organizational and sustainability goals:** Climate targets do not have to be burdensome. The Science Based Targets initiative (SBTi) encourages companies to set targets that build resilience, drive innovation, and prepare the ground for policy shifts. With this approach, utilities can serve customers, benefit the bottom line, and protect the environment.

2. **Set your baseline – what is measured gets managed:** A significant step taken by many organizations is to map their current emissions profile. Suppliers should offer both basic and advanced audits, providing analyses on the condition of assets and the risks associated with infrastructure. This type of information ensures a strong base for building an accurate emissions profile.

3. **Match short-term interventions to long-term thinking:** Commit to an emissions-reduction goal and set clear progress milestones. The SBTi recommends targets cover a minimum of five and a maximum of 10 years.[15] Utilities should also look for "quick-win" GHG reductions. Optimization and capital planning strategies are outlined later in this paper.

4. **Turn on the lights by embracing digital and data:** Digital solutions are helping water managers across the industry to address climate pressures. In many cases, this involves using data to better understand the current state. It can also involve using digital systems to improve operational and environmental outcomes at an affordable cost.[16]

5. **Tackle process emissions:** When setting targets, wastewater utilities are reckoning with a major, often overlooked, element: process emissions. By-products, particularly N_2O, can be a substantial proportion of emissions. While technologies to address process emissions are less advanced, there is momentum.

6. **Be open and transparent:** Providing a transparent view of progress is essential to engage stakeholders and scale progress. This is something that is being explored by the International Water Association (IWA). IWA is developing a community of practice around adaptation and mitigation to climate change. The initiative aims to support the bridging of science and practice, triggering the necessary cultural shifts and actions.[17]

Racing smart: optimizing energy and resources

Cost neutral strategies are being deployed across the water sector to reduce emissions while ensuring process stability. To begin, many have looked to uncover the root cause of inefficiencies:

- **Inefficient legacy assets:** For many water utilities, low hydraulic and motor efficiencies, unsteady flow, and high levels of solid content all depress efficiency. In wastewater facilities, limited process-control can result in excessive energy use by aeration blowers and ineffective biologic processes that release N_2O.
- **Under-performing assets:** Applications, particularly those with rotating equipment, are often not working at optimal efficiency. Design oversizing can lead to energy waste and higher operating costs.
- **Aging infrastructure:** In many countries, wastewater-collection assets and water-distribution networks are reaching end-of-life. Water infiltration in sewers and water losses in distribution networks result in excess pumping and treatment. In 2019, the global volume of non-revenue water was estimated to be 30 percent of the produced drinking water, equivalent to 346 million cubic meters per day, representing 3 percent of the global freshwater uses.[18] The resulting excess pumping and treatment creates emissions.

Strategy: Streamline asset and process management for Scope 1 and 2 emissions cuts

Assess and identify systems:
- Emissions-associated assets across operations
- Users of energy and their role and use within the system
- Nutrient loading in wastewater plants, including relevant emissions factors[19]

Evaluate opportunities:
- Current energy management practices
- Data capabilities including energy use and cost

Implement and monitor activities:
- Stakeholder education and communications
- Evaluate assets within the system for optimization
- Identify data gaps and areas for improvement

By deploying high-efficiency technologies, utilities can affordably progress towards net zero.

Factoring in the effort required to hit net-zero goals can seem like an added burden. In fact, many utilities have shown that digital technologies can simplify capital planning, accurately find criticalities, and pinpoint investments for the greatest impact.

- Analysis by Accenture and the World Economic Forum (WEF) found that digital technologies can deliver up to 20 percent of the reduction needed to hit net-zero trajectories.[20] **Asset optimization solutions** maximize the energy efficiency of motors and speed drives. Reducing inefficiencies associated with clogging, intelligent pumping systems can cut energy use by up to 70 percent. Optimizing the mixing and aeration of activated sludge, adaptive mixers, with integrated variable-frequency drives, can cut energy use by up to 30 percent.

