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wave

Insights from Veolia Water Technologies

Hubgrade digital services

Meeting customer challenges in the water industry

RESILIENCE

Building water system resilience with a digital roadmap

CYBERSECURITY

Stepping up defense against cyber threats

SUSTAINABILITY

Enabling sustainable reuse with real-time optimization

SERVICES

Augmented reality to boost field services

Innovative Water Solutions

Digital at the heart of our business strategy

Our ambition is to always better serve our customers.

Living through a global pandemic has ascertained the importance of being able to support our customers under all circumstances — sometimes with limited physical access to their sites — to help them face critical situations and ensure the resilience of their business and services.

From providing a continuous supply of pure water to hospitals and laboratories to ensuring the quality and compliance of ingredient water for food and beverage companies, preventing unplanned downtime for pharmaceuticals or supporting municipalities in reducing their carbon footprint, we help our customers meet regulations and achieve their sustainability goals, maximize their productivity and optimize their operating costs.

By combining digitally-enabled solutions and operational data with our unique global water expertise, we support our customers in becoming more sustainable, more performant and more resilient.

In 2018, leveraging decades of continuous co-innovation with our customers, we launched our Aquavista cloud platform and established ourselves as digital water service providers. We are now moving from Aquavista to Hubgrade, which brings together all of Veolia Group's digital offerings for data collection, management and analysis. We strongly believe that Hubgrade will take us even further into the world of connected environmental expertise "delivered as a service" to our customers.

Thanks to Veolia's global network of environmental expertise, powerful means of innovation and very active digital community, we'll be stronger at serving our customers, worldwide.

This edition of Wave Magazine will introduce you to the latest innovations — from the usage of artificial intelligence in digital twining and augmented reality in our remote services to the integration of cybersecurity when designing our solutions — as well as our customers' drivers which push us to always be more ambitious and innovative to support them.

Happy reading and thank you for embarking on this digital journey with us!

Aude Giard
Chief digital officer
Veolia Water Technologies

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Hubgrade
Powered by ⦿ VEOLIA

Meeting customer challenges in the water industry

We are experiencing unprecedented changes in our climate on a global scale. We are facing new challenges, such as the health crisis that separates us from the places we need to be. For water technologies, we need to anticipate disturbances, prepare for them and respond quickly to ensure the resilience of operations. With Hubgrade, water and wastewater operations can be safely and sustainably managed no matter the crisis or location.

Hubgrade combines digital tools with the expertise of Veolia employees to deliver operational and environmental efficiency. It capitalizes on human competency and digital power to process data and provide a continuous supply of optimized solutions according to each user's priorities: compliance, operational excellence, or sustainability. As a data management portal, Hubgrade makes water processes smarter, safer and more sustainable.

With Hubgrade, Veolia Water Technologies addresses the water optimization needs of municipalities and industries to respond to the challenges they face throughout the water cycle. We are also deploying a new organization, digital systems and innovative business models to implement change.

Veolia Water Technologies deliver three innovative services:
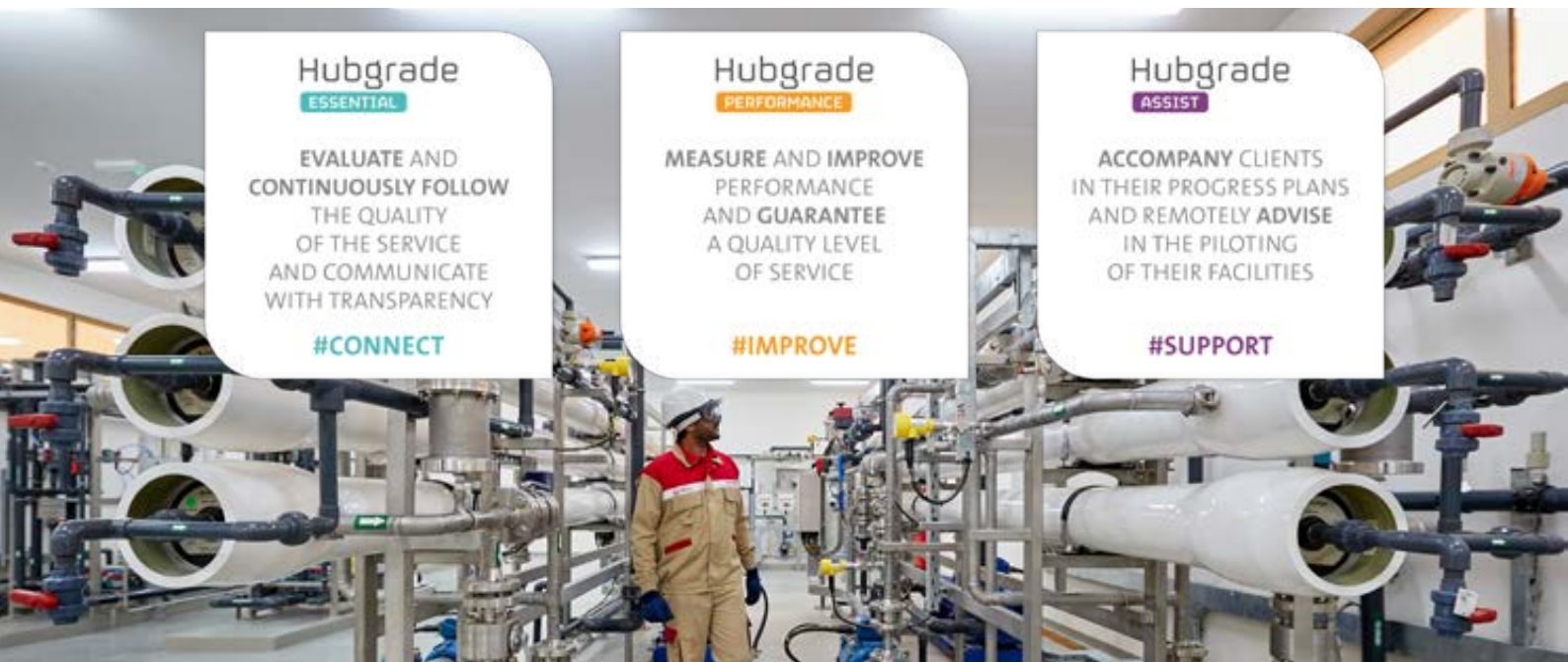
Hubgrade
ESSENTIAL

EVALUATE AND
CONTINUOUSLY FOLLOW
THE QUALITY
OF THE SERVICE
AND COMMUNICATE
WITH TRANSPARENCY

#CONNECT

Hubgrade
PERFORMANCE

MEASURE AND IMPROVE
PERFORMANCE
AND GUARANTEE
A QUALITY LEVEL
OF SERVICE

#IMPROVE

Hubgrade
ASSIST

ACCOMPANY CLIENTS
IN THEIR PROGRESS PLANS
AND REMOTELY ADVISE
IN THE PILOTING
OF THEIR FACILITIES

#SUPPORT

Veolia's global digital offer

A wide and flexible range of digital solutions responding **to operator and manager challenges**

Fast access to a global network of Veolia experts

Digital platform that relies **on multi-source data, advanced analytics** and Veolia lifelong water-treatment **expertise**

Proven solutions already **deployed worldwide** with **excellent customer feedback**

● **Main functionalities:**

✓ 24/7 private and secure access.

✓ Mobile, user-friendly interface.

✓ Customizable interface by user personas.

✓ Multiple sources of data and versatile data collection (manual and automatic).

✓ Best-in-class algorithms to ensure the reliability of data.

✓ Equipment agnostic (Veolia and non-Veolia equipment).

✓ Applicable to a standalone technology, a range of equipment or entire water and wastewater treatment plants.

● **For your water systems, this means:**

✓ Ensuring a high level of water quality to comply with stringent regulations.

✓ Reducing operating costs.

✓ Avoiding investments.

✓ Increasing productive uptime.

✓ Achieving sustainable goals.

Standard products

Packaged solutions

Water & wastewater treatment plants

10 features

Advanced analytics combined with human expertise to achieve compliance, operational excellence and sustainability in a convenient, secure and resilient way.

Hubgrade has already optimized water operations for thousands of customers around the globe, with more than 4,000 users and 640 active sites. Hubgrade is available in 30 countries and in 10 different languages.

Hubgrade

- 5 MAINTENANCE TASKS
- 6 KEY PERFORMANCE INDICATORS
- 4 AUTOMATIC REPORTING
- 7 PREDICTIVE ANALYTICS
- 3 EVENTS AND ALERTS
- 8 OPTIMIZATION
- 2 DATA VISUALIZATION
- 9 TRAINING AND MENTORING
- 1 DIGITAL LIBRARY
- 10 REMOTE EXPERT ASSISTANCE
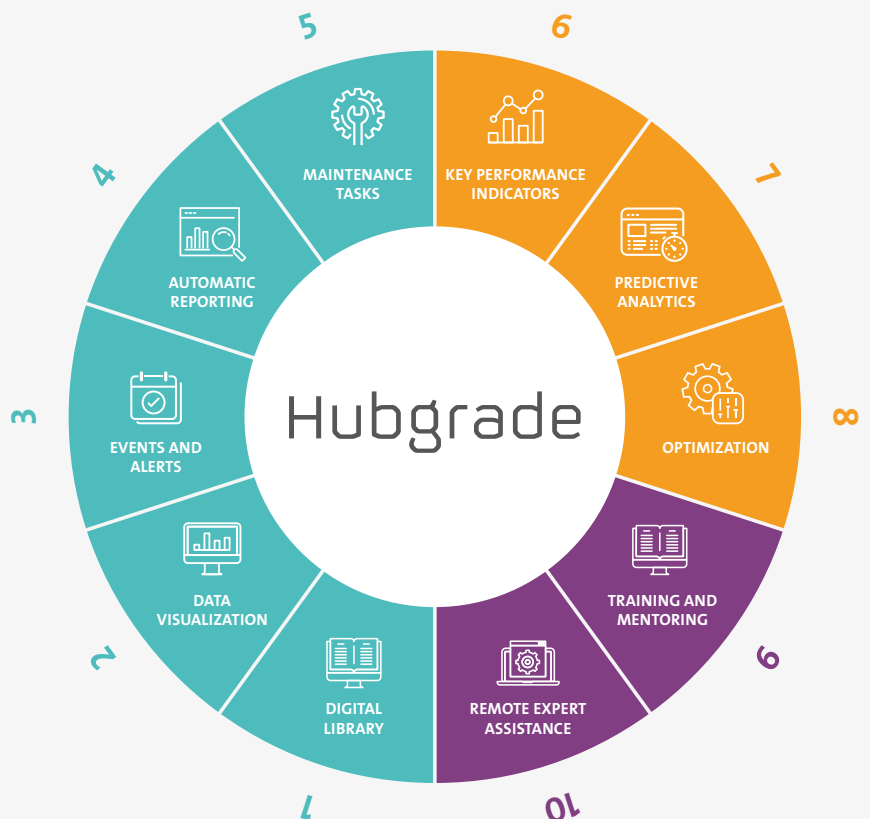
Building water system resilience with a digital roadmap

As water-reliant businesses increasingly focus on the growing challenge of disaster management in response to both natural and man-made events, process monitoring software suites have emerged as a key element when it comes to business continuity and resilience planning.

More than any other component, water is essential in countless industries and business sectors, as well as a vital element for humanity. For drinking, hygiene and almost every industry, water is critical. Food and beverage businesses such as dairies and breweries, industrial sectors like pulp and paper or oil and gas, as well municipal authorities and utilities tasked with supplying clean potable water and wastewater treatment services — the provision and quality of this resource must be maintained under all circumstances.

Simultaneously, all businesses and enterprises face the possibility of disruption as a result of both natural and man-made events. Natural disasters such as hurricanes, floods, droughts or fires, seasonal flu or unprecedented phenomena such as the COVID-19 pandemic, even localized events like power outages, terrorism or traffic disruption can all have an impact on the provision of good quality water. By reducing staff availability or making it impossible for them to reach a particular location to execute any required functions, normal business practices can be shattered by even the most unlikely developments when they affect the supply of good quality water.

