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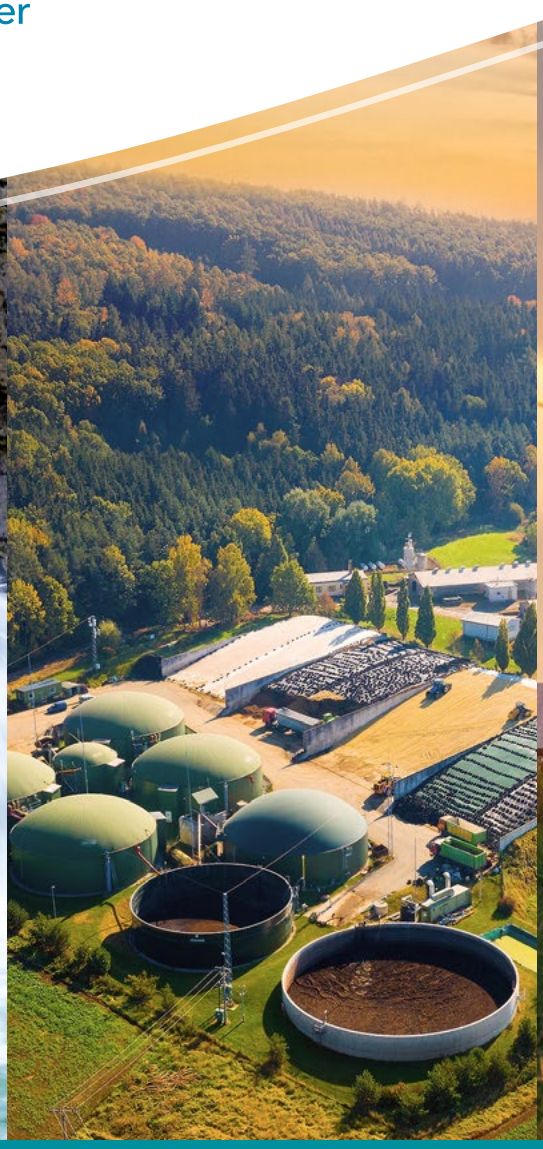
Let's Solve Water



Fast-forward to the future: Looking beyond intermittent renewables

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Foreword

The global fight to reach net zero by 2050 has brought together a huge variety of public and private institutions, inspiring millions of people across continents, cultures, and economies to work towards a common target.

This global effort has resulted in accelerated action. In Europe for example, all countries have accelerated the uptake of renewables, and virtually all have supported the sector with financial incentives and favourable taxation.

Yet, according to the latest report from the UN Inter-governmental Panel on Climate Change,[1] progress is not happening as fast as we need.

So, how can we bridge the gap between where we need to be by 2050, and where we are now?

It's clear we need to further boost the potential of dispatchable renewable energy sources, but switching to renewables might not be enough. We must also rethink how we manage the resources involved in generating renewable power – including water.

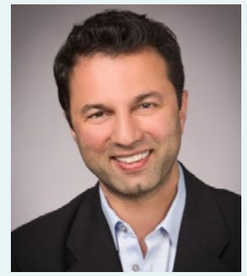
Not all renewables are created equal: some need more water than others. For example, green hydrogen requires large quantities of water to be produced, while biogas needs heavy-duty mixers and pumps for efficient and trouble-free fluid management. However, both are non-intermittent and easily storable, and can help decarbonise sectors where electrification may not be an option, such as heavy industry and logistics.

These examples show that the sustainable management of water and energy is inextricably linked, and that in the path to net zero, water is both a solution and a challenge.

We at Xylem strongly believe that finding new, effective ways to solve our water challenges will be crucial to support the growth of the renewables sector, allowing it to reach its full potential.

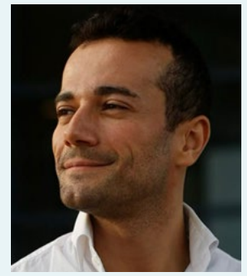
This is our mission at Xylem.

Vinayak Subramanyam, Director of Marketing and Business Development, Xylem



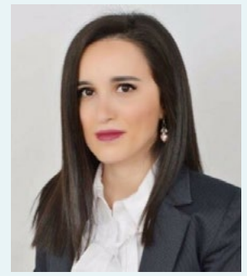
Asad Choudry, Director of Product Management, Xylem

Maja Rosiak, Vertical Market Manager - Industry, Xylem



Farzad Ferdos, Senior CFD* Expert and Technical Specialist, Xylem

Sylvie Lekieffre, Business Development Hydro Turbines, Xylem



Yasmin Refaei, Sales Director, Evoqua

* Computational Fluid Dynamics

Advancing the future of renewables, together

Europe is heating up quickly. According to the World Meteorological Organisation, temperatures on the continent have increased at more than twice the global average in the past 30 years.[2]

The results are there for all to see – heat waves, wildfires, floods, droughts and other extreme weather events are becoming more frequent, and in 2021 alone, high-impact weather caused fatalities and economic damages for over $50 billion.

At the same time, Europe is in the midst of an unprecedented energy crisis, with wholesale gas and electricity prices at record levels. European governments have taken action to protect consumers and support businesses. However, temporary support can only go so far.

To trigger long-term, sustainable development, we need policies that tackle the energy trilemma: ensuring energy security, equity and sustainability. Renewables are the way forward, and Europe is progressing rapidly in this sense.

In the EU, the share of renewable energy consumption has more than doubled compared to 2004, reaching 21.8% in 2021.[3] But despite steady progress, Europe is not yet on track to meet its emission reduction targets.

In an effort to help Europe become the world's first climate-neutral continent, the EU has implemented several initiatives to accelerate the transition to a greener power system. The boxes on the side summarise the most important.

European Green Deal

A series of proposals to adapt Europe's climate, energy and taxation systems to the goal of reducing greenhouse gas (GHG) emissions by at least 55%, compared to 1990 levels, by 2030.

Net Zero Industry Act

An initiative to scale up cleantech manufacturing in the EU. The goal is to ensure that at least 40% of the EU's annual demand for cleantech is manufactured domestically by 2030, preventing the EU from over-relying on other countries.

REPowerEU

A plan to increase Europe's energy independence through improved green energy policy, strengthened climate change and energy targets, and incentives for the deployment of green technologies.