- **Digital twin technology**, when coupled with advanced data science, helps to reduce GHG emissions by giving utilities enhanced visibility and predictive capabilities. This supports dramatically improved capital and operational decision-making. For example, with smart condition-monitoring, operators can optimize the performance of individual assets, such as pumps, in real-time, and predict failures long before they happen.

- **Leak detection and condition assessment** can deliver significant energy reductions. Free-swimming acoustic sensors can detect gas pockets, water leakages, and zones at risk of failure. These problem areas can then be targeted for maintenance. Cutting real water losses saves energy consumed in the treatment and transport of water and reduces CO_2 emissions from unnecessary pipe replacement and civil construction.

- **Sustainable energy production** is critical to help meet the growing demand for water and wastewater services. Hydro turbines, heat exchangers, and biogas producers are among the solutions utilities can use to harvest hydraulic, thermal, or carbon-based energy from water and wastewater. This is covered in more detail in the final section of this paper.

Case study: EWE WASSER GmbH (EWE)

In Cuxhaven, Germany, EWE WASSER GmbH runs a large municipal wastewater-treatment plant with the capacity to treat wastewater for 400,000 people.

As it relies on energy-intensive technologies such as mechanical aerators, blowers and diffusers, aeration accounts for more than 50 percent of energy consumption.

Until recently, Cuxhaven operated its plant based on set point controls.

To improve the efficiency of aeration, Cuxhaven first had to better understand the performance of the processes involved. Virtual sensors were created to estimate incoming carbon, nitrogen, and phosphorous loads.

With a real-time digital twin of the entire plant, it was then possible to optimize aeration and chemical inputs at each point of the process.

Outcome: Since implementing the solution, the Cuxhaven treatment plant has reduced aeration energy use by 30 percent, or 1.1 million kilowatt hours (kWh) annually – enough energy to power 275 homes for one year.[21]

Eyes on the finish line: embedding net-zero goals in capital planning

In the previous chapter, we described steps utilities can take right away. There are also medium- and long-term investments that will help cross the net-zero finish line.

Prioritizing emissions reduction does not require a fundamental shift in business practice. Nor does it mean large investments or vast new infrastructure.

Rather, the pragmatic path is about finding ways to fold net-zero considerations into existing processes and the flow of day-to-day decision-making.

Strategy 1: Map net-zero opportunities into medium- and long-term planning

Many utilities develop a set of key performance indicators (KPIs) to plan infrastructure upgrades. These KPIs are typically based on factors such as availability of permits, relevant regulatory standards, and so on. By factoring net-zero objectives into these KPIs, utilities can make significant strides in cutting emissions.

Amid upgrades to existing pump stations, treatment equipment or pipe networks, adding a GHG KPI is a straightforward way to embed net-zero strategies, such as:

- New pumping equipment must reduce associated emissions by 40 percent versus existing infrastructure.
- New blower installation must reduce energy consumption by 30 percent when compared to current operations.
- Non-revenue water must be reduced to less than 10 percent, reducing energy consumption.

Strategy 2: Take a greener approach to new capital projects

New capital improvement projects often require years of planning. Despite their timeframes, these projects offer unique opportunities for smart upgrades that can deliver material emissions reductions, and major progress towards net zero.

Consider three common types of capital projects: metrology, pumping, and treatment.

Metrology

Metrology, or water measurement, can have a direct impact on Scope 1 and 2 emissions, particularly those related to vehicles: the "truck rolls" required to read and service meters. By enabling remote, real-time – as opposed to drive-by – reads, utilities can take trucks off the road and dedicate employee time to more critical tasks. For example, the City of Walla Walla in Washington State deployed a smart-utility network to improve the accuracy of its readings. The benefits of accurate, real-time data went far beyond enhancing operations.