There are significant business impacts. UN Water, for example, estimates that economic losses from weather-related disasters are around US$250 — $300 billion annually. However, it is also becoming increasingly evident that even extreme weather events are growing in frequency and intensity. With the economic cost of disasters acting as a major incentive for companies to devote greater focus to preparedness and prevention, far more attention is now being given to business continuity planning in sectors that rely on water and wastewater treatment.

Developing a business continuity strategy based on water resilience

Developing a business continuity plan is essential for water-reliant industries and service providers to maintain productivity and services during unplanned disruptions. Utilities and businesses which use water or which rely on wastewater treatment should adopt measures to ensure their businesses are robust and able to respond to even the most extreme circumstances. A continuity strategy can help protect businesses from lost production and financial losses, as well as minimizing any social impacts that may result from natural disasters.

While, by their very nature, disasters are unique and unfold in unpredictable ways, best practice business continuity plans outline all the necessary procedures which are needed for an organization to continue to operate or enable it to resume operations rapidly in the event of disruption. Any such strategy should ensure that it is appropriately structured to address any event and at any scale, from local up to and including a global response. Indeed, an effective business continuity strategy should ensure it is able to manage all potential local events to guarantee a business is globally robust. Failure to develop such a strategy can cost a business dearly, both financially and in reputational damage.

Today, the emergence of modern information and communications technology (ICT) platforms allow an approach to business continuity that can maintain seamless access to core system performance data. By delivering all necessary data and information, such systems allow timely intervention as required, even when staff are deployed remotely or unable to physically attend particular sites.
Covering all business processes, key assets,

human resources and more, any business continuity strategy should use ICT to access business information from any remote location and from any device, even in the most extreme situations.

Building a robust water supply system for business continuity

Recognizing the challenges faced by water-reliant enterprises, Veolia developed its cloud-based Hubgrade digital platform that can support all remote data monitoring activities. A holistic suite of intelligent solutions that provides a real-time plant overview to ensure water quality is maintained. Alongside the core Hubgrade system, additional modules also support remote plant process optimization and decision-making, even under crisis conditions.

Suitable for water treatment and supply plants of any size, as well as both new and retrofit installations, the system monitors all necessary functions and appropriate qualities for all water process applications and features fully-integrated, best-in-class security. Considering business continuity best practices, companies and enterprises which rely on water quality must be proactive in

Hubgrade has helped the Nosedo WWTP achieve annual OPEX savings of more than €400,000.

Guaranteed uninterrupted supply of pure water

Regardless of size and location, every healthcare facility must adopt a robust resilience strategy to ensure patient safety and quality of care, under all circumstances. Healthcare facilities cannot afford any equipment failure or system shutdown, which consequences could lead to department closures, patient lists being cancelled, aggravated health, even death.

With a consistent supply of high-purity water a necessity for much of the healthcare sector, Hubgrade can optimize process water technology systems and prompt preventative maintenance to avoid system downtime. Operators and healthcare workers are assured of the seamless delivery of the high-purity water required by the site at all times, providing much-needed peace of mind.

An example comes from Ras Al Khaimah in the United Arab Emirates where RAK Hospital, a multispeciality facility, has been established since 2007. The hospital's clinical chemistry units — which must be operational 24 hours per day, seven days per week — require an uninterrupted supply of pure water for which both quality and quantity must be guaranteed.

Given how crucial this equipment is, response time on a service call cannot exceed two hours. With Veolia Water Technologies' closest office 90 minutes away, service teams are faced with a logistical challenge.

The hospital's critical analyzers are fed by two Elga Medica™ Pro 60 units equipped with Hubgrade for data visualization and performance alerts. Our service teams are able to remotely monitor water quality so when a drop occurred in the water resistivity, they immediately travelled to RAK Hospital to replace the consumable. The supply of pure water was restored without any impact on the operation of the facility. In another instance, Hubgrade alerted the service team that the feed water to the Elga units had stopped. The team was able to notify the customer and troubleshoot the water supply problem before the water storage was depleted.

The peace of mind procured by Hubgrade in this context is truly invaluable.

implementing technologies and protocols that can support business recovery in the event of disaster. Digital cloud-based tools like Hubgrade support water quality and help to guarantee 'business as usual' during crisis management by ensuring that water users are able to operate their businesses when staff are not available or are unable to physically reach water and wastewater treatment facilities.

Secure remote on-line access to critical water quality data is a key element in business continuity planning for all the diverse industries and applications reliant on water. Even relatively modest investment in digital technologies and ICT can make significant inroads when planning for business risk mitigation in the event of catastrophe. Simultaneously, such technologies can also help to optimize processes, equipment and facilities to reduce operational expenditure and even potentially eliminate capital expenditure requirements, delivering a return on investment irrespective of business risks emerging from unforeseen disruptive events.

An example comes from Milan in Italy where Hubgrade was commissioned in 2019. The real-time optimization tool has helped the Nosedo wastewater treatment facility achieve annual operational costs savings of more than €400,000.

It is clear that digital tooling has a key role in normal business operations, but in disaster planning, ICT at local, regional and global scales is a core part of any comprehensive business continuity strategy.

Stepping up defense against cyber threats

Imagine. It is 3:18 am and everyone for miles around you is fast asleep. You are asleep too. Yet, 5,000 miles away a hacker has gained unauthorized entry to the unsecure system that controls your drinking water infrastructure.

Unbeknown to yourself, the plant manager and the sleeping city all around you, the chemicals that are used by experts to ensure safe and compliant drinking water are being altered.

The chemicals that are used to control the pH of the water and to effectively minimize water pipe corrosion have been increased to deadly levels. And, in just a few hours, the sleepy city will awake to start a brand new day, not knowing that their drinking water is now poisonous.

Now stop imagining. A scenario like this almost happened in February 2021 when an online hacker successfully breached the online system and deliberately tampered with the sodium hydroxide levels at a water treatment plant in Florida, USA, which provides drinking water to more than 15,000 residents of the City of Oldsmar.

The worrying thing about this event is that the vital nature of the water industry makes it a prime target for cybercriminals. The first recorded act of cyber warfare occurred in June 1982 which consisted of a fraudulent modification of the software controlling the
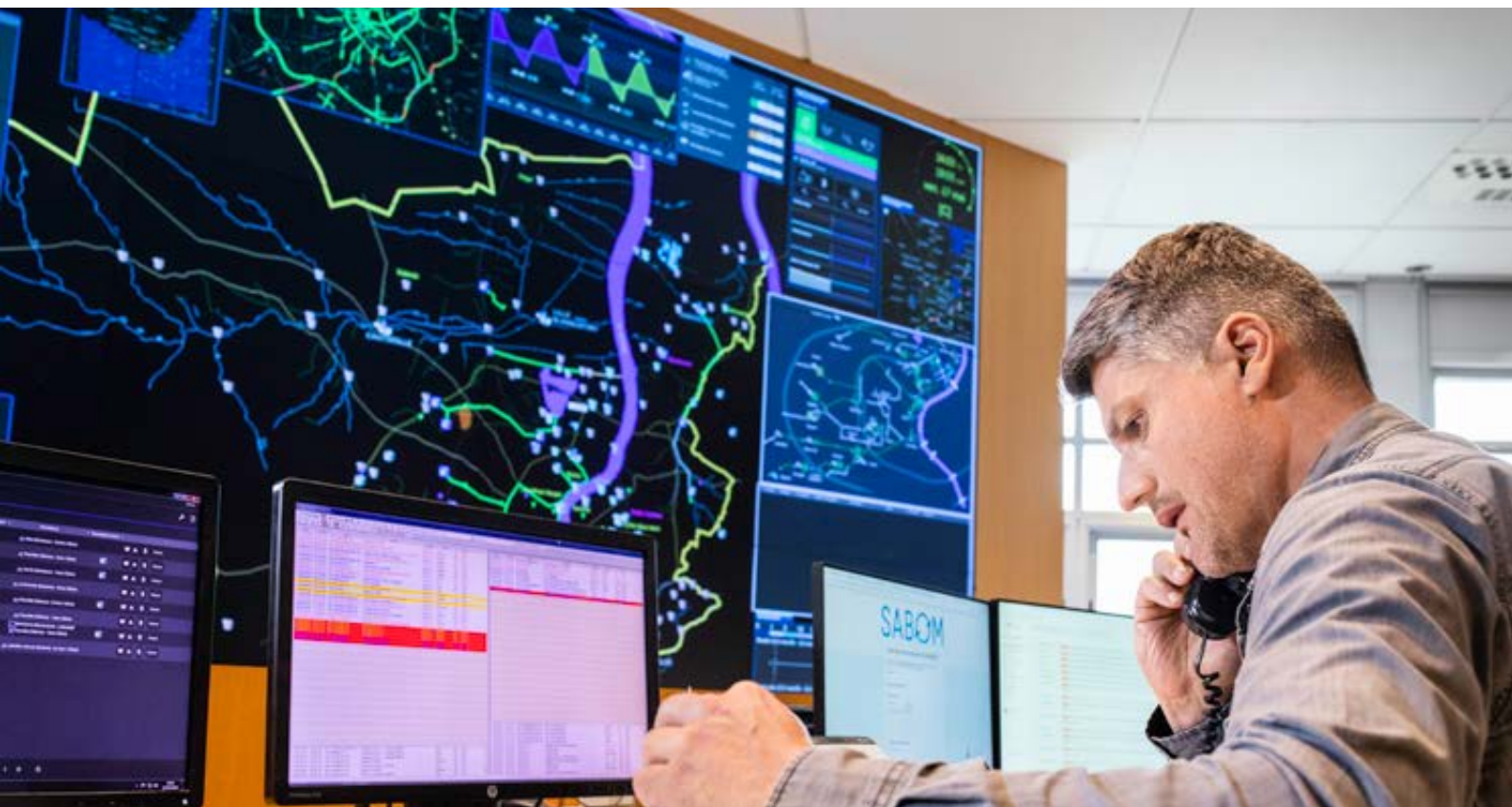
regulation of the pumps, valves and turbines of the trans-Siberian pipeline. This caused the most remarkable non-nuclear explosion ever observed from space.

Since then, cyber attacks have continued to grow in scale. In 2018, the ecosystem of cyber attacks was mainly focused on extortion by small groups or criminal organizations, using ransomware. Nevertheless, geopolitical unrest and cyber terrorism are also important risk factors that should not be minimized. For example, in just one month, May 2019, more than 170 attacks on water infrastructure were recorded in the United States alone.
In 2021, government information security agencies and specialized cybersecurity firms predict an increase in cyber attacks, mainly ransomware attacks targeting critical industries.

"When you consider all of this, it's clear that our number one priority is to offer products with top-notch digital security and compliance," explains Marcelo França, chief information security officer for Veolia's Technology and Contracting division. *"We guarantee a high level of cybersecurity, from the connectivity solution to your*

industrial control systems to the isolation of application layers. We ensure the protection of our customers' data through a robust access system, a strict encryption policy and innovative means of protection and control that are an integral part of our DNA."

Our security strategy is based on the fundamental principles of information security which are confidentiality, integrity and availability. Every element of an information security program — and every security control put in place by Hubgrade — has been designed to achieve one or more of these principles.

Our cybersecurity team provides a new driving force from 2021 onwards to meet the challenges we are set to face in the coming years. We are implementing a new strategy, which will enable us to have even greater control to boost our level of cybersecurity and to certify our security management system. We have put in place a cybersecurity academy offering different modules, covering everything from the basics to advanced cybersecurity awareness.

Hubgrade ensures

- **Confidentiality meaning sensitive information is accessible only by authorized people. It is implemented using security mechanisms such as encryption at rest and in-transit, data access control with usernames and passwords, physical secured devices.**

- **Integrity so information is in a format that is true and correct to its original purposes. The receiver of the information must have the information the creator intended him to have. It is implemented using security mechanisms such as data encryption and hashing.**

- **Availability to ensure information and resources are available to those who need them. It is implemented using methods such as hardware maintenance, software patching and network optimization. It also benefits from Amazon Web Services' cloud infrastructure to guarantee high-availability. Dedicated network and web application firewall devices are used to guard against downtime and unreachable data due to malicious actions such as distributed denial-of-service (DDoS) attacks.**

"We will offer guidance to all teams who contribute to the success of our products, including our customers, because we are convinced that everyone is a player in the security business," explains França. *"We are launching an ambitious security modernization strategy based on our experience in the industrial water sector while including the latest international standards in information protection and industrial protection."*

The upcoming years will be an opportunity for us to further develop solutions that are adapted to threats of both the present and the future by partnering with innovative and representative players in the field of cybersecurity.

