INDUSTRIAL EDGE IN WATER AND WASTEWATER

The backbone for resilient, efficient and sustainable operations

By combining the capabilities of advanced data analytics with real time, close-to-process information, water and wastewater utilities can leverage the power of Industrial Edge to improve the efficiency, sustainability, and resilience of their operations.

Executive summary

Stakeholders in the water and wastewater industry face a variety of challenges that call for significant advancements in efficiency, sustainability, and resilience. By combining speed, reliability, and enhanced data access and analytics, edge computing is uniquely suited to support these improvements.

With edge computing, data are processed directly at the individual units or systems, for example, directly at the pump stations, lightening the load on IT infrastructure and creating real-time transparency into equipment status to enable new services and applications such as predictive maintenance and automatic anomaly detection. Operators have full control over their data and can choose how and when to combine these local data with information from other sources to generate broader insights through advanced analytics.

For operators looking to upgrade their water treatment and distribution infrastructure with edge computing, Siemens is the right partner, offering all the necessary IT and OT know-how, hardware and software, and water and wastewater expertise.

The low barriers to entry and easy scalability of Siemens' Industrial Edge solutions allow plant operators to implement a proof of concept and start benefiting from digital technology with low investment costs. Scaling to a comprehensive edge computing solution then allows organizations to realize the full potential of their plant data and uncover further opportunities to enhance their systems and future-proof their operations.

Contents

A new answer to today's challenges

To improve the efficiency, sustainability, and resilience of their operations, organizations in the water and waste-water industry need to leverage the power of data and digitalization.

Water is essential to life, and global demand for this critical resource is rising as the earth's population grows. But water management also involves increasing challenges: climate change, pollution, rapid urbanization, and aging infrastructure, to name just a few. Particularly in the Western world, the water infrastructure is in place but is aging, leaving pipes and equipment at risk of failure. At the same time, many of the older automation systems in use do not have the ability to support digital technologies that can improve efficiency, sustainability, and resilience.

Leveraging the power of data

To enhance water network performance through more effective monitoring, quicker diagnostics, and precise system optimization, operators need comprehensive digital solutions that generate deep data and incorporate advanced analytics. State-of-the-art automation solutions are typically capable of providing detailed data on operational performance, but acquiring and processing these large amounts of data remains a challenge.

Both cloud and edge computing can be used to handle large amounts of data, and each of these technologies has its specific strengths and weaknesses. Cloud computing provides enormous resources for data storage and processing. Users can choose between public clouds, where computing services are delivered over the public Internet, and private clouds, where the cloud infrastructure is operated solely for or by a single organization. Depending on the type of cloud service, cloud computing can incur high initial costs and require high bandwidth for data communication, and it may require additional measures in terms of IT and cyber security.

Moving to the edge

Operators can also bring computation and data storage closer to the data source through edge computing. Edge and cloud computing are not mutually exclusive. In fact, they are often complementary – for example, operators can use a cloud system to train an advanced algorithm that is then deployed locally on an edge system for daily operation. This approach has several benefits compared to cloud-only data processing:

- Lower initial investment: A proof of concept can involve just one edge device on-site.
- Full control of data: Edge computing systems can be scaled up on a local level, and operators can define which data are stored locally and which data are transferred to the cloud for further processing and analysis.
- Little or no impact on existing systems: Edge computing can be implemented as a data analyzer system without the need of changing the automation and process systems itself.

Gaining ground across many industries

Edge computing applications are highly versatile, and edge computing is gaining ground across industries. PwC[1] expects the global market for edge data centers to reach $13.5 billion in 2024 (nearly tripling from $4 billion in 2017), thanks to "the potential of smaller, locally located data centers to reduce latency, overcome intermittent connections and store and compute data close to the end user." This finding is supported by other studies: Gartner expects that more than 15 billion IoT devices will connect to the enterprise infrastructure by 2029[2].

[1] Source: *PwC, Edge Data Centers: How to Participate in the Coming Boom, July 2019,* https://www.pwc.com/us/en/industries/capital-projects-infrastructure/library/assets/pwc-edge-data-centers.pdf.