According to the city's water distribution supervisor, data takes out much of the guesswork. It eliminates the need to send more trucks into the field, which helps reduce the city's carbon footprint and better conserve resources.

Metrology can also help identify and reduce non-revenue water. This can be a factor in driving down emissions by cutting back water losses and avoiding excess pumping and treatment.

Pumping

Building or upgrading a pump station is an opportunity to design for efficiency. The average pump station – with three 25kW pumps – will consume 652,500 kWh per year. Emissions start from 463 CO_2-eq tones per year.[22] High-efficiency intelligent pumping systems can reduce that by more than 25 percent – or 116 CO_2-eq tones per year.[23]

Scottish Water experienced even more dramatic results. As part of its asset-resilience strategy, Scottish Water replaced one pump at each of two stations with an intelligent pumping system. Each was equipped with extended performance control (XPC) capability and a level pressure transducer.

Approximately 56 hours per month of cleaning and monitoring was reduced to just two monthly checks, delivering significant cost and energy saving as a result. One of the two pumping stations now uses 40 percent fewer kWh a year, the other 30 percent fewer.

Treatment

Utilities are increasingly looking at ways to efficiently decarbonize the treatment process.

Famous for its Roskilde music festival, the town of Roskilde in Denmark was faced with managing a doubling of its 125,000 population each year during the event. Built in 1990, the Roskilde biological wastewater treatment plant required an upgrade.

To minimize operating costs and optimize system efficiency, three high-efficiency blowers, new bottom diffusers, and eight high-efficiency adaptive mixers were introduced. The plant also moved to a bottom aeration system.

The result was a plant that could cater to the seasonal influx of people to Roskilde with an efficient treatment system that also delivered a 50 percent reduction in the plant's energy consumption.

Strategy 3: Turn on the lights by embracing digital

Digital solutions and data analytics can help utilities by giving them a different level of visibility of the sewer system. By using sensors with digital tech, a utility can 'turn on the lights' and get a real-time view of its system. This information provides significantly better situational awareness, something that is vital to good decision-making.

This visibility can be augmented with other systems, such as digital twin technology that provides an accurate virtual representation of the real system. Information can be harnessed to optimize technologies and processes, saving money, cutting energy consumption, and often reducing the need for costly new grey infrastructure.

Case study: South Bend, Indiana

South Bend had a big problem every time a storm hit. Its aging sewer system could not handle the excess discharge. In 2012, the city was looking at a long-term control plan for an estimated $713 million in capital improvements, plus financing costs.

This represented a massive investment for a municipality with a population of just over 100,000. South Bend looked for a solution that would avoid the prohibitive expense.

Four years before, the city had installed a real-time monitoring system of more than 120 sensors located throughout its urban watershed. The water utility decided to expand the sensor network and use it as the basis for a system that directly controlled the pumping system and valve actuators to react in real-time.

Now, the network adapts to sudden wet-weather events by shifting excess flows to under-utilized parts of the network. The utility avoids sewer overflows and prevents water pollution.

Outcome: The smart sewer program has eliminated dry weather overflows and reduced combined sewer overflow volumes by more than 80 percent, or roughly one billion gallons a year. South Bend has achieved approximately $1.5 million in annual operating and maintenance cost savings. In addition, E. coli concentrations in the St. Joseph River have dropped by more than 50 percent, improving water quality.

The smart sewer program not only saved the utility money, but it prevented needless construction of new grey infrastructure which would have had a high level of embedded carbon.

Going further: from treatment to resource recovery

Decarbonization is an opportunity to reimagine conventional approaches to water management. Innovation across the water cycle is already underway.

While much has changed in the water sector over the past century, our approach to wastewater management has largely stayed the same. The standard model treats everything in wastewater as a pollutant to be removed, which requires energy. Making progress toward net zero requires a shift toward viewing wastewater as a resource, rather than as a by-product to be managed.