França adds: *"Without disclosing the content of our strategy, I can mention a few technologies and services, such as micro-segmentation, continuous monitoring of vulnerabilities (Bug bounty), the integration of more security in each brick of the CICD pipeline (DevSecOps) and a rigorous control over the supply chain that will contribute to the success of our system."*

To ensure our mission — to maintain essential water and wastewater services to protect human health and the environment — we require complex and fully connected, flexible systems that can use a constant flow of data from operations and connected production systems to learn, adapt to new demands and benefit from access to expertise.

This requires the processing of secure information (IT) and the implementation of operational systems (OT). *"This infrastructure must be protected at all costs,"* states França. *"And we are prepared to do this. Hubgrade is part of the essential digitization of these new industrial services. We provide our customers with the best tools and expertise to remotely monitor, evaluate and optimize the management of water and energy resources."*

Innovation that makes a difference:
Tech and the Sustainable Development Goals

There's nothing more essential to life on this planet than water. However, many of the water sources that help our ecosystem thrive and sustain our way of life are under severe stress.

The United Nations estimates that almost two billion people will be living in countries or regions with absolute water scarcity in just a few years. 2025, to be exact. And, a further two-thirds of the world's population will be facing regular water shortages.

Digital innovation has the power to make a difference by advancing water sustainability and improving resilience to help everyone access this vital resource. Innovation as a whole is cited throughout the United Nations' Sustainable Development Goals (SDGs) as a way to supercharge ideas, turning them into solutions, to create a more sustainable future for everyone.

United Nations Sustainable Development Goals

In 2015, the 193 member states of the United Nations officially swore their alliance to a historic environmental, social and economic agenda, entitled *"Transforming Our World: The 2030 Agenda for Sustainable Development."* This agenda launched 17 Sustainable Development Goals (SDGs) that were officially adopted to collectively create a better and more sustainable future for everyone, by 2030.

"It is a roadmap to ending global poverty, building a life of dignity for all and leaving no one behind. It is also a clarion call to work in partnership and intensify efforts to share prosperity, empower people's livelihoods, ensure peace and heal our planet for the benefit of this and future generations," explained then United Nations Secretary-General Ban Ki-moon.

Five years after the historic 2015 agreement, the progress of each member state and its country-specific targets was reviewed. The conclusion: *"Global efforts had been insufficient to deliver the change we need, jeopardizing the Agenda's promise to current and future generations,"* stated United Nations Secretary-General António Guterres. *"Now, due to COVID-19, an unprecedented health, economic and social crisis is threatening lives and livelihoods, making the achievement of goals even more challenging."*

With less than 10 years remaining, Guterres has since called for a decade of action to deliver the 2030 promise — by mobilizing more governments, civil society, businesses and calling on all people to make the SDGs their own.

Of the 17 SDGs, goal number six focuses on increasing access to safe, clean drinking water and sanitation since billions of people — mostly in rural areas — still lack these basic services today. Targets within goal six call for the expansion of international cooperation in water and sanitation-related activities and programs, including desalination.

A key example of this in action is the Oman Sur reverse osmosis (RO) desalination plant. This facility processes over 150,000 cubic metres of seawater to produce 130,000 cubic metres of drinking water every day — that's equivalent to 52 Olympic-size swimming pools. The plant is vital to the 600,000 residents of the Sharqiyah region where water demand far exceeds its current availability.

Artificial intelligence is the brain behind the water-operational excellence of this plant, as a complex challenge the operators face is anticipating when to clean or change the water filtering membranes. A team of data scientists and Veolia RO process experts analyzed three years of operational data to reveal membrane fouling patterns. A prototype, developed during the first wave of the COVID-19 pandemic, was then industrialized into a scalable digital solution in partnership with Amazon Web Services. Read more about Smart Membranes on page 26.

Innovation also plays a key role in supporting goal number eleven, which focuses on sustainable cities and communities. For more than 14 years, BlueKolding A/S — the utility responsible for the municipality of Kolding in Jutland, Denmark — has prioritized and applied technology to ensure they can maintain steady plant loads and avoid combined sewer overflows across their entire sewer network, owing to frequent heavy rainfalls.

Through the use of data, BlueKolding has increased sewage system resilience and this innovative approach has in turn helped maintain the wastewater infrastructure of the city. Then, in 2017, they launched BlueGrid, a project to combine the data already being captured with weather forecasts and rain radar data to ensure city and community protection, whatever the weather. Read more about BlueKolding on page 29.

Goal number nine focuses on inclusive and sustainable industrialization, together with innovation and infrastructure, to unleash dynamic and competitive economic forces that generate employment and income. And this too is linked to vital water resources.

Global travel was extremely limited during 2020, owing to the COVID-19 pandemic. This meant when food and beverage giant Nestle required a factory acceptance test (FAT) an alternative solution needed to be found.

A real-time augmented reality (AR) tool was used to beam water experts into the field. The German team was able to virtually present all the pre-assembled equipment to the customer in Jordan, the UAE and France. The full inspection was carried out live and the FAT approved in under two hours, instead of a three-day business trip. This avoided any possible delay in commissioning and production of the process water treatment plant underpinning the manufacturer's production. Read more about the use of AR on page 24.

Today, progress is being made but, overall, the world is not yet advancing at the speed or scale required to deliver the Goals by 2030. In many ways, the ongoing health crisis has accelerated the digitalization of many businesses and services, from teleworking and video conferencing systems, as well as access to healthcare, education and essential goods and services.

We need to champion ambitious action, especially when it comes to digital technology since these innovations can — and will — make a difference.

Hubgrade now available in China

Veolia Water Technologies is proud to announce that its digital service Hubgrade is fully deployed in China in accordance with the Cybersecurity Law of the People's Republic of China.

Veolia designed Hubgrade with security at its core and is committed to protecting the integrity of physical devices, networks, software and data from attack, damage and unauthorized access. The digital solution runs on today's most secure, state-of-the-art cloud-based system. Cybersecurity is a critical component that is fully integrated at every level, from data acquisition and transfer to data aggregation, analysis and reporting.

Hubgrade in China

As laid out in the Cybersecurity Law of the People's Republic of China and other relevant laws and regulations, national cyberspace sovereignty, protection of critical information infrastructure and protection of individual privacy are key priorities in the country. To provide the best experience for our customers in China and to comply with China's legal and regulatory requirements, Veolia Water Technologies has partnered with local Chinese experts (Beijing Sinnet Technology Co., Ltd. and Ningxia Western Cloud Data Technology Co., Ltd. via AWS China) to establish a local platform for Hubgrade in the country.

Hubgrade is therefore fully operational in China and deployed in accordance with national cyberspace sovereignty, offering peace of mind for users while they benefit from high levels of performance and international expertise.

The gateway to Hubgrade in China is a private and secure, customizable and mobile-friendly user interface. The customer web portal is designed to maximize transparency and control while increasing the operational efficiency of water treatment systems. It seamlessly consolidates water and wastewater treatment equipment performance data and service interactions into a robust dashboard that can be accessed from any location, anytime, from any device in China.

Hubgrade Performance

The Hubgrade Performance module is an online digital twin of the wastewater treatment and sewer network which provides prediction in real-time, leveraging a suite of powerful algorithms, intelligent software and holistic solutions offering real-time optimization. This state-of-the-art cloud computing platform is now available in China.

Hubgrade Assist

Finally, Veolia Water Technologies' local team in China can provide feedback in a timely manner thanks to real-time access to plant data. They are able to assist with preventative measures, leading to a reduction

HUBGRADE IS FULLY OPERATIONAL IN CHINA AND DEPLOYED IN ACCORDANCE WITH NATIONAL CYBERSPACE SOVEREIGNTY.

PHYSICAL SECURITY
Data acquisition

NETWORK SECURITY
Data transfer

CLOUD SECURITY
Data aggregation & analysis

DATA SECURITY
Data protection

in operating costs, and reactive measures such as troubleshooting and process support. By using the data and analytics along with technology that enables its experts to see what the operator is seeing without going on site, problems can be addressed right away while risks associated with events such as safety, plant shutdowns or compliance failures are greatly reduced.

Hubgrade brings Veolia's experts closer to plant operators and their operational needs.

The future of water

Throughout history, technology has played a pivotal role in human development but what does it hold for the future of water?

From gunpowder to the compass, every human empire has risen or fallen with the help of technology. In less than a lifetime, technology has advanced so rapidly it has changed the way society behaves and operates, on a global scale.

From the creation of the World Wide Web in 1989 to the everyday smartphone, which is more powerful than the computer that sent Apollo 11 to the moon, in just 30 years our technological advancements are clear. However, looking to the future, the next triumph of technology will not be the rise or fall of an empire, it will be the rise or fall of our species.

We are at a tipping point in our fight against climate change and resource depletion — a vital one being water. Many of the water sources that sustain our way of life are already under severe stress; however, the demand for safe, clean, water continues to rise.

Aude GIARD, chief digital officer at Veolia Water Technologies

It's projected to increase 55% by 2050 — this includes a 400% rise in demand to maintain manufacturing processes — as the global population is predicted to soar to 9.7 billion. This is two billion more people than today. According to research from the Massachusetts Institute of Technology, this means 52% of the world's projected population will live in water-stressed regions and over five billion people will suffer from water shortages due to climate change, increased demand and polluted supplies.

Without action, this paints a grim picture. But, with the help of technology, we are now able to move at a pace and at a scale that has never been possible throughout our history. And artificial intelligence (AI) is at the heart of this.

Today, AI is ubiquitous — it controls the adverts we see on social media, powers our Alexa or Siri and helps to detect fraud. In addition, AI is already proving itself to be critical in three fundamental ways to support sustainability with many possibilities for growth.

Firstly, AI is starting to have the power to analyze and comprehend the ecological complexities of local, national and global water cycles. *"The combination of AI, particularly with machine learning and water process expertise already helps predict the process and mechanical behavior of water technologies and equipment,"* explains Aude Giard, chief digital officer at Veolia Water Technologies.

"We have started using both live and forecast weather data to predict the impact on the local water infrastructure and therefore the surrounding environment. This will soon become the norm as we use algorithms for storage and optimal network flow. This is vital as extreme weather events trigger downpours since this foresight helps prevent the risk of sludge overflows."

Looking to the future of how AI can help deal with ecological complexities, Giard predicts, *"all utilities will be connected to smart, local grids that are powered by circular loops of resources — water reuse, anaerobic digestion, solar, wind, etc. These grids will be so local*

and analytics will be so advanced that there will be a digital twin of every household and we will be able to meet all individual utility needs without fossil fuels or devastating natural resources. As well as looking at the weather and managing our needs, we'll also be able to monitor what our environment needs depending on the local landscape and biodiversity. It will be possible to tell when forests and bushlands require watering to prevent forest fires, and we will be able to adapt irrigation to prevent flooding."

The second big arena where AI will play a key role in boosting sustainability is consumer education and behavioral change. Already AI is used by consumers to improve their health and conveniently manage small household items with smart home devices. In the same sense, AI will help consumers adopt more sustainable behaviors and make better choices when it comes to their water usage.

"In the years to come we will see the development of apps for users suggesting, through the use of AI models, when to use the dishwasher or washing machine to be more sustainable — this insight would be gathered by and linked to, smart, local grids," explains Louis W. Ø. Larsen, digital business developer for Hubgrade.

"In the face of climate change, these seemingly 'small' everyday necessities will need to be better controlled to lessen the impact on the environment and to make sure resources are shared. As populations grow, water supplies will become more variable as demand increases and this is where AI systems will coordinate this variating supply to the demand to satisfy the system in the best possible way."

Larsen adds, *"I imagine that flexibility to water access could in part be solved with smaller loops or grids, like the power industry, meaning air moisture capture and neighbour scale treatment systems. Where local communities*

can share the available resource via apps, for example, trends in usage could then be analysed and interpreted by AI models to predict when the water would be available and where and how it is to be used instead of discarded directly. One man's trash is another man's treasure sort of approach."