[2] Source: https://www.gartner.com/smarterwithgartner/gartner-predicts-the-future-of-cloud-and-edge-infrastructure

According to market intelligence firm CB Insights,[3] edge computing allows for faster data processing and analysis (decreased latency), lower costs, reduced network traffic, and increased application efficiency. Edge computing also offers security and reliability benefits, which are especially important for critical infrastructure such as water networks and treatment facilities. Deemphasizing the cloud reduces exposure to cyberattacks and decreases the potential to have a single point of failure, while deploying devices that operate reliably offline is particularly useful in remote locations where Internet connectivity may be limited. Edge computing allows older legacy equipment to be easily integrated into a modern, central software and hardware management system.

Applying edge computing to water and wastewater applications

All these features make edge computing an attractive solution for water and wastewater systems, which typically cover a wide geographic area and feature many devices in remote stations that need to be managed centrally. The following sample use cases illustrate how edge technology can help the water and wastewater industry address three of its major challenges: efficiency, sustainability, and resilience.

Efficiency/sustainability: Energy management

Water and wastewater plants are typically municipalities' largest energy consumers (often accounting for 30% – 40% of total energy consumption, according to the US Environmental Protection Agency[4]), so energy efficiency is a key lever to reduce costs, emissions, and resource consumption. In order to increase energy efficiency, however, operators first need to create energy transparency, which includes awareness of energy consumption patterns and load profiles, before they can take meaningful action. With edge computing, operators can collect and process energy data to gain insights into equipment use and reveal potential for reducing energy costs and maximizing operating efficiency. The resulting energy data and KPIs help utilities to measure their energy consumption more precisely and then take targeted action – for example, by identifying where it makes sense to replace a motor with a variable-speed drive, or scheduling operation of high-consuming equipment based on energy prices – to increase energy efficiency and reduce energy costs and emissions.

Sustainability: Predictive maintenance

Sustainable use of installed equipment means operating it as long as possible without increasing the risk of failure or unplanned downtime. The challenge is determining whether to simply follow the schedule for maintenance and replacement, even if the equipment is still working well, or wait until failure and thus risk downtime. With predictive maintenance, operators can use the data acquired by edge devices on-site and combine these data with advanced analytical methods such as artificial intelligence (AI) to detect anomalies that indicate defects or an impending equipment failure. This way, operators can perform maintenance based on the actual condition of the equipment, allowing them not only to act before a component or asset experiences difficulties but also to avoid unnecessary or premature replacement. This approach results in less unplanned downtime, time savings due to fewer physical inspections of remote stations, and longer service life for equipment – leading to reduced costs as well as increased sustainability.

Predictive maintenance is particularly useful in the case of meters, as failure often is not correlated with volume of water flow or time in use. Edge computing AI solutions that can analyze data on magnetic rotation and vibration, for example, can assess meters' health more accurately – helping utilities to avoid losing revenue. Edge devices can also be used to preprocess data and store them within the remote plant, assisting operators with root cause analysis when failures do occur.

Resilience: Device and patch management

Water treatment and distribution infrastructure often includes equipment from many manufacturers and features large numbers of geographically widespread stations. Maintaining these assortments of different technologies and ensuring that the hardware and software at all plants is up to date can be a challenge. Remote stations may be difficult (or at least time consuming) to reach, and operators often have limited information on the firmware versions installed on these distributed systems. Via edge computing, operators can access the data of their OT and IT inventory; manage devices and firmware, including information about updates and patches; and perform central security updates with no on-site manual intervention required. The resulting benefits include reduced risk of cyberattacks and downtime, longer device service life through avoidance of obsolescence, and time and cost savings due to no travel to remote sites.

[3] Source: CB Insights, "What Is Edge Computing," March 11, 2021, https://www.cbinsights.com/research/what-is-edge-computing/.

[4] Source: US Environmental Protection Agency, "Energy Efficiency for Water Utilities," last updated March 20, 2023, https://www.epa.gov/sustainable-water-infrastructure/energy-efficiency-water-utilities.

From system to ecosystem

Edge computing encompasses more than shifting computing power to the periphery. It can be viewed as an entire industrial ecosystem that also includes solutions for managing edge applications and edge devices.

According to Gartner,[5] "edge computing is not a technology [...] but a topology [...]. The edge can be thought of as a specific place where devices and systems bridge the gap from the physical world and sensors, to a digital world of computing and communications."

