Water and Wastewater Process Manager checklist
Using data to improve process and efficiency
Growing demand requires better process control

The water and wastewater industry faces many critical challenges to their operations, and ABB works closely with industry experts to understand and develop our water and wastewater solutions to help address these challenges. These easy to configure, integrated solutions allow you to concentrate on your business. Today’s increasingly complex challenges require smart solutions with better, more accurate monitoring, measurement and control.

ABB’s complete portfolio of water and wastewater solutions helps you optimize your facility’s entire operations, delivering quality, sustainability and value.

ABB’s water and wastewater product offering is designed around easy configuration, integration and maintenance. With a global network of specialists delivering local service and support, ABB can offer a broad range of lifecycle services for optimal product performance and customer support. From abstraction to treatment, distribution and the management of the wastewater processes, ABB supplies an extensive range of reliable variable speed drives (VSD)/variable frequency drives (VFD), motors, PLCs, measurement and analytical products, and service solutions.

Municipal, industrial water and wastewater processors have a need and responsibility to source, treat, distribute and discharge water sustainably, cost-effectively and safely. Achieving this means recognizing the power and value of data in monitoring and managing infrastructure.

ABB Ability™ Mobile Connect for drives is a module within the Drivetune smartphone mobile app that allows you to communicate with drives users or service personnel on site, helping them easily commission and troubleshooting drives.
Comprehensive solutions
serving the water industries

ACQ580 Water drives
The ACQ580 VSD/VFD delivers innovative pump and blower features for the water and wastewater industry. These embedded features create an intuitive environment for users to enhance the performance of their processes.

Automation solutions
The scalable AC500 PLC and CP600 HMI portfolio, with its various features such as extreme condition variants and water libraries, offers solutions starting from small pumping stations to complete redundant water and wastewater solutions.

The Automation Builder programming tool shortens development time with tools to flexibly integrate ABB’s innovative VSD/VFDs into a seamless Automation solution.

Improving water quality
ABB’s range of online analytical instrumentation provides accurate analysis of key measurements in drinking/potable and wastewater applications. Along with process control expertise, ABB offers water utilities several advantages, including improvements in treated water quality, increased process efficiency, reduced use of chemicals and energy, as well as reduced maintenance and personnel costs.

AquaMaster and WaterMaster electromagnetic flowmeters
The AquaMaster and WaterMaster electromagnetic flowmeters are designed to improve the management of potable water distribution networks and throughout the wastewater treatment process. Their features are targeted at the WWW industry’s specific requirements, ranging from a total water management solution for revenue (billing) applications, district metering and water distribution to leakage management. Flowrate information can be sent via GSM/SMS or GPRS/WITS, enabling operators to virtually pinpoint any difficult, small or slow leaks as they happen and providing the opportunity to rectify them quickly.

LST ultrasonic level transmitters
LST ultrasonic level transmitters provide non-contact level measurement for pump control optimization in the water and wastewater industries. Used for both closed tanks and open containment ponds, they work on the principle of time of flight (sound in air).

2600T pressure transmitter
The 2600T pressure transmitter family meets expectations and delivers accurate control in both water and wastewater. Features include a large turn-down ratio and stainless steel housing optimized for extreme conditions.

ADS420 dissolved oxygen analyzer
ABB’s intelligent optical dissolved oxygen sensors provide accurate measurement in the harshest environments. Designed to work the way you want it to work, the ADS420 uses the latest generation of drift-free optical measurement technology – minimizing operating costs and removing the need for routine calibration.

FSM4000 advanced flow meter
The FSM4000 advanced flow-metering technology combines edge filtering technology to ensure the most stable signal output in applications such as thickened sludge or two-phase fluids in wastewater treatment plant applications. The application’s tighter control reduces the energy consumption of actuators or positioners, system stress leading to less downtime, maintenance, and component replacements.
Who also benefits from process changes?