With this kind of "water resource recovery model", treatment facilities become engines of energy production: efficient refineries producing a broad range of products to meet the needs of the community.[24]

By recovering resources and employing the principals of the circular economy – which maximizes the use of resources and minimizes waste generated for disposal – the sector can leverage the full value of treated water as an input to processes, a source of energy, and a carrier of nutrients and other materials.[25]

Research points to waste-resource recovery systems that will require new and highly selective biological and non-biological separation processes. These could capture specific compounds from wastewater.[26]

While much of this is still theoretical, the early adopters in the industry have already put some of these approaches into practice.

For example, Thames Water, the U.K.'s largest water company, creates almost 140 million cubic meters of **green biogas** during the sewage treatment process. Biogas, a mixture of methane, carbon dioxide, and small quantities of other gases produced by anaerobic digestion of organic matter, can be used in power stations and co-generation facilities to generate electricity and heat.

Thames Water produces more than enough to replace fossil fuel use onsite, leaving surplus renewable power that gets injected back into the grid.[27] Generating renewable power from waste is part of the company's plan to be net-carbon zero by 2030. The plan also includes reducing the use of fossil fuels across the business, harnessing renewable energy sources and adopting alternative fuel vehicles.

The water sector has a lot to work with beyond just biogas. Potential resources include the economic value of co-digestion, the production of fertilizer, and the extraction of resources – such as cellulose, biopolymers, and struvite – from wastewater.

For example, for smaller plants where biogas production may not be feasible, **biochar** could be harvested through a process known as pyrolysis or gasification. This is where sludge is roasted without oxygen to produce biochar and syngas. The biochar could be recycled into the treatment process to absorb microplastics, algae cells, and PFAS while the syngas is combusted to generate electricity.

The **reuse of treated water** is also becoming a widely accepted and well-regulated source of clean water. Water reuse can address critical freshwater needs, whether for potable and non-potable applications.

Water scarcity around the globe is intensifying. Scarcity is spurring investment, even in projects that can be expensive, such as building dams, or involve high amounts of energy such as seawater desalinization. The use of treated wastewater offers a flexible solution with limited capital expenditure and lower GHG emissions.

Based on recent research, the full treatment of wastewater to ensure it meets drinking water quality standards still only uses half of the energy needed for seawater desalination.[28]

When considering resilience against climate change, while also seeking to avoid additional GHG emissions production, water reuse is a sustainable approach that should be front of mind.

Ambitious net-zero goals require bold approaches and innovative thinking. This means breaking away from the status quo and using technology to reimagine conventional approaches.

No one single technology will get the industry over the line in the race to net-zero emissions. A combination of proven technologies and smart thinking will.

Net zero is possible. The time to act is now.

Appendix

Resources

- **United Nations Framework Convention on Climate Change (UNFCCC)**
  The UNFCC published an updated 'vision and summary' document in 2021 that outlines the efforts needed to realize its 2050 vision.

- **Science Based Targets initiative (SBTi)**
  The SBTi Manual provides guidance and recommendations for setting science-based targets. It covers everything from understanding business benefits to communicating progress.

- **Water UK**
  The UK water sector has developed a Net Zero 2030 Route Map to help support its transition to a lower-emissions future. The route map illustrates several possible futures of decarbonization for the sector through three pathways and a more likely sector pathway.

- **Water and Wastewater Companies for Climate Mitigation (WaCCliM)**
  The WaCCliM's Roadmap addresses water-utility managers' most pressing challenges. It covers how to reduce carbon emissions through energy or water savings and by using planned investments to maintain or improve services.

- **US Water Alliance**
  The US Water Alliance's One Water Roadmap is a compendium of best practices, key strategies, and real-world examples of One Water management in action.

- **Xylem Research**
  Xylem's paper, Water Utilities: Moving Fast Toward A Zero-Carbon Future, published in November 2021, formed part of the company's contribution to COP26. The paper outlines steps to accelerate the sector's progress toward a zero-carbon future.

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1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

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