Computing at or close to the endpoint
Edge computing takes place at or near the interface between the physical world and data systems – but it is still a part of the network. As a result, edge devices that are installed locally access the data exchange at the endpoint, but they need not interact with the physical world itself. This is very beneficial for brownfield installations, as edge devices can be installed without interfering with the plant automation or plant operation systems but can still be managed centrally using an edge management system. As a result, edge systems can be installed in brownfield plants without impacting the operation of existing plants or systems. The actual value of the edge solutions stems from the applications running on the edge devices that process the data and provide insights for plant operation. Devices, apps, and management of an edge topology can involve different levels and organizational structures, resulting in an edge ecosystem rather than an edge system (Figure 1). To realize the full benefit of edge computing, the technology ecosystem should be based on an open-source architecture, allowing different parties to each contribute their expertise – for example, the pump system supplier can deploy an edge apps to support pump optimization.

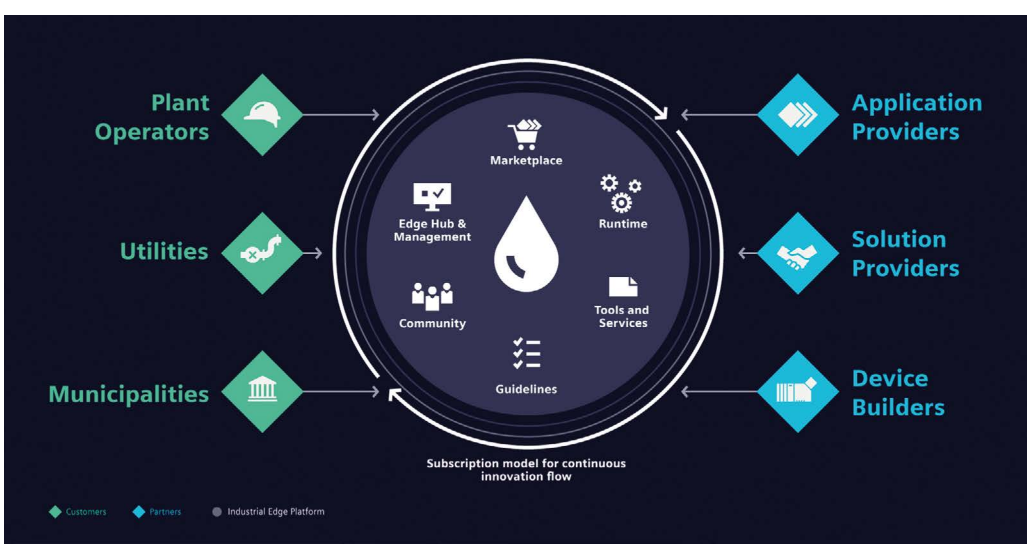

Figure 1. Edge ecosystem using Siemens Industrial Edge as an example

[5] Source: Bob Gill and David Smith, *The Edge Completes the Cloud: A Gartner Trend Insight Report*, September 14, 2018, https://emtemp.gcom.cloud/ngw/globalassets/en/doc/documents/3889058-the-edge-completes-the-cloud-a-gartner-trend-insight-report.pdf.

Edge management
Managing the installed devices and applications is an important part of edge computing. Here, we use the Industrial Edge Management (IEM) system, which is the management infrastructure for Siemens' edge computing ecosystem, Industrial Edge (Figure 2), to illustrate how edge devices are managed in an edge ecosystem from the top (central management system) to the bottom (local edge device). The IEM is designed to install, connect, update and also configure all Industrial Edge computing applications and devices across sections and sites or facilities, even globally. The IEM can be hosted on-premises by the customer itself, running virtualized on a virtual machine (VM) or on customer-owned Kubernetes clusters. In addition, it can be set up in the form of software as a service (SaaS) and operated by Siemens for an individual customer.

Edge apps
To process, visualize, and analyze the data, operators can deploy edge apps from the management system to the edge devices. In addition to ready-to-use Industrial Edge apps provided by Siemens, the IEM's Industrial Edge Marketplace includes third-party apps and an open environment in which developers can create custom private applications or apps to sell to a global industrial audience through the marketplace. The Industrial Edge Marketplace is thus an open ecosystem allowing all players to contribute their know-how via applications.

Edge applications are deployed via Docker, a tool that deploys applications in lightweight containers so that they can work efficiently in different environments and are isolated from one another. Any software, even applications written in high-level languages such as C++ or Python, can be converted into an Industrial Edge app. This means that AI and machine learning–enabled applications can also be run (for example, to implement predictive maintenance). In addition, apps can also be developed using low-code applications such as Mendix.