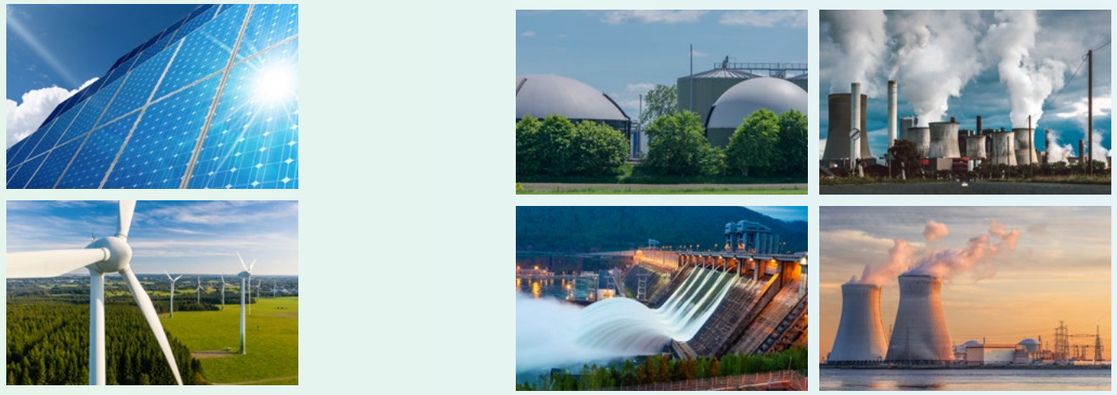
However, simply generating more renewable power might not be enough. To achieve net zero as fast and efficiently as possible, it is important that we investigate the link between energy and water, managing water resources effectively and sustainably.

Low-carbon does not necessarily equal low-water. In fact, some renewable power generation processes – such as the extraction of hydrogen via electrolysis – can be water-intense, while others – such as hydropower generation – imply a careful management of water resources.

> Luckily, there are options available to create a virtuous circle where the water and energy sectors contribute to each other's efficiency and resilience – it's up to us to implement them.

The technology is available now, and we are ready to advance the future of renewables in Europe, together.

Beyond wind and solar: the importance of dispatchable renewables



Dispatchable renewables:
the term "dispatchable" refers to sources of electricity that can be turned on and off, adjusting their power output on demand (e.g. fossil fuels, but also renewables like hydropower and biogas). By contrast, "intermittent" renewable sources can only generate electricity when their energy source is available (e.g. solar PV, wind).

The conversation around net zero often focuses on large hydropower stations, solar photovoltaic (PV) and wind, the fastest-growing renewable technologies worldwide.[4] But there are more resources available to help us in the green energy transition.

"Overcoming the net zero challenge requires us to make the most of all available resources," comments Vinayak Subramanyam, Director of Marketing and Business Development at Xylem. "Some of the most promising renewable sources available today remain relatively untapped, meaning there is potential for clean energy generation that is currently being underutilised."

In particular, we need to diversify our energy mix, and to incorporate dispatchable alternatives that can contribute to stabilising the grid. Access to non-intermittent energy generation is crucial, and can be achieved with minimal to no consequences for the environment.

For example, small-scale hydropower repurposes existing infrastructure with no need for disruptive construction work. On the other hand, green hydrogen can convert wind and solar power into readily available, storable and shippable fuel.

It's also important to think of solutions that can help decarbonise sectors where electrification isn't a possibility, such as the logistics and aviation sectors. Here, the use of sustainable gases, such as biogas and low-carbon hydrogen, offers a promising alternative to fossil fuels.

While all renewable technology will play a role in reaching net zero as fast as possible, we believe that these sectors – small-scale hydropower, biogas and low-carbon hydrogen – hold great potential to unlock a true green energy revolution.

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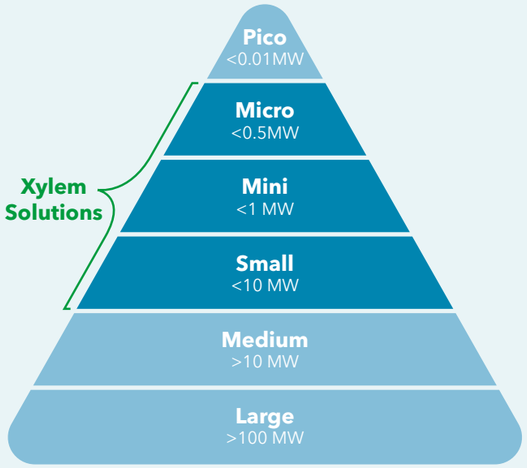
A wave of potential: supporting the development of small-scale hydropower

Small hydropower plants are ideally suited to produce energy cost-effectively and closer to the demand centres. They can be based on existing infrastructure, which can be modernised to ensure maximum efficiency. This allows municipalities to benefit from low upfront costs, while communities can enjoy a reliable, stable source of clean power for decades to come.

UNIDO, the United Nations' specialised agency for sustainable industrial development, also confirms that this technology has little to no environmental impact. When the necessary infrastructure has already been built, this removes the need for further construction work that might jeopardise the local flora and fauna.[5]

Yet, 66% of the world's small-scale hydropower (SHP) potential remains untapped, with SHP representing only 4.5% of the global renewable energy capacity.[6] It is clear that the sector has huge potential for growth, and its expansion would lead to improved quality of life for millions of people.



So, how can we ensure that the barriers to SHP are successfully overcome and that the sector is ready for a future where clean energy is a must?

Overcoming barriers to SHP development

	In-pipe Hydropower	Solar Power
		
Surface use	20m²	2,023m²
Capacity factor	60%	20%
Annual electricity production	525 600 kWh	138 952 kWh
Investment	2 500 €/kW	2 500 €/kW

Theoretical revenues based on pure merchant electricity sales - day ahead average price

Hydropower is the most mature renewable source of energy. Sites dating back to the late 1800s are still operational today, highlighting the durability and reliability of hydropower investments.

However, this also means that a large number of hydropower plants deploy ageing equipment that is no longer fit for today's efficiency and sustainability requirements. This is particularly relevant in Europe, where hydropower has been exploited for centuries.

Hydropower technology can have a long lifespan, with turbines easily operating for 50 years or more. However, the European hydropower fleet is reaching a tipping point, with much of its existing solutions needing upgrades or refurbishment.

An additional concern is that high-impact weather is becoming more common, and in some cases, it can threaten existing hydropower projects.[7] Droughts happen increasingly frequently in many European countries.[8] This means that large hydro turbines that have been installed in the past may no longer be effective due to low water levels, and that small hydro plants may be more suited. On the other hand, in areas where flood risk is increasing, hydro turbines can be used as a cost-effective flood control measure.