Generating more data is not a challenge for today’s utility companies. The real challenge is being smart with the data. With only a small percentage of today’s data being used to make real-time process changes, identifying inefficiency gaps, improving visualization, engaging the right stakeholders and applying predictive analytics to adopt a proactive approach to water and wastewater treatment is a team solution.

Productivity and resilience

“Today’s processes are often designed based on the maximum treatable load and not average loads, leading to overdosing of chemicals to be on the safe side along with other process inefficiencies.”

Process Manager

Built-in resilience...

Water and wastewater plants need to run without interruption and in the most efficient and environmentally conscious way. Ensuring the reliability of plant assets is the best way to ensure uninterrupted operation, reduce the environmental impact, and keep your business efficient and effective. The speed at which a pump motor runs determines how much energy it consumes, and VSD/VFDs attached to the pump motors enable pressure and flow rates to be controlled by the speed of the pump motor rather than mechanically by valves, which can lead to significant energy savings of 30 to 60%.

... with flexible motor-driven solutions

Using dissolved oxygen monitoring helps significantly reduce the power required to operate aeration systems by controlling to optimal levels. ABB’s ADS420 provides fast, accurate and reliable measurement of DO for improved process control.

—

“Sensor accuracy, reliability, a faster sampling technique and results analytics offer great potential for improvement. Reliable real-time instruments providing results within a minute are still not the norm but offer outstanding benefits when it comes to control.”
Reliability and maintenance

“Uptime is our number one priority.”

Maintenance Manager

Lower operational overheads...
Wastewater pumps suffer a higher wear rate because of grit, rags, debris and other solids. Managing these issues saves energy by avoiding pumping against partial blockages.

... by utilizing smart functionality

Multi-pump control ensures stable and uninterrupted production with multi-pump controls by optimizing the speed and number of running pumps.

The blockage/pump cleaning function in the ABB ACQ580 keeps the pump’s impeller clean by running a sequence of ramps between minimum and maximum pump speed, depending on configurable triggers. This feature avoids the high costs associated with removing the pumps to clean manually and the health and safety implications of the lifting operations.

Temperature, load, under/overvoltage protection and warning features help anticipate breakdowns.

A real-time clock allows timed tracing of faults, so you know what happened, and when.

ABB Ability™ Condition Monitoring services support remote pumping stations by delivering accurate real-time information about VSD/VFDs and motors, ensuring equipment is available, reliable and maintainable.

Energy efficiency

“We need to cut our energy bill and reduce our carbon footprint.”

Energy Manager

Know where to look...
In every stage of water treatment, there are opportunities to improve processes, while saving large amounts of energy.

... and how to unlock the saving potential
Pumps and aeration equipment are the largest water and wastewater energy consumers. Because of catchment area characteristics, pumps and aeration blowers are often oversized, with limited control feedback from the process (e.g., flow/pressure/dissolved oxygen).

... by improving control feedback

When managing pump efficiency, consider current operating conditions and startup low flows. Then determine the power consumption of the pumping system (motor, VSD/VFD and pump) across the range of pumping rates, from current flow to design flow to achieve the best efficiency point (BEP) pumping through VSD/VFD control.
Finding process improvements every step of the way in water treatment

In every stage of water treatment, there are opportunities to improve processes, while saving large amounts of energy. Identify the areas with the quickest payback in your clean/potable water process.

1. **WATER ABSTRACTION**
   - Water abstraction involves the extraction of raw water from a river or lake source to a treatment facility, depending on the raw water quality.
   
   **Applications:**
   - Centrifugal and submersible pumps

   **Process efficiency opportunities:**
   Source water is traditionally monitored through labor-intensive methods such as sampling and field testing. With the growth of online continuous monitoring, utilities can both gain better resolution and insights in quality and use this data to control their pumps through VSD/VFDs.