And of course, companies can load self-developed apps into their IEM to provide applications solely to their own organization. Global organizations can even share apps between different IEHs via the Hub-to-Hub transfer functionality.

Edge devices
On the field level, the plant's processes or assets are connected to edge devices, for example, industrial PCs (IPCs). In this setup, the edge device is connected to the programmable logic controller (PLC) or other devices, such as cameras, sensors, or I/Os, and retrieves the required process data from there. For the first named example, no change is required to the PLC or PLC code. Edge technology can also be integrated within an existing device, for example, on edge-capable operator systems like the SIMATIC HMI Unified panels. Moreover, edge devices can also be set up as virtual devices.

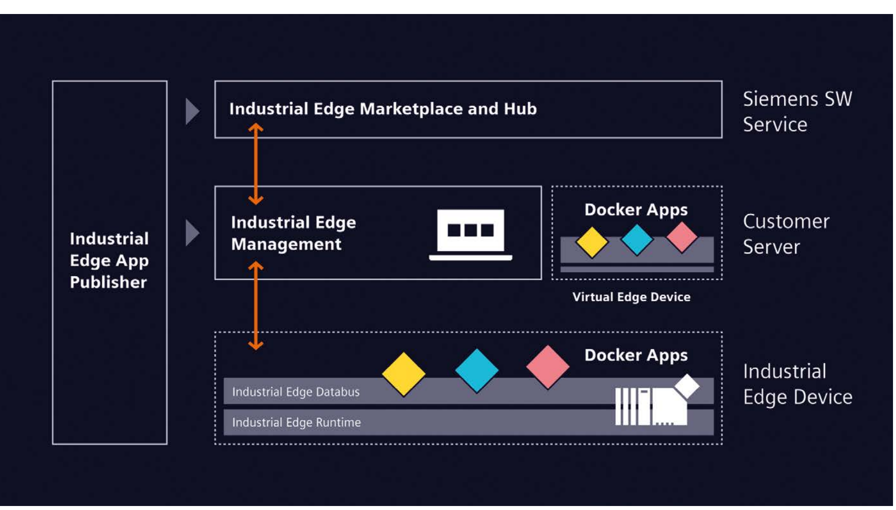

Figure 2. Siemens Industrial Edge computing platform

Industrial Edge Marketplace

Scan the code to access the Industrial Edge Marketplace

Edge connectivity

Especially in the water and wastewater industry, where operators typically have large legacy installations and mixed-vendor OT systems, edge computing applications must be able to interact with products from different vendors, and thus also different protocols. To enable interfacing with the OT and automation level, any industrial edge system should support a broad variety of protocols. For example, Siemens Industrial Edge currently offers, as standard, connectivity for a wide range of different protocols, including e.g. OPC UA, S7 / S7+. Modbus TCP, Ethernet/IP, MQTT and many more. Custom connector apps can also be used to integrate into different IT environments or to ensure communication between edge devices. The connectivity landscape is constantly expanding.

Edge Architecture

Using the example Pump Station. Optimizing the operation of water pumps can significantly reduce energy consumption and costs. Saving energy also helps the water and wastewater industry reduce its emissions and overall environmental impact. However, pump stations are usually distributed over a wide area, and networking them with a central data hub can involve substantial bandwidth requirements and high installation costs. Edge computing can provide an efficient and effective alternative, as depicted in Figure 3.

The different pump stations are equipped with different numbers of pumps and PLCs from different vendors, different ages and using different protocols. However, every station has been retrofitted with an edge device that gather the data independent from the installed base, processes it, and if required, forwards them (Figure 4).

One of the key challenges in this scenario is ensuring that the data are consistent and protected to prevent any data loss. This is particularly critical for edge devices in remote locations, where manual data recovery or reboots would cost time and effort. In the event of power failure, the operating system must shut down correctly and restart autonomously when the power comes back on. For this purpose, the SITOP Manager edge app, together with the required hardware (e.g., SITOP DC UPS), acts as a safeguard to buffer the system during power failure and to perform a graceful shutdown and start-up of edge devices and apps.