With an in-pipe solution vs solar generation

- Electricity production **~4x higher**
- Predictable electricity generation
- Reduced footprint
- Use of existing infrastructure
- Similar investment level
- Longer lifetime (~40 y)

High electricity prices bringing strong revenues

A hydropower plant with 1 x 500 kW unit and 65% capacity factor would have had 2022 revenues* of:

Germany	France	Norway NO 1	Sweden SW3
€0.67M	**€0.79M**	**€0.55M**	**€0.37M**

*Based on day ahead average price

These changing needs require plant managers to invest in future-proof power systems that meet the efficiency and sustainability criteria of the green revolution, while repurposing existing infrastructure to contain costs and avoid the environmental impact traditionally associated with large construction projects.

What policy is needed?

"Traditionally, policy has focused on solutions with quick return on investment (ROI), such as wind and solar, but the untapped potential of sustainable hydropower is astronomical. Industry stakeholders and policy-makers are now starting to realise that."

Sylvie Lekieffre, Business Development Manager, Hydroturbines

Hydropower plants can offer reliable power for centuries, representing one of the cheapest forms of renewable energy generation currently available. But the upgrade of existing infrastructure can come at a considerable cost.

That is why, to support asset managers and municipalities, policy-makers will need to address two main areas: access to financing, and the elimination of unnecessary or redundant red tape.

At COP27, the International Hydropower Association (IHA) has called for more support from governments, asking to incentivise investments with suitable financial mechanisms and streamlined permitting.

Luckily, the combined efforts of trade bodies and international associations are paying off, and new incentives are now in place to support the growth of sustainable hydropower. For example, the XFLEX HYDRO initiative, a project to demonstrate the effectiveness of new technology in increasing the sustainability and resilience of hydropower, was awarded EUR 18 million.

More recently, the EU updated its Taxonomy Climate Delegated Act, a classification system for environmentally sustainable economic activities, aligning it with the principles of the Hydropower Sustainability ESG Gap Analysis Tool. This means that it will be easier to apply for funding for projects that meet the recommended sustainability criteria.

"Modernising technology is crucial to ensure the growth of sustainable hydropower. By limiting upfront costs with suitable financial incentives, policy-makers can play a huge role in helping Europe become the first carbon-neutral continent."

Sylvie Lekieffre, Business Development Manager, Hydroturbines

Debunking hydropower myths

"Hydropower has a big environmental footprint and ruins the local landscape"

The environmental impact of large dams can last for several decades and have major consequences on the surrounding ecosystems. However, small-scale hydropower repurposes or upgrades existing infrastructure and requires no further construction work. Moreover, run-of-the-river hydropower plants don't block the river flow. This means that local communities can have access to clean, reliable power with no consequences for the local ecosystem and its cultural heritage.

"Hydropower is a threat to fish"

There are several ways to modernise hydropower plants with fish-friendly designs, protecting at-risk species such as salmon and eel. Fish-friendly guidance systems can redirect fish so they do not swim through the turbines. Some turbines are also designed with safe pressures and an appropriate distance between blades, so that local species can pass through unharmed. Upgrading existing infrastructure offers an opportunity to install fish-friendly technology and help preserve the local ecosystem.

"Hydropower requires large upfront investment and is expensive to operate"

According to IRENA, the global average levelised cost of energy (LCOE) of newly commissioned hydropower projects is lower than any other renewable energy source except for onshore wind. Also, 56% of hydropower projects commissioned in 2020 were cheaper than the most cost-effective fossil fuel option.[9] However, small-scale hydropower projects tend to repurpose existing infrastructure that just needs modernisation, meaning that the costs will be even lower compared to a newly built project.

A stream of new opportunities – the role of technology in future-proofing the sector

Upgrading existing dams and locks with the right technology is the way forward to make the most of sustainable hydropower. But what are the key considerations when choosing the best water management technology?

Our hydropower experts, Asad Choudry and Farzad Ferdos, share their insights.

What is the most important thing that asset managers should consider when specifying technology for small hydropower?

Asad: "One of the most important considerations, without a doubt, is the expected lifespan of the technology. Hydro turbines can be in operation for 50 years or more, but to reach that lifespan, you need reliable, durable products.

"Another key consideration would be energy efficiency. Choosing submersible hydropower solutions with excellent thrust to power ratio is a great choice for future-proofing operations."

Why use submersible technology as opposed to traditional, externally-installed systems? What are the benefits?

Farzad: "Submersible hydro turbines offer an easy, plug and play installation. But the main benefit is that they can't be seen or heard, so they don't compromise the landscape and cultural heritage of a site.

"Another benefit is that submersible tech is not affected by floods. Normally, a shaft about 50 metres tall is needed to keep technology out of the water in case of high water levels. But this is not a concern with submersible tech. An added bonus is that submersible generators don't need cooling, further improving the efficiency of a site."

Given the benefits of submersible technology, why isn't it more widespread?

Asad: "There is so much potential to upgrade technology that has been installed over a century ago. These systems kept running for decades, so in many cases they haven't been refurbished. But this sort of complacency with the status quo can no longer be tolerated. To get started, we recommend that plant operators consider performing an energy audit of their equipment to determine its efficiency and how to improve it."

What else can be done to further simplify maintenance and ensure long-lasting, safe operations?

Farzad: "At Xylem, we take a modular approach that is very flexible and easily adaptable to our customers' needs. This means that you can have standard parts fitted in a customisable design, so the single parts can be easily maintained, replaced or upgraded as needed, without compromising the functionality of the whole project."

Focus on: Flygt submersible turbines

Benefits:

- Durable and reliable: installed since 1983, with most units still in operation
- Adaptable – can be installed at almost any site
- Quick ROI thanks to low initial investment and long lifetime
- Can be installed in minutes, with no assembly or shaft alignment
- Easy removal for servicing
- Invisible and quiet

Technical specs:

- For applications with heads up to 65 feet (20 m), and flows up to 350 cfs (10 m³/s) per unit
- Semi-Kaplan turbines with auto-adjust option can accommodate varying flows
- Fully submersible generators to a depth of at least 65 feet (20 m)
- Class H insulated generator for extended lifetime
- Temperature and leakage sensors for condition monitoring
- Four or five blades in either bronze or stainless steel
- Option to regulate blades manually in 1 degree increments
- Planetary gear box for turbines that require a speed increaser
- Unique mechanical seals

Holistic support with Xylem Lifecycle Services:

- Aftermarket support (installation, operation and maintenance manuals; regular maintenance contracts)
- Engineering support (CAD drawings; consulting)
- Turbine consultation and optimisation (number, size and type)
- Computational Fluid Dynamics ensures ideal hydraulic conditions
- Remote generator monitoring

For a detailed overview of Xylem's product offering for small-scale hydropower, download our guide to submersible hydro turbines.