   **Additional benefits**
   - **Potential savings:** Up to 40%
   - **Potential payback period:** 6–36 months

2. **GROUNDWATER OR WELL PUMPING/EXTRACTION**
   - Groundwater extraction involves the extraction of raw water from an underground source and conveying it to a distribution network or to a treatment facility, depending on the raw water quality. The depths of the underground aquifers can vary around the world, and as they get depleted, the depths increase.

   **Applications:**
   - Multistage pump with special submersible motor

   **Energy-saving opportunities:**
   Borehole/well or vertical turbine pumps are the most commonly used pumps for extracting water from groundwater sources alongside vertical multistage pumps. The pumps are often connected in series to generate high pressure and are also suitable for fitting to VSD/VFDs and saving energy.

   **Additional benefits**
   - **Potential savings:** Up to 40%
   - **Potential payback period:** 12–36 months
DISTRIBUTION NETWORK

From the large transmission mains, potable water flows into smaller pipes called distribution mains or branch mains. These become progressively smaller and eventually become service connections outside homes. Globally, water losses of greater than 50% are not uncommon, varying greatly region by region, and the first step in reducing them is closer monitoring and measuring of the water network. The immediate need to reduce non-revenue water (NRW) and water quality concerns resulting from ageing infrastructure, combined with adverse weather events, leaves utilities addressing very complex issues not only to meet service needs and comply with regulations but also to help ensure they are a cost-effective and efficiently run utility.

Applications:
• Centrifugal pumps

Process changes with data linked to VSD/VFD control:
Protecting the environment and conserving water resources is a global responsibility. In many regions, water shortages have led to a need to control and report the amount of water lost through distribution. Smart flow meters placed in the network provide utilities with high-resolution data that can be analyzed to provide information about the location and approximate severity of leaks. This enables appropriate actions from operators such as reducing flow and pressure.

Additional benefits
Potential savings: Up to 45%
Potential payback period: 6–18 months

OTHER APPLICATIONS

Other applications within the water treatment process include:
• FLOCCULATION
• CHEMICAL COAGULATION
• DISINFECTION
• SEDIMENTATION
• FILTRATION

These applications have process opportunities and benefit from the application of VSD/VFDs for improved control. Ultrasonic level and flow measurements are already found throughout the water process and in chemical treatment. For example, the accurate measurement of these parameters enables safe products and cost reduction when combined with a VSD/VFD.
Clean water process

Today’s process opportunities focus on flow, pressure and temperature sensors to provide closed loop control with a VSD/VFD. Further process efficiencies can also come from water quality sensors such as turbidity, conductivity, pH, etc.

<table>
<thead>
<tr>
<th>Clean water treatment process benefits</th>
<th>Check ✓</th>
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<tbody>
<tr>
<td><strong>Direct savings</strong></td>
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<tr>
<td>Reduced chemical use</td>
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<tr>
<td>• Through process optimization and real-time raw water monitoring, a significant reduction in the amount of chemicals needed via accurate and frequent sampling is achievable.</td>
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<tr>
<td>Energy efficiency</td>
<td></td>
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<tr>
<td>• Reductions in energy consumption can be achieved by monitoring, optimizing and connecting pumping control.</td>
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<tr>
<td>Improved abstraction compliance</td>
<td></td>
</tr>
<tr>
<td>• Monitoring raw water volumes destined for treatment to become drinking/potable water through accurate pumping control with VSD/VFDs enables utilities to maximize their abstraction when required to stay within governance limits and avoid over-abstraction.</td>
<td>☐</td>
</tr>
<tr>
<td>Public health</td>
<td></td>
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<tr>
<td>• Continuous monitoring can alert operators to changes and problems in the treatment steps, allowing early alerts about the public with potential problems about the quality of their water supply and improve customer communication and satisfaction.</td>
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</tbody>
</table>

Historically, most of the energy savings budget in the potable water industry was given to the distribution networks. This was in part because of the large size of the pumps and motors, providing large scope for reducing energy costs. Through a change in philosophy to a more “catchment-to tap” approach, the demand for sophisticated data analysis across the entire process has grown. This increase in data and integration of external data like weather and geological information have allowed greater process control and higher integration of VSD/VFDs throughout the operation.