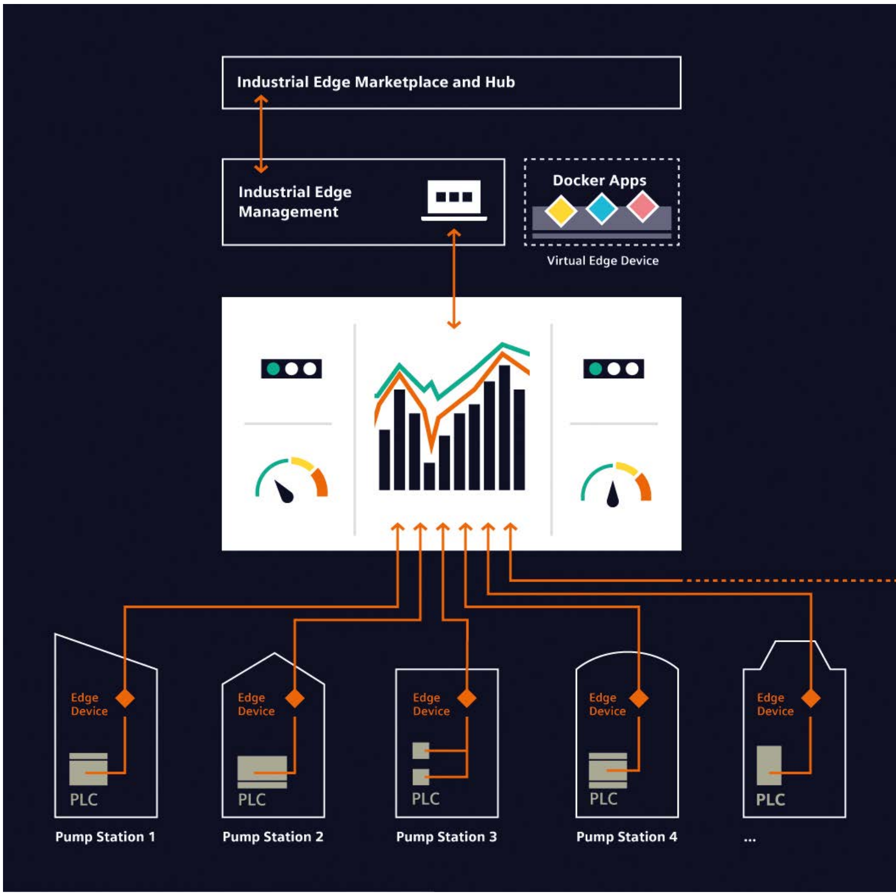

Figure 3 Illustration of a pump station energy management use case

Figure 4 Pump station energy dashboard

Edge computing step-by-step

Following a step-by-step approach, operators can set up edge computing with Industrial Edge in legacy installations with little initial investment and then scale up according to their specific requirements.

For plant operators that want to start setting up Industrial Edge within their organization or get an Industrial Edge app up and running, the following steps provide a brief overview of the process.

Step 0: Set up the Industrial Edge Management (IEM) system
This preliminary one-time effort is where IT know-how is required. The set-up process includes the following:

- Providing the Kubernetes cluster (the container orchestration system for automating software deployment, scaling, and management) or, optionally, VM on a local server or PC
- Purchasing Industrial Edge Hub access, including access to the Industrial Edge Marketplace
- Setting up user management (the organization's existing system can be integrated)
- Cybersecurity strategy (a checklist for the plant operator is available)
- Installing the IEM

Alternatively, the IEM is also available as a SaaS for a monthly fee, meaning that Siemens sets everything up for a customer. After the set-up, specific IT know-how is no longer required, as apps from the Industrial Edge Marketplace can be purchased and used.

The following steps are a repeating process.

Step 1: Define the use case
To create an effective solution, the organization first needs to identify the challenge it is trying to resolve or the added value it would like to achieve.

Step 2: Define the required app or apps
The second step includes the identification of what is to be measured and/or analyzed, the system architecture, and what apps are required (those available in the Industrial Edge Marketplace and those yet to be created). If an app is not available yet, users can develop their own app – for example, using code from open-source platforms like GitHub and "Dockerizing" it, contract a third party for this purpose, or create apps via low code applications like Mendix. As edge use cases are easily scalable, users can start with just one device, which means low initial costs for a proof of concept.