Finally, AI will continue to support supply chains throughout manufacturing processes to optimize how vital resources, including water, are reduced, used and reused as part of ecological transformation.

"Food manufacturing is a prime example," says Peter Stokes, director of global key accounts. *"The growth in the population means we will need to produce more food, but with ever-decreasing water availability, the food we eat in the future will look very different."*

"Plant-based foods and man-made proteins will require a higher capacity to manufacture and, in order to reduce transportation, more concentrated products will be made and consumed like we see the astronauts do on the International Space Station. The consumer will demand a shorter time from order to receipt and so the factories will need to be more predictive and agile. The factories will also become smaller, producing smaller volumes of products but with a higher number of product lines, which means the factories require more frequent cleaning and change over."

Stokes continues, *"We already see the use of digital control within our manufacturing base, with remote control of operations becoming more commonplace; however, in the future, AI will be the link between consumer demand, factory inventory, manufacturing process and distribution. AI will predict manufacturing requirements for steam, cooling water, ingredient water, production line cleaning and availability for downtime by predicting consumer demands — for example, warm weather will trigger ice cream production.*

Louis W. Ø. LARSEN, digital business developer for Hubgrade

Peter STROKES,
director of global key accounts

With the continuing decline in the volume of water consumed in the factory processes, both during manufacturing and for ingredients, AI will play a bigger part in providing much greater control and predictability over availability, quality, waste and reuse of the water the factory does use."

"Even at the start of the food chain, in agriculture, the use of hyper-local weather forecast could help adapt crop growth to weather conditions," predicts Chloe Dupont, head of digital transformation at Veolia Group. *"It will have the potential to optimize the use of water and reduce mitigating the activities' environmental footprint."*

"The foundations of all of these future technologies are already in place. In addition to better managing water throughout production processes, today AI also helps identify water leakage meaning we can go one step further in reducing water wasted. And when it comes to equipment, algorithms help predict when to change filter membranes which significantly contributes to an uninterrupted clean and safe water supply in manufacturing processes," explains Dupont. *"All of these things help better protect our water cycle and help us work more in harmony with the local ecology."*

Chloe DUPONT, head of digital
transformation at Veolia Group

"I dream that AI becomes part of the day-to-day life of water operators with live data, predictions, suggestions of actions all together supporting quicker and more informed decisions to protect water resources. I believe solutions are still to be invented in the face of increasing water challenges and collaboration between manufacturers, water experts, data scientists, start-ups and beyond will become even more fundamental to imagine innovative and digital solutions for ecological transformation."

So, there we have it. The future of water has already started thanks to the power of AI matched with human expertise. And it will prove to be our period's equivalent to Newton's apple, Fleming's penicillin and Bell's telephone. Our experts predict the true rise of humankind will come from our ability to understand and action what we learn from super-advanced AI so let's embrace AI for both pace and progress to protect our global empire.

A digital twin for the plant

Digital twin is a new integration platform that connects technology and operators in a unique way as it provides a holistic view of a utility's water system and enables data-driven decision-making.

We have all dreamt at some point of having a twin who could replace us during class or do our job in our place. A twin who would be more efficient and would succeed in achieving all the goals we struggle with. But what if this twin was in fact a digital double, exactly like us, able to try out and test all the things we cannot?

The concept was developed at NASA: full-scale models of early space capsules, used on the ground to reproduce and diagnose problems in orbit, eventually gave way to fully-digital simulations during its Apollo missions. Today digital twins are used in all industries, with analysts MarketsAndMarkets indicating that the market is expected to grow from $3.8 billion in 2019 to $35.8 billion by 2025.

Digital twins have already started to play a role in managing wastewater infrastructure. Simply put, they are a digital representation of physical infrastructure and its inner workings, providing a description of the current state of the system as well as predictive analysis of its future evolution from data acquired in real time.

The idea is to let us see what might happen if we were to make certain adjustments in real life. These adjustments can be trialed on the digital twin without having to test potentially expensive or risky changes on the real-world counterpart.

If implemented properly, digital twins can influence the design, build and operation of the system throughout its life cycle. **Given its vast expertise as both operator and technology provider, Veolia is uniquely positioned to propose the most powerful digital tool to optimize operation** — through informed insights — according to the objectives of savings, performance or capacity that were set at its implementation.

The Plant module of Hubgrade Performance is an online digital twin of the wastewater treatment plant. It creates a digital representation of the customers' assets which uses predictive analytics in real time to provide optimized setpoints to the PLC control and deliver insight to the operators, process engineers, and management.

The robust algorithms used help address challenges such as handling increases in load, meeting compliance requirements and reducing operating costs. The concept is simple: do more with less.

Everything starts with data

Digital twins are continuously updated with historical as well as current data from SCADA systems, sensors, meters and other measured sources to create an up-to-date representation as soon as new information becomes available. This enables utilities to better understand the past and current performance of their wastewater treatment

plant while helping them predict future performance and simulate the impact of potential changes in the virtual world before taking actions or committing funds. Historical data basically allows forecasting the future.

Hubgrade Performance's Plant module is rendered truly unique thanks to the robustness of its algorithms, which rely on data from more than 100 plants in operation, some for more than 25 years, for a total aggregated number of years with operational experience exceeding 800.

Through the system, the operator can decide to retrieve instructions from the Cloud, set Hubgrade Performance Plant to optimize or use existing PLC setpoints. Benefits include increased machine availability and reduced maintenance costs, with priority set on optimizing either savings, capacity increase or performance guarantees.

When the digital twin is used to predict the future — and the predictions are used to optimize and find the best control actions — it is known as Model Predictive Control (MPC). The idea is simply to imagine all the possible outcomes and then choose the best one. MPC explores the consequence of changes to processes without disrupting customer

operations. It also allows more robust control, because if data is missing for a period of time, the digital twin uses its virtual representation to reconstruct the process. Finally, MPC can have a positive impact on the environment by identifying the "best" control, therefore reducing greenhouse gas emissions.

Digital twin in action

The digital twin can be made available to operation teams to test stress scenarios or specific settings before actually implementing them. Another useful application is for planning teams to test new work to be carried out, or test temporary situations (during the work phase on certain parts of the network, for instance).

Automated data quality check and associated fall-back strategies secure the best achievable optimization at all times, taking into account the fixed boundaries of the existing PLC so that the whole operation of the plant can never be below or beyond what the operator has defined, and the outlet performances can never be lower than what the PLC allows for, even in case of failure of the digital system, should that happen.

Hubgrade is inspired by the Sustainable Development Goals and assists municipalities and industries in improving their environmental footprint and reducing their carbon emissions.

Optimizing wastewater treatment in Lithuania

Located on the Baltic Sea, Klaipeda is the main Lithuanian seaport and the country's third largest city. A growing population and tighter regulations meant that the wastewater treatment plant (WWTP), in operation since 1998, was nearing its maximum load capacity. Local utility AB Klaipėdos vanduo looked for a smart, cost-efficient solution to reduce total nitrogen in the effluent, optimize energy and chemical consumption, and increase the hydraulic capacity of the plant for it to handle higher flows during wet weather events.

from the left: CEO - Benitas Jonikas, Plant Manager Head of wastewater treatment service - Kristina Bereišienė, Director of production - Algirdas Špučys

Faced with the challenge to meet the effluent demand of 10 mg/l total nitrogen on the fully loaded WWTP, Klaipėdos vanduo implemented Veolia's AQUAVISTA™ Plant — now Hubgrade — in 2019. The holistic digital solution, composed of a suite of intelligent software solutions for real-time optimization of process performance, would be used to improve nitrogen removal while saving operating costs.

Commissioning was done in March 2020, remotely and digitally due to the COVID-19 pandemic. The plant optimization started on 1st of April and within weeks the first results were identified. Head of wastewater treatment service Kristina Bereišienė observed: *"An intelligent use of real-time data from our entire system reduced our operating expenses and effluent concentrations."*

While Hubgrade was being commissioned, there was a significant increase in industrial loading and the plant was now challenged by overloading in relation to design capacity. However, despite a 28% increase in loads being discharged to the plant and a 17% decrease in wastewater flow, the advanced algorithms

have in the first 12 months:
- Reduced effluent concentration of total nitrogen by 11%, from 9.9 to 8.5 mg/l.
- Reduced energy consumption:
  - mixer's operation in biology by 41%.
  - nitrate recirculation in biology by 34%.
- Only an 8% increase in aeration to handle additional 28% load.
- Reduced external carbon dosage by 85%.

Kristina Bereišienė further stated: *"Innovative digital solutions like Hubgrade are a sustainable, cost-effective way for us to continuously improve our WWTP operational processes."*

Hubgrade ensures the wastewater treatment plant a stable, automated operation, adaptability to load variations and an overall resilience.

While digital transformation can be a challenge with aging infrastructure, inadequate investment, changing climate and demographics, digital water is no longer viewed as an option but rather as an imperative. Veolia and Klaipėdos vanduo have successfully engaged in this journey together.

> "Innovative digital solutions like Hubgrade are a sustainable, cost-effective way for us to continuously improve our WWTP operational processes."
>
> **Kristina Bereišienė, Head of wastewater treatment service**

Augmented reality
to boost field services

When augmented reality (AR) is mentioned, people often think of the Iron Man movies, or the popular mobile video game Pokemon Go. But AR has long moved beyond Hollywood and gaming into everyday, practical applications. The COVID-19 outbreak and the experience of lockdown have shed new light on digital solutions that facilitate remote working; AR has proven to be a valuable asset in that aspect while ensuring operational resilience and reducing operational costs.

Augmented reality has been around for decades, having been developed at Harvard in 1968, but the technologies required to unleash its potential have only become available in the past few years. These technologies are used to transform volumes of data and analytics into images, text or sounds that are then overlaid onto the physical world around us.

According to the International Data Corporation, worldwide spending on augmented and virtual reality is forecast to accelerate out of the pandemic, growing from just over $12.0 billion in 2020 to $72.8 billion in 2024. On the commercial side, the largest investments are expected to be made in training and industrial maintenance — two applications that Veolia Water Technologies has already successfully integrated into its digital offering.

Innovation propels experts into the field... from their desk

In 2018, Veolia Water Technologies Canada was contracted by dairy producer Lactalis (Parmalat) to design and supply a complete wastewater treatment plant (WWTP) for its factory in Winchester, Ontario. As part of an extensive service coverage plan, the contract included the digital solution Hubgrade, and its services Essential and Assist.

When time came to commission the plant, the COVID-19 pandemic had started and some suppliers couldn't travel to Canada to perform the required operations. Lactalis was facing compliance issues and strong social pressure to start up its WWTP and treat sludge in a timely manner. The main challenge was the start-up of a centrifuge, which supplier Andritz had never yet done remotely.

One of the digital tools available as an Hubgrade Assist feature is an augmented reality platform, which provides remote assistance for commissioning, troubleshooting, maintenance services and emergency support. Martin Caspar, director of technical services for Veolia Water Technologies in Canada, explained: *"Following extensive negotiations related to the process and contractual risks mitigation between our customer, our supplier and us, we made the decision to rely on our digital tools to start the sludge treatment."*

Despite the difficulties faced, the team was able to successfully start and optimize the equipment in less than one week. *"Our customer, who was deeply involved in the process, was able to meet his treatment objectives and was very satisfied. Our digital tools allowed us to innovate and exceed*

customer expectations," continued Caspar. The customer agreed, with Anthony Leneveu, corporate environment technical manager for Lactalis Canada stating: *"In the midst of the pandemic, the strong collaboration between our teams and Veolia's teams has made it possible, thanks to new digital tools, to start-up complex equipment remotely, and achieve the expected performance in record time.»*

Based in Jordan but virtually in Germany

Another customer to benefit from the use of AR during the COVID-19 pandemic was Nestle, when the food and beverage giant required a factory acceptance test (FAT) done in Germany for a factory in Jordan. With global travel being extremely limited, an alternative solution needed to be found.

The Hubgrade team again used AR, which let the user see the real-life environment with a digital augmentation overlay. In this case, the German team was able to virtually present all the pre-assembled equipment to the customer in Jordan, the UAE and France. This means, without actually being there, the customer could still speak to the experts, thoroughly check the equipment and get answers to a wide range of situations.