**River and groundwater extraction**
Technological advances in monitoring methods are allowing utilities to obtain real-time and near-real-time data, which can be used to cut costs by optimizing control processes. Having greater insights into the raw water intake can allow process efficiency gains and improved water quality in the treatment process.

The increased use of online water quality sensors can enable the real-time collection of quality data. When a change in quality occurs, it can be detected, and the plant operator can be alerted and armed with process changes like flowrates via VSD/VFDs. A better-quality water intake may also allow a reduction in chlorine dosage levels. By measuring bacterial contamination in water, it could allow treatment plants to dramatically reduce their chemical consumption by using only necessary amounts of chlorine when disinfecting, instead of taking the current precautionary approach (often at a high constant level).

<table>
<thead>
<tr>
<th>Clean water treatment – Commonly monitored parameters – River abstraction and groundwater extraction</th>
<th>Check ✓</th>
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<tbody>
<tr>
<td><strong>Turbidity</strong></td>
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<tr>
<td>• Turbidity is the term used to measure/determine the relative clarity of a liquid. The turbidity of water is an optical characteristic of liquid (haziness or cloudiness) and is a measurement of the light reflected through the materials present in the water.</td>
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<tr>
<td>• In addition to affecting the appearance of water, high turbidity levels can also affect the performance of water treatment processes and the ability of aquatic organisms to thrive. It can also interfere with the effectiveness of disinfectants used to treat water, as the suspended particles can interfere with the ability of the disinfectant to kill bacteria and other contaminants.</td>
<td>☐</td>
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<tr>
<td>• As a result, it is important to monitor and control turbidity to maintain water quality for various purposes.</td>
<td>☐</td>
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<tr>
<td><strong>Conductivity/pH</strong></td>
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<tr>
<td>• Conductivity is the measure of the concentration of ions present within a water sample. The calculation of the conductivity electrical current is transmitted over a defined area. “pH” is the measure of hydrogen ion concentration in a sample used to determine the acidity or alkalinity of a product.</td>
<td>☐</td>
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<tr>
<td>• High conductivity is closely related to high TDS (total dissolved solids) concentration in water and a high amount of dissolved mineral salts in water.</td>
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<tr>
<td><strong>Manganese and Iron</strong></td>
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<tr>
<td>• Manganese and iron are naturally occurring metals in soils. Higher levels of iron and manganese are often common occurrences due to differing soil types and hydrogeological conditions.</td>
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<tr>
<td>• Discolored water and strange odors are often the cause of bad customer relations, but for the municipalities, there is often a link with problems in the treatment processes, reduced pressure and arsenic contamination.</td>
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</table>
Abstraction

To abstract large amounts of water for cities (drinking/potable water), agriculture (irrigation) or industrial use (e.g., cooling water or commercial fish farming), permanent water intakes are necessary. A pump strategy using the latest technology can help lower energy costs, reduce abstraction demand and improve the environment.

Pumping from a river to the raw water pumping station often requires a static head to be overcome. Borehole or vertical turbine pumps are the most commonly used pumps for extracting water from groundwater sources, but from lakes, reservoirs and rivers, the choice of pumps depends on pump location and the height that it needs to be lifted. A pump is designed for a specific load point, called the design duty point (DDP) on a pump curve. This is typically close to the best efficiency point (BEP) of the pump. But in reality, most pumps are NOT running at their DDP or BEP, but at a lower load. This lower load has often been set by a throttle valve, creating loss, and this is where variable speed pumping offers the tremendous advantage of the ability to adapt the speed to the actual need, minimizing the losses.