Case study: A major lock expansion in Belgium

Located on the Belgium-Netherlands' border, the Lanaye Locks link the Albert and Juliana Canals, providing a vital route between Northern and Southern Europe. The three locks have operated alongside each other since 1964, but only one of them can accommodate canal traffic. The goal of the project was to expand this lock while capitalising on available hydropower.

The BESIX Group was selected for the engineering, procurement and construction of an expanded lock, which would include a hydroelectric plant and a pump house. In line with modern sustainability requirements, the new construction had to be integrated with the landscape and almost invisible. The project started in March 2012 and was completed in September 2015.

Xylem was commissioned early in the project to help address the challenges associated with seasonal water level changes in the canal, with the pump and hydropower station needing to be installed between the locks.

After performing a hydraulic model study, Xylem's Flygt engineers proposed an innovative station design concept that allowed the installation of eight large CP3800 submersible pumps and five EL7585 hydro turbines. These would be installed in side-by-side chambers, so that the turbines would not interfere with one another during operation.

The goal of the pumps was to add water to the Albert canal during the dry season, which occurs in the three summer months, maintaining adequate water levels for canal traffic. The new hydropower plant would then operate for the remaining nine months, when surplus water is available.

A successful collaboration between BESIX Sanotec-Balteau and Xylem led to a compact solution that does not have any visible impact on the surrounding landscape, and ensures high efficiency and low maintenance costs. The expansion of the existing infrastructure with energy-efficient, state-of-the-art technology means that the local community will have access to carbon-neutral power for most of the year, while preserving the current characteristics of the local ecosystem.

Supporting the fast growth of biogas

The European Biogas Association reports that the sector is growing at a fast pace. The number of biogas and biomethane plants in Europe has more than doubled between 2018 and 2020,[10] and in the course of 2021, 99 new biogas and 184 biomethane plants began operation.[11]

According to the latest statistical report by the European Biogas Association, biogas is already providing 18.4 bcm of renewable gas to Europe. By 2050, this figure could reach 167 bcm, covering 35 to 60% of gas demand.[12]

Biogas plants can operate flexibly, and therefore balance the output of intermittent renewables such as wind and solar PV. They are a crucial asset to accelerate Europe's ambitions to become the first carbon-neutral continent, while supporting its efforts towards energy independence.

Policy support and feedstock availability have already allowed Europe to become the biggest producer of biogas worldwide, with Germany being the largest market.[13] But to support the fast growth of the sector, key technologies such as pumps, mixers and digesters must also keep pace, providing the tools for maximised, continuous and cost-effective production.

When reliability is of the essence

The fast pace of biogas deployment means that original equipment manufacturers (OEMs) and engineering, procurement and construction (EPC) companies must rely on equipment that ensures durability, safety and hassle-free maintenance.

At the same time, end users must have access to equipment that is easy to operate, monitor, and troubleshoot, and that has been specifically designed to minimise the challenges of high-density fluids.

To help asset managers specify the best equipment for their biogas systems, Maja Rosiak, Head of Xylem's Biogas Centre of Excellence, gives us an overview of the main challenges of these complex applications.

What are the biggest challenges of fluid management in biogas applications?

Maja: "In anaerobic digestion, the high percentage of solids in the feedstock can make mixing and pumping very challenging. Feedstocks can be a combination of very different organic materials, from liquid ones like manure, to relatively dry ones, like the by-products of food processing plants. So, the first challenge is to mix different streams in the feeding tank until we achieve an ideal percentage of dry content matter. This should be about 8-10%.

"Another challenge to consider is whether the feedstock will change in the future. For example, a farmer who runs a biogas plant on manure might partner up with another farmer who has agricultural waste or gets access to the by-products of a food processing plant or a brewery. In this case, we need to specify equipment that can handle these changes, without compromising the continuous operation of the plant."

How can asset managers overcome these challenges?

"In terms of mixing requirements, a high percentage of solids in the feedstock calls for high-quality, reliable mixers that can prevent common problems such as crusting and sedimentation. Crusting won't allow gas bubbles to escape, meaning the biogas output will be compromised. On the other hand, high levels of sedimentation will reduce the operational volume of the tank.

"Another challenge is specifying the right pumps to transport substrates between tanks. High-density feedstocks can lead to frequent clogging, which is why it's essential to choose pumps that can handle tough substrates. For example, non-clog pumps – like the N and F series from Flygt – are perfect for fibrous substrates, while cost-effective Lowara pumps are ideal to handle thinner liquids, such as when transferring wastewater or condensate."

Focus on: Flygt chopper pumps

Benefits:

- Designed for continuous operations
- Cutting action for the toughest biomass
- Self -cleaning
- Non-clog design (ideal for manure and high-density feedstock)
- Resistant to corrosion
- Easy to install and maintain
- Can be retrofitted to existing installations

Technical specs:

- Power up to 45kW/60hp Kw (50/60 Hz)
- Adjustable suction cover for easy maintenance
- S-shaped impeller on spheroidal graphite cast iron (robust and non-clog)
- Closed-loop cooling system to avoid contamination of the coolant
- Cooling jackets available

What are the key considerations when choosing the best mixers for biogas applications?

Maja: "Mixers for biogas applications should be heavy-duty, which is why we recommend relying on well-known brands like Flygt.

"Another important consideration is the ability to react to potential issues in a timely manner. Our Flygt submersible mixers are mounted on a guide bar, meaning they can be moved up or down in the tank to prevent crust formation on the surface, or sedimentation at the bottom. This is not possible with dry installation mixers, where the motor is placed outside the tank, and the propeller is in a fixed position inside the tank.

"Another benefit of submersible mixers is that the mixer can be removed for servicing or replacement without emptying the tank. In terms of maintenance, dry installed mixers offer easy access to the motor, which is placed outside the tank. But if the propeller breaks, then the entire tank has to be emptied."

Benefit	Submersible mixers	Dry installation mixers
Ability to react to substrate issues (crusting, sedimentation)	✓	X
Easy mixer/propeller maintenance	✓	X
Easy motor maintenance	X	✓

Finally, how can asset managers minimise operational costs?

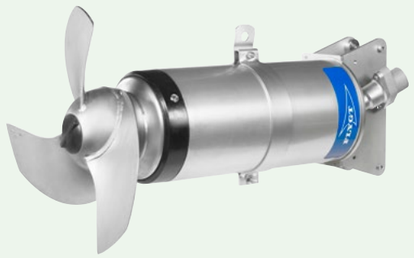
Maja: "It's important to consider the total cost of ownership (TCO) of biogas projects. Premium equipment comes with a higher price tag, but by investing in high-quality products, asset managers can avoid breakages, maximise their gas yield, and achieve the highest possible thrust-to-power ratio to reduce energy consumption.