The full inspection was carried out live and the FAT approved in under two hours, instead of a three-day business trip. The equipment was then shipped, avoiding any possible delay in commissioning and production of the process water treatment plant.

AR is also used to create a library of step-by-step instructions on how to troubleshoot equipment and process issues. The ability to collaborate with experts in real-time via smart glasses, smartphones, mobile devices and web browsers has helped in training employees and customers, and enables virtual visits for inspections or visual verification of equipment and network layouts.

Resolving issues via AR remote assistance also increases safety due to the hands-free nature of the smart glasses. The need for bringing in technicians from around the world to service remote locations is reduced, which helps businesses realize substantial savings.

Immediate intervention in Brazil, from Europe

When a large power facility in Brazil needed immediate intervention to assist in repositioning, parametring and troubleshooting the reverse osmosis (RO) units within its water desalination plant, once again, augmented reality was used through Hubgrade. The customer was provided real-time access to Veolia experts and was able to re-start the RO plant with the correct operational envelope, successfully overcoming this operational issue with reliable remote assistance, in a timely and cost-effective manner.

AR has proven to be extremely useful in assisting with commissioning, troubleshooting, maintenance services and emergency support during a time when travel, even for short distances, was strongly hindered. It has provided options to safely maintain services and honor commitments to customers.
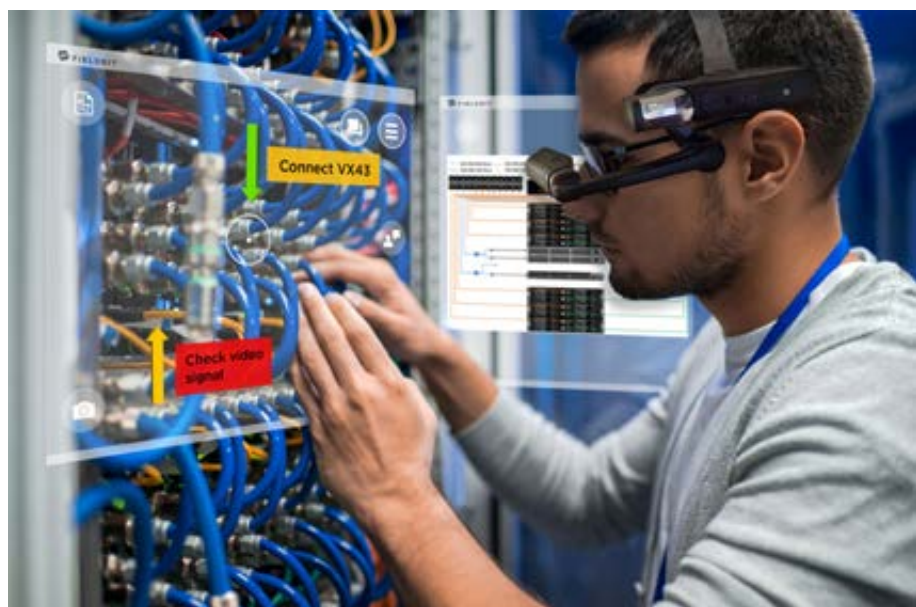
Using machine learning for water filtering membranes maintenance

Anticipating when to clean or change water filtering membranes in desalination plants is complex. Veolia Water Technologies worked with Amazon Web Services (AWS) to develop a solution to optimize the timing of the maintenance. Historical time series data was fed into an algorithm to learn from previous patterns and predict the future evolution of fouling indicators such as differential pressure or conductivity of the water, to allow the operating team to efficiently monitor the state of the system and anticipate possible deviations.

Membrane filtration is the most advanced technical process for desalinating seawater, purifying fresh water for drinking water and for industrial processes. These membranes, when combined with design and operating expertise are reliable, efficient and durable. They are vital when it comes to removing salt, micropollutants or any other undesirable dissolved material.

But like any technology or component in contact with water, reverse osmosis (RO) membranes used in desalination plants age over time. To slow this aging as much as possible, membranes must be carefully monitored, rigorously maintained and appropriately cleaned.

It is well known that RO systems can be very sensitive to changes in the operating environment, making it difficult for the operator to identify and anticipate the real state of fouling and aging of the membranes. In order to fully assess the state of membranes, it is important to rapidly and accurately normalize the raw data to eliminate the influence of external parameters and to diagnose and deal with problems before they become irreversible.

Digitalizing membranes in Oman

The Sur desalination plant is located in the Sultanate of Oman's eastern region of Sharqiyah. The plant helps fight the depletion of the region's limited groundwater

resources by producing over 130,000 m³/day of seawater, supplying more than 600,000 inhabitants across the Sharqiyah region. The plant is operated by Veolia Bahwan, who sought a data-driven decision tool to help maintain the quality and continuity of water production as well as predict when the membranes needed to be replaced or cleaned before they failed or fouled. Doing so would also reduce the downtime and prevent excessive energy and chemical consumptions.

Aditya Akella, operations manager at the Sur desalination plant, explained: *"An emergency shutdown can not always be avoided. But having the ability to better plan the short-term preventative maintenance as well as long-term curative maintenance provides the operator with the ability to optimize water storage capacity to limit the negative impact of unavoidable shutdowns."*

Veolia Water Technologies, who designed and built the Oman Sur plant, collaborated with other Veolia entities to see how data could be harnessed and developed into practical artificial intelligence. In March 2020, the teams started to work with AWS to create a system that would anticipate the timing of maintenance events and predict aging of the membranes.

As a starting point, three years of historical data coming from the Oman Sur plant was pre-processed, cleaned and prepared for machine learning processing. The clean data set is then normalized by a machine learning algorithm developed together with Veolia's membrane experts. Finally, AWS machine learning services, including Amazon Sagemaker and DeepAR algorithm, are applied to learn from previous patterns and predict future behavior of fouling indicators — such as differential pressure and conductivity of water — which allow operators to anticipate maintenance operations days or weeks in advance.

These advanced analytics and machine learning algorithms are integrated into the Smart Membranes module of Hubgrade Performance, which has been in operation at the Oman Sur plant since September 2020. Since then, Hubgrade has provided operators with a holistic visibility of the operations and processes, empowering evidence-based decision making when planning for membrane cleaning or replacement. Benefits have included predictive maintenance which has helped improve maintenance planning and decision making, and access to key normalized fouling indicators to monitor the effectiveness of CIP and production cycles. Hubgrade allows the Oman Sur team to save valuable time by preventing lengthy manual data extraction. As Maintenance Manager Grégoire Bourguignon

puts it: *"Thanks to Hubgrade, it's possible to identify any membrane issues sooner and be more proactive in planning the corresponding corrective action. Normalizing operational data can now be completed in two-clicks instead of 12 hours of data management and analysis."*

Advanced analytics and artficial intelligence treatments on top of Veolia Water Technologies' process expertise propelled the Oman Sur desalination plant into the future. Hubgrade has created a significant edge in the value that is delivered to customers, particularly in helping them better operate their water plants and reduce the risk of their business.

Aude Giard, chief digital officer at Veolia Water Technologies, concludes: *"The applications of machine learning, and more largely of AI, are endless for us. We recently moved our data on a cloud-based data lake and automated all these steps, from data capture up to machine learning. I see us using it across the core of our operations and truly changing the way we look at our data, helping us to develop better services for our customers to be more sustainable and resilient!"*
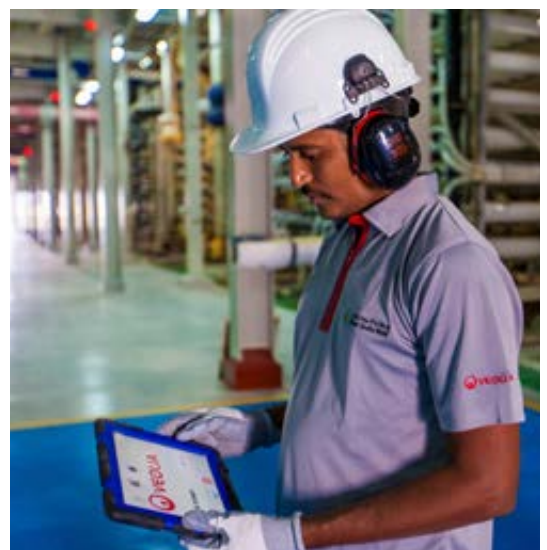
Enabling sustainable reuse with real-time optimization

Digital optimization solutions are improving water treatment facility performance in real-time, supporting industries and municipalities in reducing their environmental footprint and carbon emissions and enhancing operational cost savings.

For companies that have a strong water agenda, sustainability is fundamental for long-term success and resilience. Industries such as municipal water and water resource recovery authorities, or those that have water efficiency as a key driver — relying on large volumes of water for processes. The food and beverage, pulp and paper, and even oil and gas sectors are shifting sustainability to the heart of their businesses. It is far more than an attractive add-on. Increasingly, sustainability is becoming a differentiator that is having profound impacts on businesses and operations.

Increasing need to reuse water

The need to put sustainability front and center for water-heavy industries is increasingly being recognized by regulatory authorities, as well. In April 2020, the United States Environmental Protection Agency released a development to the National Water Reuse Action Plan (WRAP). A coordinated effort across the water use sector to advance consideration of water reuse to ensure the security, sustainability and resilience of water resources, WRAP identifies 37 actions, implementation milestones and target completion dates across 11 strategic themes. Similar measures to include sustainability at the core of water-using industries are also underway in Europe,

with the European Commission (EC) reaching a provisional agreement on minimum requirements for water reuse in agriculture. Among other measures, the new rules detail a set of minimum water quality standards for the reuse of urban wastewater in agricultural irrigation. This will ensure that treated urban wastewater — which is already subject to the Urban Wastewater Treatment Directive — is suitable for use in agriculture.

The EC notes that, at present, about 1 billion cubic meters (m^3) of treated urban wastewater is reused annually. However, that represents only about 2.4% of treated urban wastewater effluents and less than 0.5% of annual European Union (EU) freshwater withdrawals. They argue that the EU potential is far higher, estimated at some six times the current volume. Cyprus already reuses more than 90% of its wastewater, clearly indicating a significant potential for improvement. Clean water and sanitation — one of the 17 Sustainable Development Goals listed by the United Nations — demand improved efficiency in its use and reuse. In response, today many diverse companies are turning to digital solutions to help them meet their sustainability goals.

Adopting digital solutions to improve business performance

Alongside the core sustainability business imperative, operators of water and water resource recovery facilities across a range of sectors face an array of additional commercial challenges. These include the need to reduce operating costs and capital expenditures, while increasing efficiency, reducing maintenance and downtime, as well as minimizing non-compliance events and regulatory interventions.

Many industries are now adopting a new generation of digital tools. These tools enable better monitoring of equipment and process performance and ensure the feasibility of real-time optimization to reduce energy demand, chemical usage, and the environmental impacts of water treatment processes.

According to a recent analysis from Frost & Sullivan, water and wastewater utilities are actively exploring Industrial Internet of Things (IIoT) solutions, and the global smart water network market was expected to be worth some US$22.2 billion in 2020 alone. Meanwhile, smarter, more advanced asset management strategies are expected to save water utilities of the order of $42 billion in capital expenditures by 2027, according to Bluefield Research.

Working with utilities to develop solutions

So, what do these growing markets mean for facility owners and operators?

By using specific live data from water resource recovery facilities, real-time optimization algorithms automatically optimize the facility's performance (relative to variations in the incoming load) while reducing costs and enhancing the biological and hydraulic capacity of the facilities.

One example is Hubgrade — a cloud-based suite of digital intelligent software solutions that provide these functions and allow

municipalities as well as industries to boost their performance.

Features have been developed in conjunction with clients since 1990. They include complex algorithms that act holistically across the entire wastewater cycle according to strategies and settings defined by the operating staff. For each facility, specific parameters are paired with actual performance data and are sent up to the cloud, computed in the algorithm, and then retrieved by the facility again to be executed automatically at individual physical items.

Operators, process engineers and managers are able to choose from a variety of features that target their specific needs. Data may be retrieved every two minutes, while set points can be recalculated and reestablished as physical parameters for any optimization set point.

This could translate to operating aeration blowers less frequently, performing reduced pumping operations, and dosing fewer chemicals. All of these benefits lead to minimization of operating costs while still being compliant with regulatory effluent standards — which is always first priority. With this approach, the full orchestra of all the facility's equipment can play tunefully together. This corresponds to facility-wide and real-time optimization.