Water levels are typically lower in the summer than in the fall and winter months. A higher speed is needed during the summer to overcome the increased static lift just to get the water out of the borehole. Levels will drop when the pump starts – this difference between the static level and the level in the borehole is called the drawdown, and it is linked to the yield you can get from the specific borehole. A low water level in a borehole can be a real problem. It can lead to a risk of cavitation due to a low Net Positive Suction Head. Cavitation detection software within the ACQ580 VSD/VFD can be a solution, or the information from a level sensor can be used. Having a vortex is also a risk: It will let air into the pump, and decrease the performance of the pump system.

The need to manage water supplies more carefully has led to the introduction of water abstraction controls in many parts of the world.

The ACQ580 water VSD/VFD has a range of options, depending on various scenarios. Monitoring several parameters in a borehole application results in better control options and efficiency benefits. Monitoring flow, energy and turbidity enables more control options that can reduce the turbidity and allow “lower-cost water.” With the fast acceleration normally required to ensure an adequate bearing film between the mechanical parts in the pump, the tendency was for a stirring effect in the well and an increased turbidity and treatment cost. In combination with the ABB AX420 Turbidity sensor, the ACQ580 VSD/VFD is programmed to have “stepped” ramp periods to allow lubrication of the pump but reduce the stirring-up effect of the silt at the bottom of the aquifer for the best solution.

Watch points include long cable runs and cooling. The addition of an output filter is often required for borehole installations to protect the pump motors electrical insulation and Upeak.

Today’s stringent water quality legislation demands ever more accurate measurement to help protect the world’s aquatic environment.
**Best efficiency point Pumping**

In water and wastewater systems, the best efficiency point (BEP) is crucial for pump operation. The BEP is where the pump operates at its most efficient, providing the greatest performance with the least energy consumption.

**Pump Curves**

- **H = Head**
- **Q = Volume**
- **h = Static head**
- **H<sub>f</sub> = Friction head**

There are various examples shown, including:

1. **Raw water pumping example – three VSD/VFD controlled pumps**
2. **Raw water pumping example – one VSD/VFD and two fixed speed pumps**
3. **Raw water pumping example – three speed pumps**
4. **Raw water pumping example – three VSD/VFD controlled pumps**

These diagrams illustrate how different control strategies (VSD/VFD, fixed speed pumps) affect pump performance and energy efficiency at the raw water pumping station.
1. PUMP CURVES

A pump is characterized by the performance curve showing: Head (H) as a function of flow (Q), also known as the QH or HQ curve. Most pumps are classified to the ISO9906 standard which gives Grade 3B. Higher grades with smaller tolerances are also available.

Grade 3B tolerances:
- Q: +/- 9%
- H: +/- 7%
- P: +9%
- Efficiency: -7%

These values apply to the pump, but motor uncertainties need to be considered as well.

2. RAW WATER PUMPING EXAMPLE

In this example, a set of three booster pumps are abstracting water from a river to a raw water pumping station. This requires the water to be lifted to overcome a static head (H).

Each pump is designed for a specific load point, called the design duty point (DDP). For this set of pumps, the design duty point is not the same point as the best efficiency point (BEP) of the pump but is at a lower load. The pump’s flow is controlled by a throttle valve.

3. RAW WATER PUMPING EXAMPLE – THREE FIXED SPEED PUMPS

This example shows three fixed speed pumps with the system curve. With a static head of 25 and a pressure loss of 0.01, the black vertical line representing the desired extraction flowrate of 22 (this can be read as the full extraction rate based on a legislated amount set by the season and river levels). With pumps 1 and 2 at full speed, the extraction rate is below the licensed extraction flow. With the third pump at full speed, the flow is above the licensed extraction amount.

4. RAW WATER PUMPING EXAMPLE – THREE VSD/VFD CONTROLLED PUMPS

If you install VSD/VFD control on all three pumps with the core intention of energy saving by speed reduction, using cube law, a 20% speed reduction may offer a 50% energy saving. In this example, all three pumps have been reduced to 40 Hz, as illustrated by 1, 2 and 3. Since the required goal of the site is to meet the extraction limit, the 50% energy saving would not achieve the desired flow.