"By taking a TCO approach to biogas and keeping on top of maintenance with connected IoT technologies, professionals in the sector can maximise the longevity and efficiency of their assets, and contribute to accelerating the transition to a carbon-neutral Europe."

Focus on:
Flygt single speed mixers

Benefits for asset owners:

- Ideal for though substrates with up to 30-40% of solids
- Adjustable positioning: the guide bar allows you to move the mixer up or down to prevent common issues in the tank
- Easy maintenance: the mixer can be removed without emptying the tank
- Durable and heavy-duty: reduced maintenance costs thanks to their long lifespan



Benefits for OEMs/EPCs:

- A vast product range with mixers for any tank size and shape
- The mixers combine large diameters with slow speed to generate excellent thrust with minimum energy consumption
- The duplex steel propellers ensure longevity and durability
- Heavy-duty gearboxes for reliable, non-stop performance

For a detailed overview of Xylem's product offering for biogas producers, download our guide to Biogas Production with Xylem.

Busting biogas myths

"Biogas production wastes food that could be used to feed people or animals"

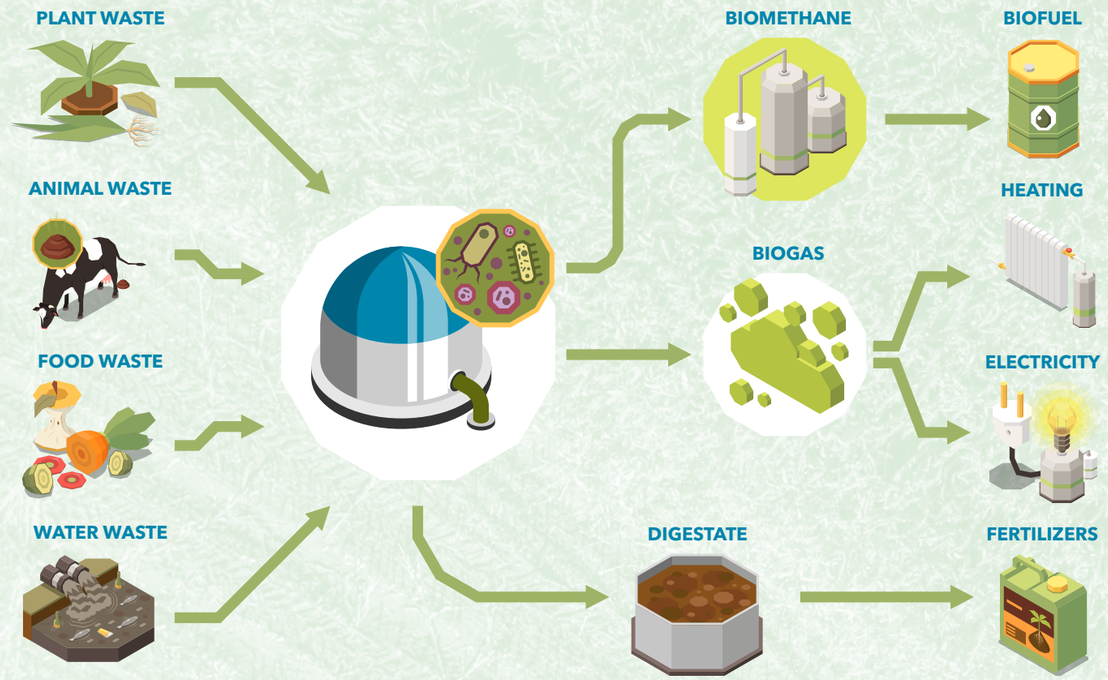
Since 2017, almost no new plants are using monocultures as feedstock. Most biogas plants repurpose organic waste such as manure, organic municipal waste, agricultural waste, and by-products of the food and beverage industry. As such, biogas production contributes to limiting the amount of waste that would end up in landfills, while producing sustainable energy, biogenic CO_2, and fertiliser in the form of digestate.

"Biogas plants are smelly and this is unpleasant for local communities"

The anaerobic digestion process takes place in a sealed tank, which is why modern plants do not generate odours when functioning correctly. When the tank needs to be vented for maintenance purposes, this can be done with filters that remove unpleasant odours. An effective feedstock management strategy can also ensure that odours are not emitted when delivering and unloading the feedstock, for example by transporting it in sealed vessels and ensuring all processes take place in closed buildings with proper filters and ventilation.

"Biogas does not play a significant role in the fight against climate change"

Biogas and biomethane play a crucial role in balancing the grid when weather-dependent renewables are not available. They are also important to decarbonise sectors where, at least at the moment, electrification is not an option. Moreover, the by-products of biomethane production – biogenic CO_2 and digestate – further contribute to removing CO_2 from the atmosphere.



Racing to 2050: a Q&A with the European Biogas Association

Technological progress can only go so far without suitable legislative support. To discuss how Europe is progressing in this sense, we've talked to two representatives of the European Biogas Association: Angela Sainz Arnau, Communications Manager, and Lucile Sever, Policy Officer.

Angela Sainz Arnau, Communications Manager, European Biogas Association

Lucile Sever, Policy Officer, European Biogas Association

What is the role of biogas in accelerating Europe's transition to net zero?

Angela: "Renewable gases will play a crucial role in the net zero transition, and Europe is really pushing for incentivising their use.

"At the moment, the EU is producing about 18 bmc of combined biogas and biomethane, which is about 5% of the total gas consumption in the EU – equivalent to the total consumption of Belgium. By 2035, the EU has a target of producing 35 bcm of biomethane, meaning we will have to substantially increase production and also upgrade some of our biogas plants to produce biomethane."

> 5% of total EU gas consumption comes from biogass and biomethane production.

Lucile: "We also need to consider that a valuable by-product of biogas is digestate, which can be used as a high-quality fertiliser. This would allow us to eliminate the greenhouse gas (GHG) emissions associated with the production of synthetic fertilisers, further advancing the net zero agenda.

"Another very interesting by-product is biogenic CO_2, which is produced as a result of upgrading biogas to biomethane. Biogenic CO_2 has a lot of applications in the food and beverage sector and in the chemical industry. Repurposing it is not just in line with our decarbonisation targets, but also with the idea of a circular economy. By capturing and using the CO_2 produced during biomethane extraction, we can turn biogas projects from carbon neutral to carbon negative."

> Upgrade and repurposing helps achieve CO_2 neutrality and contributes to a circular ecomony.

Are there any targets in place regarding the future applications of biogas, for example for how much biogas should be injected into the gas grid?