Keeping BlueKolding green

An example of successful use of digital optimization tooling comes from BlueKolding A/S. A utility company that covers the entire Denmark seaport municipality of Kolding, BlueKolding treats wastewater from the 100,000 residents. Of the total water treated, some 12 million m^3 is processed at the Agtrup central water resource recovery facility annually.

Looking to optimize the entire sewage system and deliver capacity expansion

through software solutions, the company began adopting the Hubgrade facility solution, which was known as AQUAVISTA™ Plant, in 2007. Initially, the aim was to ensure operational savings while remaining compliant and improving effluent quality. The result was 25% lower total nitrogen (total-N) and a 45% reduction in chemical precipitant, as well as a catchment overflow reduction of more than 70%.

Subsequently, the introduction of an integrated control system at Agtrup ensured an 80% increase in peak hydraulic capacity at the facility. This reduced the costs of a planned basin extension by 22% and simultaneously cut the number of overflow events from an estimated 35 a year to less than 10.

BlueKolding had been required to reduce combined sewer overflow (CSO) volumes discharged to the Kolding Fjord bay to half of pre-2012, and to reduce the frequency of CSO occurrence by two thirds. Its initial solution had planned the development of a 6,000 m^3 combined sewer storage. By using existing infrastructure, the need for additional storage capacity was reduced to just 3,000 m^3. Three additional water reuse facilities were equipped in 2012 and 2013 to ensure stable, optimized operations while maximizing operational savings.

Compliant effluent at the lowest cost

In 2017, the cloud-based solution was adopted to provide integrated optimization of Agtrup, the three satellite reuse facilities, and the sewer network for the City of Kolding.

"The solution is now cloud-based, and that means that our data security is on a very high level which is very important to us," said Per Holm, chief executive officer of BlueKolding. *"It makes it possible for us to have an overview on our cell phones or any mobile device, and on our computers in the office as well."*

By adopting Hubgrade, BlueKolding has achieved compliant operations under all conditions. Karin Refsgaard, operations manager at BlueKolding, highlights another key operational benefit from the optimization software: *"We can use the basins to store spare water when electricity is expensive and so when electricity is cheap, we can pump the water and clean it and so we save money,"* she said.

"It's helping us to act more sustainably on a daily basis," Holm emphasized. *"All in all, we have a lot of opportunities to be more efficient as a utility company."*

From green to blue

With the BlueGrid project, the utility took yet another exciting step into the intelligent use of data from the entire sewerage system, combined with weather forecasts and rain radar data. The goal was to sell balancing services to the electrical grid with a short response time via up or down adjustments of the energy consumption and production. The need for alternative balancing options increases as more and more fluctuating renewable energy is being produced.

The BlueGrid project increases the security of electricity supply and allows more renewable energy to be used while ensuring a sustainable and compliant treatment of wastewater at the lowest possible cost.

Beyond municipal water, beyond Europe

Alongside conventional municipal water resource recovery facilities, such as those at BlueKolding, digital optimization tools are also yielding results for other sectors that potentially rely on water reuse.

For example, a coke production site in Northern Europe has reduced total-N in its effluent by 50% — allowing the facility to comply with new and more stringent regulations and eliminate the need for significant capital expenditure that would otherwise have been incurred.

Beyond Europe, the City of Liberal (in the US state of Kansas) is constructing a new water resource recovery facility to handle increases in flow with improved treatment capabilities. A combination of solutions is being provided to help treat average peak flows of up to 26,875 m^3 per day, while achieving effluent total-N of less than 8 milligrams per liter (mg/l), total phosphorus of less than 0.5 mg/l, and suspended solids of less than 5 mg/l. The facility, which will be online in late 2021, will take full advantage of Hubgrade Performance Plant to ensure effluent goals are met at the highest possible levels of efficiency.

Fully flexible, real-time digital optimization solutions can be implemented for just a single facility, but can include multiple water resource recovery installations and sewer networks, as well as applications in the food and beverage, pulp and paper, and other industrial sectors that are reliant on water for their processes.

Significant operational advantages are achievable, even when managing large variations in biological loads and flow volumes. Perhaps most significantly, though, digital optimization solutions can help businesses and organizations meet their key sustainability goals to secure their long-term success.

Nosedo facility achieves 60 to 70% reuse for agriculture in Italy

In 2019, Italian public utility company Metropolitana Milanese SpA adopted Hubgrade at its Nosedo water resource recovery facility — the main water resource recovery facility for the industrial city of Milan — which began operations in 2004 with full nitrification and denitrification. Hubgrade is used to optimize energy usage and chemical consumption, as well as increase hydraulic capacity to handle higher peak flows during rain events. With 60 to 70% reuse of the final effluent for agriculture, Nosedo is the largest recovery facility in Europe.

"Our challenge is to guarantee, every time, the best condition for reusing water," Andrea Aliscioni, chief operating officer for the Milan Water Service, Metropolitana Milanese SpA., explained. *"We need — even in a high hydraulic-stress [event] — to constantly guarantee the performance of our facility. Digital innovation can do this in a simple way."*

Following the commission of Hubgrade, Nosedo has seen operation costs savings of more than €400,000 per year, with significant energy savings found in aeration, mixing, return of activated sludge, grit chamber aeration, and nitrate recirculation activities. The overall efficiency of the biological process in terms of energy consumption was improved by 25%. In terms of chemical usage, there is a 60 to 80% reduction in the use of precipitation chemicals like ferric chloride, while chemical sludge production is reduced by around 120 tons per year.

"Digital solutions can help us to link the data from our wastewater network and sewage network to operational instruction of the final plant. Using these two kinds of data, and by digital interaction between them, we can reduce the operational cost of the plant and we can reduce the tariff for the citizens of Milan," explained Aliscioni. *"The future of water, in this case of wastewater, is recovery."*

25 years
of operational data valorized through AI

Can artificial intelligence (AI) improve wastewater treatment processes and facilitate the work of operational teams? To answer this question, a group of process engineers from Veolia Water Technologies' Danish subsidiary Krüger A/S got together with some digital innovation experts from Veolia's Research & Innovation department. Together — virtually, of course — they got their creative juice flowing in a hackathon which took place from April to July, 2020.

Wastewater treatment processes are complex, with their performance depending on several parameters such as meteorological data, wastewater composition, biological behavior, complexity of sewer systems and diversity of treatment plants built for decades. Their proper optimization allows for a reduction in both the operating costs and environmental impact of the treatment facilities, while extending their lifetime by improving their biological and hydraulic capacity.

For more than 25 years, Veolia Water Technologies has been using advanced optimization techniques for automated data collection through Hubgrade Performance's Plant module (previously called Aquavista™ Plant), to improve treatment by transmitting system optimization instructions.

This operational data is collected by more than 100 different processing systems within Veolia; improvement and harmonization of the procedures and technologies used within these systems are therefore necessary.

A hackathon is an event of any duration where people come together to solve problems. In this case, the objective was to figure out how to reduce the cost of setting up and fine tuning the real-time optimization system for installations to be fitted with the Plant module of the Hubgrade Performance digital service.

The first step was to analyze the feasibility of developing an AI model that would automatically suggest operating parameters. By combining their knowledge of water treatment with that of data science and AI, our experts created a predictive model for the parameterization of equipment regulations, enabling them to improve the implementation of optimization algorithms. The model was tested by historical data from about 100 wastewater treatment plants and is now being used in the implementation of Hubgrade Performance Plant. It predicts the parameters and settings needed to efficiently operate wastewater treatment processes to save commissioning time.

20% time reduction

AI has proven to be a fast and reliable way to help operational staff commission Hubgrade Performance. A great analogy for tuning the algorithms is a golf game: at each plant, we strike towards the goal and now AI helps us make the first strike go all the way to the green area. In fact, we expect a 20% reduction in the time required to commission the digital solution.

Don't make me think!
The role of user experience in digitalization

Digitalization is changing the understanding and execution of wastewater optimization. But what does that mean for our customers' use of Hubgrade Plant? And how must we respond when designing services and products?

When you buy a standard car for your household, you expect to get a finished product that does not change during its lifetime. The function and form of the car is fixed. If your needs change or car technologies change, you buy another car.

The car example has been the customer logic for decades. However over the last 30 years this logic has changed, first slowly and now (very) rapidly. As software enters every market, products are no longer fixed: they change literally in the hands of the user. You no longer buy a fixed product but rather an access to an ever evolving one. The difference is significant.

Digitalization means that data is used to streamline processes, improving existing products and creating entirely new services. As technology changes so do our workspace, our companies, our institutions and laws, and our personal use of digital services. In a user experience perspective the ease and convenience of Spotify, Dropbox, Amazon, Netflix and online banking, to name a few, signify that they way you as a user can control the product, defines the product.

As a user we like software products that make us feel powerful and efficient. The psychological contract between product and user is the underlying mechanism that defines what the product will be used for, how often it will be used, and how quickly

the user and organization adopt the product and make it part of working routines. A good product creates a desire to be used.

The user welcomes development and maybe even participates in the product development process. All of this is possible when the underlying contract between user and product is positive. And this is very interesting because most digitized business models are relying on volume of usage and widespread use of product functionalities in order to be sustainable.

Let's look at how such a contract builds up when optimizing wastewater treatment

processes. Hubgrade Plant monitors and interacts with biological processes, hydraulic capacity, compliance as well as energy and chemical consumption. The product uses advanced digital technology to function. This includes connected devices and artificial intelligence (AI) in order to process calculations and make adjustments in real time to reach a high level of optimization.

When clients invest in Hubgrade Plant they are basically buying three things: savings, compliance and part of a digital strategy to better exploit data and keep up with expectations from stakeholders. But what they also buy — and this is a more hazy point — is a different way of working.

Digital products change the client's ability to control processes and to reach a higher optimization level. This ability is twofold. Because we work in agile sprints and release a new product version each month we give the client an ever evolving product. A wastewater plant used to be a collection of hardware with basic controls for smooth operation; now we can make well-known hardware behave in new ways because of advanced

software — just like the Tesla car software has changed the perception of a car product. This means that the ability to drive optimization of wastewater management gets more powerful.

But Hubgrade Plant is not a fully automated system: customers still need to decide which optimization strategy to follow. So when the optimization power of Plant is unleashed, how willing the client is to change his working habits is critical. So when we unleash the optimization power of Plant, the way the client changes working routines are business critical. This is where the psychological contract kicks in.

As part of our product development process we talk to customers on a regular basis. We build prototypes and invite customers to interact. This gives us insight in the usefulness of features and how user context forms the user experience of our software product. In other words we evaluate not only how our product is perceived but also the client's ability and possibility to perform advanced optimization.

There is no right and wrong in optimization. It is about being appropriate and adaptive to new options. Our ambition is to design software products that create a positive psychological contract.

With that in mind, we conducted 30+ interviews with 8 wastewater facilities in Denmark as well as wastewater specialists in France and in the UK.

Here are some conclusions that our product team drew.

1. Universal usability

Can you walk up and use the product without any explanation, training or special skill set? ATM machines are an example of a product with high universal appeal. However in our case the appeal is low. We are designing an expert system where skillful employees must have an understanding of what they are doing in order to use the product. The product has a stiff learning curve but for the trained professional, it becomes an efficient tool of precision over time.

KEY TAKEAWAY:

the onboarding of users is crucial for novice users to quickly gain experience.
The reason is that expert precision tools are not intuitive for the untrained eye. But over time well-designed tools deliver higher levels of effectiveness and efficiency where tools that seem intuitive at first do not.

2. Situational usability

Where universal usability centers on user interface, situational usability addresses the alignment between people, tasks, tools and goals. This parameter impacts the sensemaking of the individual when using our product and creates a variation of motivation and user needs. It also creates the perspective of different IT systems interwoven in a collaborative practice within the wastewater plant.

The combination of motivation, different user needs and different collaborative practices challenges our design with increased complexity. Every client we talked to wants savings and environmental-friendly solutions which equals holistic optimization, the core value of the Plant product.
But their understanding of how to achieve this differs.