Step 3: Deploy the apps
This step deploys the app, which could be a customer's own app or one from the Industrial Edge Marketplace, on the local IEM of the edge device. As the Industrial Edge apps do not interfere with the plant or process per se but are used only to process and analyze the data provided by the OT or automation systems, this deployment will not interrupt ongoing operation. Easy deployment also facilitates test and trial installations, further lowering the risk and cost of introducing Industrial Edge.

Step 4 (ongoing): Update the apps
In addition to performing periodic updates of firmware, users can make frequent iterations of edge apps, either to scale them up for additional plants or to increase function within the specific edge applications.

Siemens offers a comprehensive menu of service options to support operators throughout the implementation process, including technical support (for example, in selecting Industrial Edge devices), consultation (for example, contributing know-how regarding app development), and services (ranging from training over IEM SaaS all the way to turnkey solution offerings).

Protecting the edge

While edge computing solutions can be deployed as a strictly on-premises solution, most implementations ultimately involve some external communication or communication with Internet-connected IT systems. This is why in any edge computing solution, cybersecurity must be a high priority.

Siemens recognizes the significance of cybersecurity for any type of industrial installation and especially for critical infrastructure.

Comprehensive strategy as recommended by IEC 62443
Siemens is a core member of the Charter of Trust, which is working to make the digital world a safer place. The company has not only taken steps to ensure that its own products and services are trustworthy but has also provided guidelines for plant operators implementing edge computing solutions, to support a secure set-up.

The Industrial Edge security guidelines – like all Siemens guidelines – adhere to the principles outlined in the IEC 62443 standards (Figure 5). The IEC 62443 standards for cybersecurity in industrial automation and control systems call for clear objectives and accountability at each phase of a plant's or facility's life cycle, with security measures coordinated and communicated between the various roles and stakeholders. IEC 62443 also recommends defense in depth as a comprehensive security strategy involving three key security domains:

- Plant security (physical access, organization security measures, etc.)
- Network security (firewalls, network segmentation, etc.)
- System integrity (user management, malware detection, system hardening, etc.)

Creating a secure environment
Industrial Edge offers a high level of built-in security, but as it is part of a larger system, an appropriate cybersecurity strategy must also address the plant and company levels. Whenever processed data from an edge device are sent to external networks, users should always use encrypted connections and protected remote access. To prevent unauthorized access, user accounts and device certificates should be used for authentication. Siemens recommends using only trusted apps and keeping application data internally or processing the data via a data broker in the so-called demilitarized zone, so only the IEM and data broker communicate to external networks.

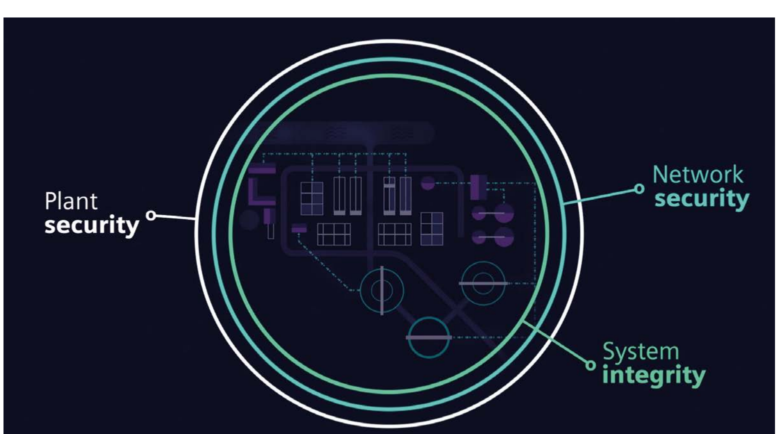

Figure 5. The defense-in-depth industrial cybersecurity approach

Glossary

AI	artificial intelligence
HMI	human-machine interface
I/Os	input/output
IEH	Industrial Edge Hub
IEM	Industrial Edge Management
IPC	industrial PC
IT	information technology
KPI	key performance indicator
OT	operational technology
PLC	programmable logic controller
PLC	programmable logic controller
SaaS	software as a service
VM	virtual machine

Links and resources

Siemens Industrial Edge

Industrial Edge Community

Industrial Edge Marketplace

Industrial Edge Devices

Industrial Edge Guidelines for Secure Setup

Industrial Edge Documentation

Industrial Cybersecurity for Water Industry

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