Angela: "Every member state has a different situation. For example, Denmark has very specific targets in place to replace natural gas, and has already started to inject about 30% of biomethane into its gas grid. In Italy, on the other hand, there is a big push for using biomethane in long-haul transport, where electrification is not a viable option.

"In general, there seems to be a discussion in the EU to set targets around the use of biomethane in the gas grid, and to foster the development of potential applications of biogas and biomethane, as well as supporting their production."

The sector is experiencing fast growth in Europe. What are the main causes of this growth and where is the highest uptake?

Lucile: "The current geopolitical situation has been quite favourable to the development of the sector. The sad situation of the war in Ukraine means that the EU is trying to secure its energy independence. The goal of reaching 35 bmc of biomethane by 2030 has been included in the REpowerEU plan as a way to diversify our gas supply and end the reliance on Russian fuel."

Angela: "Germany is currently the country with the largest biogas and biomethane production in the world, but there are other countries where the growth of the sector is really rapid, such as Italy, France and the Scandinavian region.

"On the other hand, there are countries that have great potential in terms of feedstock availability, but have not yet developed a suitable level of legislative support, such as Spain and Poland.

"An initiative that will make a difference is the introduction of Guarantees of Origin, which are certificates that demonstrate that energy has been generated from a sustainable source. When biomethane is injected in the grid, it becomes indistinguishable from natural gas, so it's important to have a certification that demonstrates the percentage of sustainable fuel in the gas mix."

What are the barriers that are currently preventing the sector from growing further?

Angela: "The European Biogas Association has identified specific barriers to overcome in the short, mid and long term. The most important one at the moment is feedstock availability. We need to incentivise the use of many different types of feedstocks, but there are some that are not so well known. The European Energy Directive regulates the use of feedstocks, but there are ongoing discussions on how to develop this further.

"Another barrier is the permitting process, which needs to be accelerated. Lastly, we need to incentivise the use of biogenic CO_2, because this is going to make a stronger business case for biogas deployment."

Lucile: "A barrier we're working hard to overcome is the integration and harmonisation of current guidelines on a European level. This would really help in promoting a more widespread use of biogas. Also, more work needs to be done on implementing regulations for incentivising the use of biogas in specific vertical sectors, such as logistics."

Do you think the current level of financial support is enough?

Angela: "Support is important for the early stages of a project, but it's also crucial we raise awareness of the business case for biogas, so that the sector can be as independent as possible from any type of incentives. Compared to other renewable gases, the cost of producing biogas is already competitive, especially when we consider all the possibilities to monetise from it.

"Our aim at the moment is to make the 35 bmc by 2035 target binding. We think this would be a great driver for biogas, and would really contribute to Europe's decarbonisation targets."

More info at www.europeanbiogas.eu.

Our aim at the moment is to make the 35 bmc by 2035 target binding. We think this would be a great driver for biogas, and would really contribute to Europe's decarbonisation targets.

Case study: Ensuring efficient mixing in a Polish biogas plant

The Falknowo biogas plant, built between 2019 and 2020 by MDI Energia and owned by Polish Biogas Group, turns corn silage, manure and food processing waste into electricity and heat for the local community.

The diverse nature of the feedstock makes mixing complex, and to ensure a homogeneous substrate and efficient operations, the plant's management team approached Xylem's biogas experts.

The Xylem team fitted two types of Flygt mixers, a compact and a slow-speed one, with a propeller diameter of 1.25 m. The supplier established guidelines for proper placement, as well as ensuring that the shape and size of the blades are ideal to efficiently mix the biomass in the fermentation tank. Mixers work on a set schedule, but this can be changed if required, ensuring flexible operations.

The electricity produced from biogas at the Flaknowo plant is transmitted to the power grid and used for the plant's needs, as well as by local residents. Heat is also recovered and used for drying wood in the plant, and to heat a nearby manufacturing facility.

Results:

- A homogeneous substrate
- Maximised gas yield
- Prevention of crusting and sedimentation
- A self-sustaining plant that runs on the electricity it generates

Case study: Providing a sustainable pumping system for an Italian farm

In a major breeding farm in Bergamo, Italy, Rota Guido Srl installed two reverse osmosis (RO) and ultrafiltration plants that, coupled with a biogas plant, ensure livestock operations are efficient and environmentally responsible.

The plants treat waste disposal from cattle and pigs, which is processed to create biogas and digestate. While the biogas provides clean energy for the farm's operations, the digestate is separated into solids – used as fertiliser – and slurry, which is further treated and reused.

The farm needed a sophisticated pumping system to manage fluids at all stages of the biogas and digestate production process. Crucially, all components needed to be reliable, correctly sized and made of materials that can withstand corrosion.

To ensure reliable and environmentally-safe operations, the farm decided to approach Xylem.

The Xylem team advised to install Lowara pumps for lifting and transporting slurry for storage and treatment:

- A Lowara DLV pump with vortex impeller moves the slurry in its rawest state
- Three e-SHE horizontal, single-stage stainless steel pumps handle the concentrate resulting from the ultrafiltration process
- Four vertical stainless steel multistage pumps provide water pressure for the RO operation

Water can safely be disposed of, or reused for irrigation and other agricultural or industrial processes onsite. Lowara pumps are also used to move water to the process tanks and stripping tower, which produce ammonium sulphate to be used as fertiliser.

Results:

- A reliable and environmentally compliant pumping system
- The ability to turn organic waste into clean energy, fertiliser and water for irrigation
- A circular economy project that will reduce energy bills and ensure environmental compliance

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Overcoming the challenges of low-carbon hydrogen generation

According to the International Renewable Energy Agency (IRENA), the potential of low-carbon hydrogen worldwide equates to more than 20 times the global primary energy demand in 2050.[14]

As opposed to other forms of hydrogen production, low-carbon hydrogen – or green hydrogen – is also completely or almost carbon neutral. In fact, green hydrogen is produced through a process called electrolysis, where electricity coming from renewable sources is used to split water into hydrogen and oxygen.

Sustainably produced hydrogen can play an important role in accelerating the path to net zero. In particular, its use has promising applications in hard-to-decarbonise sectors, such as heavy transport, shipping and aviation.

There are also several projects underway to research the feasibility and benefits of injecting hydrogen into the gas grid. For example, the HyNet initiative in the UK aims at building the infrastructure to deliver 100% hydrogen to selected residential trial areas, with construction starting in 2025.[15] Similar initiatives in Germany, such as the GetH_2 Nukleus project, aim to build the core for a European Hydrogen economy in Germany and the Netherlands.