KEY TAKEAWAY:

one size does not fit all.
We need to break down the complexity of the use situation through an iterative design process. Doing so allows users — step by step — to discover new possibilities to incorporate into their understanding of what they want the new optimization situation to be like, and new requirements to incorporate into their understanding of what is possible within the concept of optimization.

3. Perceived usability

This has to do with how people experience the relation between the returns they get from using a system and the resources they must expend using it. If users consider a system excessively hard to use they may adopt bad habits such as postponing tasks, finding a colleague to take over, experience distress, or lower their performance criteria.

Perceived usability makes the individual user the final judge on usability and consequently values information about the user's subjective experience of usability over performance measures such as task completion times.

KEY TAKEAWAY:

perceived usability builds a reputation as a «difficult system», «nice little feature», «central to our processes» and so on. This reputation is communicated internally between colleagues and externally between organizations as peer reviews.

It is difficult to single out the key parameter to reputation building as a mix of different factors come in play:

- system trust.
- a balance between mundane tasks, such as start and stop of process, and holistic optimization.
- historical preference of IT systems defines and limits newer IT innovations.
- controlling complexity by designing UI/AI to make advanced optimization simple by clear recommendations.

To be truly customer centric we must be able to design a system that does not slow down the user. Ideally we design a digital product that keeps pace with the thought process of its user.

Don't make me think.

The **VistaForce** project

Real-time water treatment monitoring during humanitarian emergencies

In the face of disasters and humanitarian emergencies, Veoliaforce teams mobilize and support the various Veolia Foundation partners in the field so that the affected populations can regain access to water. Hubgrade provides access to all of Veolia's expertise throughout the water cycle, ensuring an optimal and permanent monitoring of installations. Together, Hubgrade and the foundation have developed VistaForce to maximize the benefits of digital monitoring during emergency missions.

Created in May 2004, the Veolia Foundation supports community-oriented, nonprofit projects contributing to sustainable development, in France and abroad.
Its priority areas of action are humanitarian emergencies and development aid, employment and social links, and environmental conservation and biodiversity.

Since its creation, the foundation has provided emergency aid to ensure access to drinking water in response to both natural disasters and humanitarian crises, collaborating with such partners as Médecins Sans Frontières/Doctors Without Borders, Médecins du Monde, the French Red Cross,

the French Ministry for Europe and Foreign Affairs' Crisis and Support Centre, etc.
To accomplish these missions, it relies on a network of volunteers among the Group's staff called Veoliaforce; members leave for missions of up to three weeks and alternate with each other on the ground until the water supply is restored.

One equipment developed and used by the Veoliaforce teams is Aquaforce. These mobile water treatment units are used during humanitarian emergencies to produce drinking water for affected populations and health facilities.

Until today, data from the units was hand-collected in the field, with the operators recording the daily volume produced along with laboratory data such as pH, turbidity and residual chlorine. With VistaForce, the mobile water treatment units are connected to Hubgrade Essential to evaluate and continuously monitor the quality of the service and communicate with transparency.

VistaForce benefits

The advantage of installing a system such as VistaForce is to be able to access as much data as possible. A first step is to track the GPS location and the production volumes, both easy information to obtain.

VistaForce allows real-time production follow-up thanks to real-time data gathered by the modem and computed before being made available through Hubgrade via the data visualization and key performance indicators features. The manual entries paired with an event module allow the operator to register the lab analysis and key maintenance tasks such as membrane cleaning.

Tested and ready to deploy

The VistaForce system was tested during a training session for 30 VeoliaForce volunteers near Le Mans in France in September 2020. As Romain Verchère, project manager in charge of VistaForce with the Veolia Foundation explained, *"The training session was a great opportunity to deal with any adjustments required to ensure that the system functions correctly, and that the data is retrieved in the best possible way once the Aquaforce units are deployed on the field"*.

VistaForce is now ready for such deployment. The use of the embedded connectivity module on the Aquaforce units will provide key data to the Veolia Foundation and its partners to report on their actions and their efficiency.

REAL-TIME & PRODUCTION FOLLOW-UP

DIGITAL LOGBOOK & MAINTENANCE FOLLOW-UP

GEOLOCATION

KEY DOCUMENTATION

FLEET MANAGEMENT
Equipment transportation
Equipment safety

REAL-TIME MONITORING AND FOLLOWING
How many m³ produced?
Produced water quality?

RETURN OF EXPERIENCE
Key information gathering
Membrane lifecycle knowledge

COMMUNICATION
Reporting and visibility for partners
Empowered communication

Get onto the digital sewer wave

The intelligent sewer system

A digital wave of information is rolling all over the world and words like "Smart City", "Digital Twin" and "Water 4.0" sound appealing and interesting. But how do you get started on the digital journey if you are just "another ordinary utility"?

Most people don't know — and really don't want to know — what goes on inside their sewer systems. However, information about sewers dynamics can help reduce negative water quality impacts on the environment as well as the risk of flooding. Using just a fraction of today's digital technologies can provide a lot of valuable information, paving the road for better decision making and reduced costs through optimal utilization of existing structures and data available.

First things first: Getting the data

Nearly all sewer systems around the world run at least some sensors in real time, for instance to report on the status of pumps and the pumping rate. At this first digital level, the information is typically transferred by a SCADA system to a control room where the staff can follow the performance of the pumps on a screen and jump into a car in case they need to inspect a suspicious situation.

At the second digital level more sensors are deployed into the sewer system, for instance to monitor overflows or the degree of filling in basins, or to provide real-time information from rain gauges. Once again this information ends up displayed on physical screens in the control room where staff members analyze the measurements in order to make qualified decisions. This is the level at which the vast majority of utilities are today. But why stop at this point, when the next level on the digital journey is just around the corner and provides so much more?

More than a SCADA system

The third level on the digital journey is reached when the measurements from the sensors are compiled and translated to new and valuable information. A fast and elegant way is to use data-driven modelling, which replaces the tedious deterministic models. The data models are generic but still defined for specific purposes, and they provide completely new streams of information compared to the raw data streams.

In SewerView — a module in Hubgrade Performance — the tools are standardized and can be set up for any sewer system to provide real-time, high-value information to the operators about what goes on in the sewer system. The information easily accessible from the control room or any mobile device are:

- Overflow alerts together with automatic reporting of overflow statistics.
- Information and alerts concerning abnormal situations, e.g. blockages in pipes.
- Flood warnings based on real-time information from rain gauges or weather

radar, including monitoring of actual flood depths and traffic conditions in streets.

- Forecast of inflow to any given point in the system which can be used to optimize the wastewater treatment plants.
- Warnings of poor bathing water quality.
- Monitoring of pump performance for energy optimization and reduction of carbon footprint.
- Present status of infiltration (I&I) to the sewer system.
- Data from any type of sensor that exists in the system and is of relevance to the local operators.

Once the data streams have been established in SewerView the possibilities for analysis are endless, as the staff can set up their own alerts and small models based on the data flow. It is at this stage of the digital journey that we go from trivial manual analysis to informed decision-making based on automatic calculation of key performance indicators, with in-depth analysis of the root cause relations.

The intelligent optimization
The fourth level on the digital journey is when the sewer system is optimized in real time based on measurements and data-driven modelling, and feedback is sent to pumps or other controllable devices in the shape of a new set-point for the operation. The optimization can be anything from a simple local control where the pump setpoints in one basin depend on level measurements in another basin, to a global optimization algorithm-based predictive control, where measurements throughout the system are combined with rain radar data and flow forecasting in order to find optimal setpoints for the entire system to avoid overflow.

In addition to a reduction of overflows, the operation of the wastewater treatment plant can be optimized by using an inflow forecast to activate a stormwater mode where the hydraulic capacity can be increased, significantly reducing the risk of sludge escaping.

Inflow forecast at the Damhusåen wastewater treatment plant in Copenhagen

An inflow forecast was developed for the catchment of the wastewater treatment plant (WWTP), based on real-time flow measurements from the inlet, radar data and a conceptual model. The flow measurements were gathered in SewerView, the radar that was used was a nowcast with 10-minute time steps and 3-hour forecast horizon, and the inflow forecast was built on a lump conceptual stochastic rainfall-runoff model using a Kalman Filter for real-time data assimilation.

The result was a forecast of inflow to the WWTP, which increases the hydraulic capacity of the plant and predicts future periods of dry weather when storage basins can be emptied in the sewer system in accordance with the current biological treatment capacity at the plant. A predicted dry weather period is also used to schedule maintenance of sewer installations (e.g. pumps or level measurements in storage basins).

You are not alone…

The fifth level on the digital journey is reached when the sewer system and the wastewater treatment plant are seen as one collective system that needs to perform as one unit, aiming at a minimal impact on the receiving waters and a minimal carbon footprint.

This holistic approach to the system calls for integrated, real-time control. While it may seem an unreachable holy grail to some people, there are currently a few frontrunning utilities on the way down this path with real-life implementations. This currently takes place in Kolding, Denmark (population 100,000), where local utility BlueKolding has implemented global real-time control in 19 basins in the combined sewer network. The objective of the implementation was to reduce combined sewer overflows (CSO), minimize the flood risk and reduce the necessary construction of basin volume from 6,000 m³ to just 3,000 m³ to fulfill environmental regulations and maintain the same service level for the customers.

The wastewater treatment plant has been upgraded with Hubgrade Performance Plant, a cloud-based, real-time performance optimization system, thereby achieving a holistic, fully-optimized wastewater system where the control is integrated with the information flow from the sewer system. Finally, during dry weather, the BlueGrid development project will add the functionality of flexible power consumption using demand/response at both the treatment plant and sewer network, thereby achieving a flexible, all-weather optimization, which minimizes environmental impact during rain events and reduces costs for power consumption during dry weather.

How to get started?

Getting started is not as overwhelming as it may seem. The very first step is to decide on what and where more information concerning the sewer system will be valuable. Once the data is set in place, a new understanding of the system dynamics will emerge and pave the road for the subsequent digital levels.

Take the digital journey step by step, enjoy the ride, the enlightenment and the reduced environmental impacts and costs.

Floods Detected
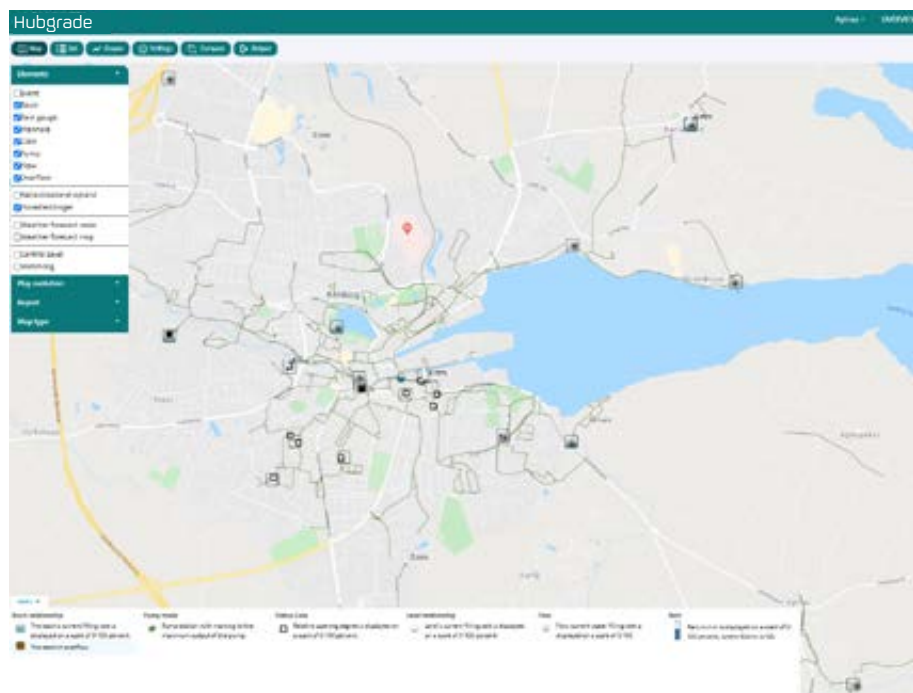
Smart Actiflo®

Digital innovation at the heart of the water flocculation process

Plant operators are faced with increasing demands for continuous process optimization including reducing water usage, wastewater production and chemical and energy consumption. They must achieve this without jeopardizing the process stability and while meeting tightening regulations. For the Actiflo® process, proprietary artificial intelligence is now being used to reach the right balance between cost and compliance.