5. RAW WATER PUMPING EXAMPLE – ONE VSD/VFD CONTROLLED AND TWO FIXED SPEED PUMPS

This illustration shows the pump performance curves of two fixed speed pumps at 50 Hz (pumps 1 and 2) and pump number 3 with a VSD/VFD installed and running at 44 Hz. The black line indicates the desired extraction flowrate of 22, and with a VSD/VFD fitted, the site is allowed full extraction within abstraction levels.

6. RAW WATER PUMPING EXAMPLE – THREE VSD/VFD CONTROLLED PUMPS

Fitting three VSD/VFDs allows speed reduction and energy savings combined with reliance. The illustration shows 3 VSD/VFD controlled pumps at 47 Hz. Using a relative power consumption between the two system approaches allows both process and energy efficiencies. Savings will depend on the static lift required and on the actual power curve of the pumps. The amount of any saving will vary, depending on the actual application.
Clean water process – Distribution network

Preserving water by cutting leakage in water networks massively increases security of supply and reduces the cost and carbon footprint associated with taking water from the environment. Water companies across the globe are working to detect and fix leaks. By involving VSD/VFDs in their program of investment, they can go a step further toward the goal of reducing leakage rates.

Unexpected or fast pressure changes are one of the prime causes of leaks—control this, and you can prevent many leaks occurring in the first place. Many pumping stations will operate on a schedule that runs the pumps at full speed until the pressure gets up to the desired level (and sometimes slightly above). The pumps will then turn off and turn on again when the pressure drops below the specified setpoint.

This results in frequent starting and stopping, which leads to pressure transients that can cause pipe walls and joints to crack or separate. Flow match demand using pressure sensing as a control will cause less stress on the distribution network, resulting in reduced leakage.

VSD/VFDs can be set to produce a flow of water from the pump that offers the best combination of flow and pressure and ramp up the speed slowly to the desired level. Pressure transients are reduced, avoiding water being forced through existing gaps, while a steady speed cuts the need for frequent starts—when starts and stops are needed, they are gentler and less damaging. Using VSD/VFDs to tackle leakage has the double effect of not only cutting pressure but also significantly lowering energy usage and costs.

A World Bank study has estimated that over 32 billion cubic meters of treated water are lost every year through leakage.¹)


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<table>
<thead>
<tr>
<th>Clean water – Distribution network</th>
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<tbody>
<tr>
<td><strong>Pressure</strong></td>
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<tr>
<td>• Drinking/potable water networks are pressurized to ensure customers receive a sufficient flow of water. If the pressure gets too high, pipes can be damaged, causing leaks or bursts. Pressure can be optimized to minimize damage to pipes while ensuring customer demand is met with the control of a VSD/VFD. A drop in pressure could mean that there is a leak in the network.</td>
<td>☐</td>
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<tr>
<td>• Inline pressure sensors transmit back to a central system for analysis and allow changes in the network pressure in real time.</td>
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<tr>
<td><strong>Flow</strong></td>
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<tr>
<td>• Flow meters provide data on either entering or leaving water sometimes localized within a district metered area (DMA), enabling identification of leaks and providing data that can be used for process improvements.</td>
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<tr>
<td>• Measuring the minimum night flow (MNF) allows better insights into leakage rates with DMA and the identification of hidden leaks.</td>
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</tbody>
</table>
Distribution network

Detecting leaks when they happen is today’s goal for utilities. Tomorrow’s is putting appropriate measures in place before the leaks occur. This can be achieved by using advanced analytics and maintenance sensors for motors, bearings and pumps to take a much more proactive approach to leakage management and minimize disruption to the customer, as well as reducing the cost of repairs.