However, according to IRENA, only about 1% of the global hydrogen output is produced in a sustainable way, while the great majority of hydrogen is extracted from the reforming of fossil fuels, in particular natural gas.

So, what are the barriers hindering the development of this promising technology, and what can be done to overcome them?

Fast-forward to the future: Boosting the potential of non-intermittent renewables

Identifying key barriers

The low uptake of low-carbon hydrogen means we must do everything we can to support producers and industry stakeholders, including EPCs and OEMs that are involved in the manufacturing, installation and maintenance of key equipment for low-carbon hydrogen generation.

One of the key barriers to overcome will be reducing production costs. The IEA reports that depending on regional gas prices, the average cost of producing 1 kg of hydrogen from natural gas is between USD 0.5 and 1.70, while the cost of producing it from renewables is between USD 3.00 and 8.00.[17] The cost of renewable electricity can make up 50-90% of total production expenses, and this can increase as the electrolyser ages and loses efficiency. Green hydrogen plants and electrolysers are also capital-intensive, with pumping and water treatment equipment making up a significant portion of the initial investment.

> Both the cost of renewables and of electrolyser technology are expected to fall in the future, making low-carbon hydrogen production more competitive, but another key challenge remains: water.

Large quantities of water are necessary at all stages of green hydrogen production – from the actual electrolysis process, to cooling equipment. Electrolysis requires about 9 kg of water for every kg of hydrogen produced, but the total water consumption can be over 60 kg.

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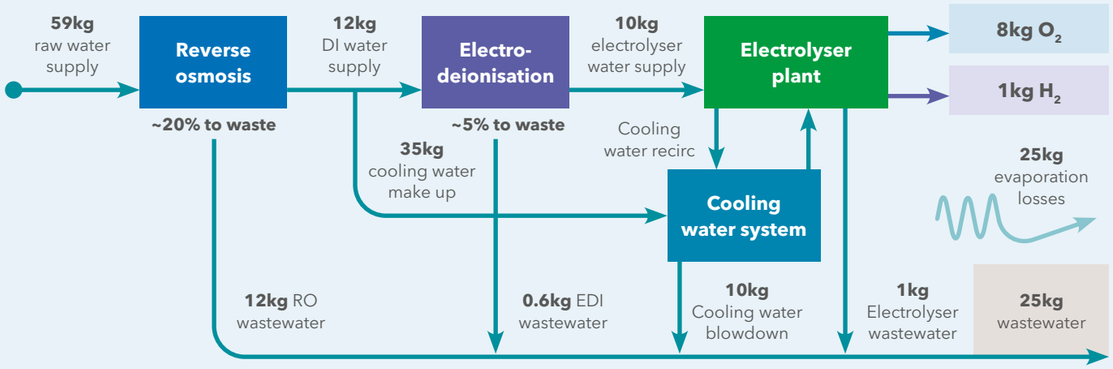
Water for electrolysis must go through reverse osmosis and deionization process which increases the amount of water that is needed



Cooling electrolyzers requires 30-40 kg of water per kg of hydrogen. Over time, electrolysers can lose efficiency and easily overheat, further increasing water consumption. More water is also needed to cool other equipment, such as compressors to store hydrogen at a suitable pressure.

Furthermore, 20-40% of the feedstock water is sent to waste before even reaching the electrolysers.

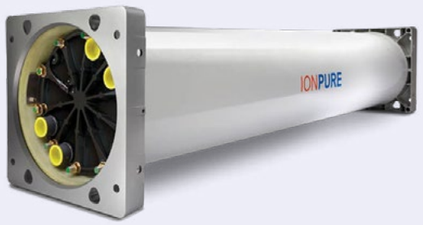
Electrolysis requires ultra-pure water, meaning that feedstock water must be demineralised and deionised before the process.

This means that the purity of the feedstock water will impact how much will be sent to waste, and how much can be actually used for hydrogen production. In the case of seawater or industrial wastewater, the percentage of water that is discarded rises dramatically.

Focus on: Evoqua Ionpure®Continuous Electrodeionization (CEDI) solutions

What is Continuous Electrodeionization (CEDI)?

CEDI is a chemical-free, self-regenerating technology used to provide a consistent flow of high-quality deionized water. It deionized water using a combination of ion-exchange resins, membranes and direct current to avoid chemicals and reduce the system's operating and maintenance costs.



Benefits of CEDI technology:

- Chemical-free: using ion-exchange resins, membranes and direct current to deionize water
- Self-regenerating: no regeneration waste and no need to replace the deionization tank
- No acid or caustic bulk storage, pumping, waste neutralisation or disposal issues
- Reduced operating and maintenance costs
- No downtime or exchange service
- Energy efficient
- Safe for employees and the environment

For a detailed overview of Ionpure CEDI solutions, check out Evoqua's website.

The importance of effective water management

The cost of freshwater can be negligible compared to the total cost of managing a green hydrogen plant, but the environmental impact must be carefully evaluated. According to Bluefield Research, 85% of planned green hydrogen facilities are in regions suffering from medium to high water stress.[18] Also, depending on local regulations, excessive or unsustainable water consumption could prevent hydrogen plants from obtaining the permits to operate.

There's no denying that the cost of renewables and the availability of water are big challenges in boosting the uptake of green hydrogen, but a holistic approach to water technology can make a real difference, making production more cost-effective and environmentally conscious.

The first thing to consider is that investing in energy efficient water treatment equipment will reduce power demand, driving down the cost of operations.

It's also crucial to optimise energy consumption before water reaches the electrolyser, at the demineralisation and deionisation stages. Yasmin Refaei, Sales Director for EMEA at Evoqua, explains:

> "To produce ultrapure water for green hydrogen plants, we recommend using electrodeionisation (EDI). At first, EDI may seem like a more expensive option when compared to other existing technologies such as ion exchange tanks or single use resin. However, it is far more cost-efficient in the long term, with extremely low OPEX that negates the initial capital cost compared to other solutions.
>
> "It is also far more cost efficient than rental units, making it an ideal on-site solution with lower maintenance and operational requirements. On top of this, EDI has an upper-temperature limit of up to 60°C, which would be detrimental to most ion exchange resins. As a result, EDI offers continuous operation and regeneration with minimal downtime, ensuring peace of mind and thus providing the best ultrapure water solution."

Another important consideration is the durability and reliability of equipment. Electrolyser stacks have an average lifespan of about ten years, so it's important to choose ancillary equipment – such as pumps, heat exchangers, sensors and meters – with similar longevity to prevent downtime and ensure uninterrupted operations. This won't necessarily drive down the costs associated with energy and water, but can avoid unnecessary emergency repairs and costly unplanned downtime.