Actiflo is Veolia Water Technologies' patented high-rate clarification process. Available in standardized modular units or as a custom-designed solution, it covers all municipal and industrial treatment applications. Benefiting from over 25 years of operational experience, Actiflo is used at more than 1,000 references around the world to treat over 50 million cubic meters of water every day.

With Smart Actiflo, we combined our extensive process knowledge and artificial intelligence to enable best-in-class operations and process optimization. Using powerful algorithms to predict the effluent quality and run optimization scenarios, operating teams can be more proactive, anticipate and mitigate process deviations and reduce operating costs while preserving quality and meeting production targets.

How we respond to your needs

REAL-TIME ACTIONABLE INSIGHTS

With real-time OPEX calculation and predictive chemical stock management, be proactive, detect drifts and optimizations and save time on analysis and reporting.

RISK MITIGATION

With effluent quality prediction, anticipate process deviations and act in time to avoid non-conformities.

OPEX OPTIMIZATION

Run operating scenarios with our cost and quality balance feature to find the optimum chemical dosage.

Hubgrade Performance optimizes precious bacteria growth at biofarm

The biofarm concept allows pre-seeded carriers to be harvested to seed the start-up of new Anita™ Mox plants around the world. A small percentage of carriers used as seed will dramatically reduce the start-up phase — from between 9 to 19 months to between 2 to 5 months.

The Sjölunda Biofarm is a combined biofarm and testing facility designed to facilitate testing of various media, aeration and mixer types. Built in 2010, it was the first Anita Mox plant and was designed to treat up to 200 kg of NH_4-N per day with 85% total nitrogen removal and 95% ammonium removal. Located at the Sjölunda wastewater treatment plant (WWTP) in Malmö, Sweden, the biofarm is operated by personnel from Veolia's subsidiary AnoxKaldnes who perform sampling, analysis and control.

The challenge with any deammonification is the slow growing anammox bacteria and the interactions of multiple microorganisms which often translate to a long and sensitive start-up period and a risky operation. A good aeration control is required in order to produce nitrite (NO_2) while avoiding the production of nitrate (NO_3). High ammonium (NH_4) concentrations as well as intermediary products of the process can also be inhibitory to the most sensitive group of microorganisms, the anammox bacteria.

## Process expertise supported by digitalization

Through Hubgrade Performance, installed in Spring 2019, algorithms adjust the dissolved oxygen setpoints and the inlet flow in real time, according to on-site conditions. These adjustments ensure sufficient oxygen for nitritation, avoiding nitrate oxidation bacteria growth and anammox inhibition, and ensuring a stable loading.

The introduction of the Hubgrade Performance Plant module at the biofarm has reduced required operational manpower by 50% and the number of weekly samples for analysis, from two to three down to one.

Personnel is now available to accomplish more value-added tasks to further develop the Anita Mox process. Having online control of the process 24/7 has also led to more stable operations, thereby reducing operational risks and reducing stress on the operator.

"One should never underestimate the well-being of operators when having confidence in the data they get, and that the control system will act as intended. For plants without Hubgrade Performance, where data is generated from unreliable ICE sensors and with a rather manual approach for regulation of air and flow, it can be stressful for the operators to have this lack of confidence and control of the process," explained Magnus Christensson, senior research manager at AnoxKaldnes.
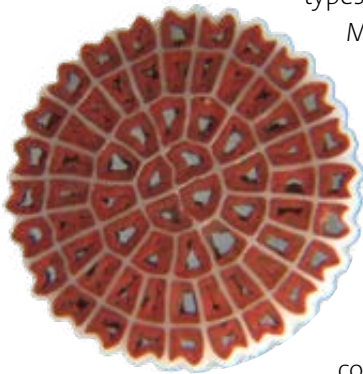
Developed by Veolia Water Technologies, Anita™ Mox offers an alternative to conventional nitrification/denitrification processes used to treat effluents with a high ammonium concentration. This process can treat sidestream nitrogen load without any additional source of carbon while reducing electricity consumption by 60%.

Anita Mox is the ideal solution to reduce operating costs and contribute to reaching the target of an energy self-sufficient wastewater treatment plant while meeting regulatory requirements on nitrogen concentrations in the treated wastewater.

Hubgrade Performance

→ Cloud-based digital solution composed of a suite of intelligent software solutions.

→ Automated real-time performance optimization.

→ Remote monitoring of operation via user interface.

→ Algorithms scale operations that can be adjusted by the operator. The user then decides whether it is Hubgrade Performance or themselves that controls the operation.

→ Expert feedback on performance and recommendations for further optimization.

Increased stability

Risk reduction   Cost savings

Reduced manpower   Operator peace of mind

Water resource recovery facilities
can save money and carbon emissions using intelligent control of electricity consumption

Water resource recovery facilities account for a large amount of electrical energy consumption. A new research project led by Veolia Water Technologies has looked into how the electricity consumption in such plants can be made flexible to benefit both the electricity grid and operating costs of the plants, as well as the environment.

Wastewater treatment can be both cheaper and release fewer greenhouse gases when processes are controlled smartly. But could such control assist the grid in using excess electricity? This is the idea behind the new research collaboration between Veolia Water Technologies and the Technical University of Denmark (DTU) departments of computer science and of environmental engineering.

"Electricity production from wind turbines is generally increasing but how much they actually produce varies from hour to hour. It would make sense to coordinate the processes at a plant so they use electricity at the right times." says Peter Alexander Stentoft who has completed an industrial PhD study with Veolia Water Technologies and DTU Compute.

The electricity consumption at water resource recovery facilities can be made both cheaper and more sustainable if the energy-consuming processes are limited to periods where wind is blowing and the wind turbines produce cheap, renewable electricity. This is possible because the most electricity intensive process at the facilities is flexible.

Electricity-consuming treatment

Wastewater treatment requires a relatively large amount of electricity. The specific number varies from country to country, but generally it accounts for about 1% of a country's total electricity consumption. One of the processes at a plant is particularly electricity consuming, namely the biological treatment step.

In this step, nutrients such as ammonia, nitrate and phosphate are removed by bacteria. Since these bacteria need oxygen, a large amount of air is added to the water using special equipment. This process is known as aeration. *"Different numbers are found in literature but typically, aeration accounts for somewhere between 40 and 75% of the total electricity consumption at a water resource recovery facility. Compared to the plant's total consumption, this is quite a lot,"* says Stentoft. But with bacteria needing changing conditions, aeration is not necessary at all times and so it is possible to plan the aeration during periods where electricity is cheaper or greener — or both.

Buy cheap electricity during night

The price of electricity, like all other goods, depends on supply and demand. It is therefore cheaper to use electricity in periods where the national consumption is low or the production is high, typically at nighttime or when wind is blowing.

There are several markets for trading electricity. To keep the balance between electricity production and consumption,

a special market — the balancing market — was created. Here consumers can be rewarded with cheap electricity if they can help the grid by using excess electricity. *"If you are a flexible consumer such as a water resource recovery facility, it's interesting to see if you can direct the aeration to points in time where there is a need for regulating the electricity consumption in the balancing market. Then you can generate some very nice savings,"* says Niclas Brabrand Brok, PhD student at DTU-Compute.

Intelligent control must also pay attention to how often aeration must be performed, which means that the system requires an algorithm to balance the need for aeration with the electricity prices.

Can run for longer periods of time without interruptions

The system was tested on Vamdrup Water Resource Recovery Facility, a plant operated by utility company BlueKolding, where Plant Operator Karin Reefsgaard was very positive towards the idea. *"We are constantly looking for new ways to optimize electricity consumption so that wastewater treatment becomes as cost-effective as possible"* Reefsgaard said.

While a full, commercial-version is still in the works, the algorithms are continuously improved so they can run robustly without the need for interruptions. The potential rewards for the facilities are yet to be confirmed — with electricity prices varying greatly during the year, long periods of testing are needed to get reliable estimates — however simulations indicate savings of 10 to 20% in electricity consumed for aeration.

Another interesting benefit is the potential for reducing greenhouse gas emissions. Maximizing the use of renewable energy to power their installations helps utilities achieve that important goal.

Bundling through Hubgrade in the upstream energy market

*Upstream deepwater assets are often challenged, or even compromised, by technology procurement driven by a customer's specifications. **The overly simple concept of 'lowest procurement cost' can often create a much higher life cycle cost than desired.** Such systems, although highly customized, often give little attention to operational experience and real data when making pragmatic decisions on plant availability. Poor availability equates to lower injection volumes and production targets missed.*

There is clearly a digital revolution underway, but data should also be viewed as a digital revelation that can allow assets to function more effectively. Change is underway in this area but it is moving much more slowly than might be expected. The global pandemic we are experiencing, paired with the downturn in the oil price, have an impact on the willingness to contract specialist technical support with proven ROI for a service.

Despite there being a rich vein of available operational data for seawater injection systems, it is hard not to be pessimistic regarding some of the project procurement strategies being employed. Whereas data does afford service providers future opportunities for improvement, far earlier engagement in the process should be encouraged (i.e. right at the start of the specification development).

Choosing the correct option does not automatically mean that it is expensive; it is simply a question of know-how and taking the right approach. Typically, water injection demands can rise to as high as three barrels of water injected for each barrel of oil produced. A floating production storage and offloading (FPSO) unit therefore needs to be as much a water injection facility as it is an oil producer.

To understand why system availability is seriously impacted during the asset lifecycle, it is important to review the very start of the project phase, when consultancy and engineering groups are contracted to develop the project specifications. Such bodies invariably have a widely fluctuating workload, which requires an ever-changing staff base. However, staff skill sets — from the conceptual design phase through to project procurement phase — that neither have the technology expertise nor data resources to verify fundamental project decisions usually lead to the wrong path being followed.

Service solutions through Hubgrade

Veolia Water Technologies subsidiary VWS Westgarth is the largest single supplier/operator of sulphate reduction membrane systems. Their experts have a deep understanding of offshore water treatment processes coupled with an extensive reference list in upstream water treatment applications. Their service team recently conducted an innovation workshop where they looked at lessons learned and captured how to better create and demonstrate customer value by using digital tools.

David Lothian, head of upstream services, explained: *"On the topic of valves, we discussed the ability to provide a dashboard to the customer showing the number of cycles the valve has completed since its start up or its last overhaul or service. This generates a maintenance alarm to alert the operator to ensure the relevant valve spare parts are available for shutdown maintenance. In doing so, the operational integrity of the process is maintained."*

The industry norm is a set percentage based on the volume of valves used on the project and this is a problem too. The real issue is that a valve is good for a certain number of cycles, just like a car engine referenced against mileage, hence service intervals are needed to ensure availability. Having combined the valve capability from the manufacturer with the monitoring of the cycles and alert maintenance provided by Hubgrade, the obvious next step is to ensure valves and spare parts stocks, and display the information in the Hubgrade dashboard.

The valve data sheet and spare parts listings can also be available on Hubgrade to permit the customer to order additional parts and stocks, based on data-driven functions. This capability provides much needed assurance to have the relevant parts available at critical points in the asset lifecycle, thus ensuring its uptime performance.
"Using digital tools and modules, we can

create customer value for each service sector and component within the water injection system, as a bundled approach," said Lothian. *"Hubgrade portal is Veolia's customer communication tool or platform for such and we see this as the future for our services."*

This particular example is associated with valves and details how it is possible to drive customer value in terms of system performance, using key performance indicators for valve maintenance and selling spare valves or parts. However, as Lothian continued, *"it is only one item as an example and I am confident that embracing this culture of a digital approach will unlock many opportunities, and generate improved system performance for the lifecycle of equipment items and process plants."*

Data is increasingly driving key project decisions and therefore the maintenance of systems will in time become predictive and scheduled. If this can be implemented successfully, there will be increased water availability and more effective oil recovery.

Lothian concluded: *"We continue our quest to support customers with such technical support packages and drive value for these investments. Whilst the current global pandemic and the downturn in the oil price largely contribute to the challenge to sell this Veolia service, the results for the Hubgrade support service are excellent and effective on increased injection volumes, which is typically 30% across the assets involved. Continued evolution of these services in terms of bundling further scopes will largely increase further ROI."*

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Resourcing the world