To further reduce costs, it's important that plant managers have access to sustainable water sources. Freshwater offers the best business case for green hydrogen generation, because it minimises the need for purification treatments. However, this might not be possible in water-stressed areas. Desalination is a viable alternative, but the costs associated with it, and the necessity to dispose of brine in a responsible way, make this method challenging.

Focus on: Single Stage Double Suction Centrifugal Pumps for Cooling Water

Benefits of these pumps:

- **More Powerful**
  Up to 11.400 m^3/h and maximum head of 220 m.
- **Tailor Made**
  Available in standard and engineered-to-order material options.
- **Longer Running Life**
  e-XC can run for 100.000 hours (L10) when working in its preferred operating range before the bearings need to be changed.
- **Secured Process**
  Optional temperature and vibration sensors on the bearing bracket for real time measurement.
- **Energy Savings**
  With 142 different size options and optimised hydraulics, the e-XC range allows you to select the most efficient pump for any duty point.

For further details, please visit the Xylem website.

Europe leads the way in the race to 2050

Europe has been leading the way in the hydrogen economy. EU policy-makers have been particularly active in implementing measures to support the growth of sustainable hydrogen and mitigate the risks associated with its production.

In September 2020, the European Commission launched a call for tenders for projects to build electrolysis plants at the 100-MW scale. The resulting proposals have been evaluated, and several winners have already been announced. The Commission also included hydrogen in its Important Projects of Common European Interest, meaning that projects validated by both member states and the Commission can receive public support beyond what is normally granted by single states.

More recently, partly due to the efforts to end imports of Russian fuel, the European Commission has announced the creation of a European Hydrogen Bank, capitalised with at least EUR 3 billion, which should be operational by the end of 2023. The Commission has also announced a plan to offer green hydrogen producers a fixed premium per kg, in an attempt to compete with the US and its hydrogen tax credit system.[19] This will be part of the EU's Green Deal Industrial Plan, which identifies a series of initiatives to accelerate the transition from fossil to sustainable fuels.

The subsidies will be distributed through a series of auctions, the first of which will offer around EUR 800 million. The auctions will serve as a mechanism for the European Hydrogen Bank to allocate funds as part of its contract for difference scheme, which aims at closing the price gap between green hydrogen, and hydrogen produced from fossil fuels. According to Hydrogen Insights, the EU is also considering extending this bidding mechanism to grant incentives for components for electrolyser manufacturing.[20]

These policies are bearing fruit. According to UK energy analyst Delta-EE, more than 1.5 GW of green hydrogen projects will be built in Europe by the end of 2023, which will contribute to the EU's target of having 6GW of renewable hydrogen generation in place by the end of 2024.[21]

Tackling green hydrogen myths

"Green hydrogen production isn't really green"

Green or low-carbon hydrogen plants exclusively use energy from renewable sources to prevent – or drastically reduce – the carbon emissions associated with the generation process. It's true that generating hydrogen from electrolysis is a water-intensive process, but by repurposing water from other industrial processes, and using state-of-the-art water management technology, the amount of water can be minimised, too.

"Low-carbon hydrogen can't be produced at scale"

Although the percentage of sustainably generated hydrogen is low at the moment, this does not mean that green hydrogen can't be produced at scale. With the cost of renewable energy rapidly decreasing, and suitable support from the EU to close the price gap between grey and green hydrogen, low-carbon hydrogen is expected to become increasingly important in allowing Europe to reach net zero by 2050.

The energy conversion ratio to produce hydrogen from water is about 83%, and the ratio to convert hydrogen into electricity is only about 30%. However, these figures are constantly improving, indicating that the technology is becoming increasingly efficient and has potential for being produced at a larger scale in the future.

"Droughts and water scarcity make green hydrogen production unsustainable"

The use of renewable energy sources, like low-carbon hydrogen, is crucial to fight climate change and limit the negative effects of heat waves and water scarcity. In water-stressed areas, water for electrolysis can come from desalinated seawater, or purified wastewater.

Conclusions

Achieving net zero by 2050 will require us to make the most of all our available resources. While more established renewables like solar PV and wind are playing a crucial role in cutting harmful emissions, we believe that diversifying our energy mix will be essential to accelerate the net zero transition and get us back on track.

In this context, managing water and fluids sustainably is a moral imperative. Proper fluid management will increase the efficiency of renewable energy applications, driving costs down, promoting technology uptake, and incentivising access to clean, reliable and cost-effective energy for all.

> This is not a journey on which organisations can embark on their own: true change will require the joint efforts of multiple stakeholders, and an acknowledgement that building **sustainable partnerships** is the key to success.

At Xylem, we are ready to support the renewables energy sector with excellent technology and outstanding consultancy. Our global team of over 17,000 water experts is fully committed to our sustainable ethos, and ready to deliver the best possible solutions to promote a true energy revolution.

The Xylem history: ensuring smooth sailing in the renewables transition

As a global water technology leader, at Xylem we have a clear mission: **we want to solve water.**

Xylem was founded in 2011, but the heritage of our brands is much longer: since 1848, core products in our solutions portfolio have been transforming how we manage water. Over the years, we have expanded rapidly. We now have:

350
locations

50
countries

17,000+
water experts

We have rapidly become an established supplier of water solutions for the renewables sector, with a focus on dispatchable technologies such as hydropower, biogas and low-carbon hydrogen.

Our long-standing achievements in the hydropower sector:

- **400+** successful installations
- A **worldwide** presence
- **40+ years** of reliable operations at several installations

How we support the booming biogas market:

- **Heavy-duty Flygt mixers** support the industry since 1992
- Xylem's **Biogas Centre of Excellence**, open since 2021
- A team of **biogas R&D specialists**
- A commitment to **continuous innovation**

Tackling the challenges of green hydrogen generation:

- New **collaborations** in the green hydrogen sector
- **Vast range** of solutions for pumping, deionisation and purification
- 2023: acquisition of Evoqua, offering **cutting-edge CEDI solutions**
- Plans to move forward with **more partnerships** in this space

1848	our core products from our brand portfolio enter the market
1980s	first collaborations in hydropower
1992	first collaborations in biogas
2011	Xylem is officially established
2021	launch of the Xylem Biogas Centre of Excellence
2022	starting collaborations with the green hydrogen sector
2023	350 locations, 50 countries, 17,000+ water experts

Moving forward: building sustainable partnerships

We look forward to growing and nurturing our sustainable partnerships, and can't wait to see the results we can achieve by joining forces with our clients.

> Water is never static. Neither are we.
> **We're Xylem, and we're solving water.**

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Xylem |'zīləm|

1) The living 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 environmentm 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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