Pressure transients in a water network stem from several causes, but by far the most damaging are those created rapidly over a small distance. Examples include a valve being opened or shut too fast, a pump inducing suction instantaneously, or a large water user such as an industrial plant opening or shutting it’s supply valve. The kinetic energy of the water is transferred into strain energy on the network, and a shock wave is sent through the system, unduly pressuring equipment.

Much of the infrastructure in the developed world was built many decades ago, and as a result, is struggling with the demands of advanced control systems. To optimize processes, utilities are requiring the greater flexibility made available by fitting VSD/VFDs to the distribution network. Reducing the amount of Non-Revenue Water (NRW) in networks can be achieved through greater control of flow and pressure in the system and is a good example of the need for smarter pumps.

Leakage falls into two main categories – background leaks and bursts or breaks. Background leakage is the aggregation of losses from all the fittings in the network. Such leaks are typically too small to detect individually. Major bursts and gushes on the surface tend to be reported to water companies by the public, but it is vital to keep on top of other, less obvious leaks.

Optimal operating efficiency, such as adjusting pump motor speeds depending on the time of day to reduce energy usage while still meeting customer demands, is a key way in which utilities aim to optimize their network operations.

Over US$14 billion of revenue for water that is being delivered to customers is not being invoiced due to theft, corruption or inadequate metering.
Finding process improvement opportunities every step of the way in wastewater treatment

In every stage of wastewater treatment, there are opportunities to improve processes while saving large amounts of energy. Identify the areas with the quickest payback in your wastewater process.

1. **WET WELL / LIFT STATION**

   Wet wells or sewer pumping/lift stations are used to move wastewater to higher elevations to allow further transportation to the wastewater works by gravity flow.

   Level instrumentation determines when a pump is started to lift the sewage upward through a pressurized pipe system (sewer force main or rising main). Accurate results from pressure measurement in a pumping/lift station application are critical to the success of water processes.

   If the nominal process pressure is exceeded or not maintained, the entire system could be subject to failure or inefficiencies. If a water system pressure is too high, the pumps will struggle to maintain pressure, while the excess pressure will cause additional costs and leakage throughout the system.

   **Applications:**
   - Sewage pumping stations (lift stations)
   - Submersible, dry well or suspended pumps

   **Energy-saving opportunities:**

   While prioritizing reliability above energy efficiency, the increasing distances between catchments and treatment works and high energy costs present opportunities for savings.

   Oversizing is a common practice in the design cycle. The use of ABB VSD/VFDs can reduce energy costs significantly.

   **Additional benefits**

   **Potential savings:** Up to 50%

   **Potential payback period:** 6–36 months

2. **AERATION**

   Wastewater aeration is the process of adding air to wastewater to allow aerobic bio-degradation of the pollutant components. Loading of the treatment plant varies continuously and uncontrollably because of variation from population activity and seasonal rains or industrial loads.

   The variation of the process disturbances is enormous, and their time scales vary from hours to months, making it a challenge to optimize, so a common approach is often to oversize equipment.

   Over 60% of the electrical costs of a wastewater process plant arise from compressor/blower operation for aeration beds. Most customers are looking for ways to reduce the amount of air required to maintain the correct level of bacteria in the beds. A simple answer is to monitor the oxygen levels to ensure the correct amount of oxygen is present and then not to exceed that level.

   **Applications:**
   - Blowers, fans
   - Surface aerator mixers

   **Energy-saving opportunities:**

   Removing dampers and restrictions and controlling motor speed with a VSD/VFD can significantly reduce energy use. Further controlling dissolved oxygen levels with built-in process controllers can improve overall efficiency.

   **Additional benefits**

   **Potential savings:** Surface/mechanical up to 50%
   - Blower up to 40%

   **Potential payback period:** 10–36 months
Clarification or sedimentation is an essential step in the wastewater treatment process to remove suspended solids through gravity settling, providing a clarified liquid effluent. Clarifiers are settling tanks with "mechanical" means for the continuous removal of solids left by sedimentation.

**Applications:**
- WAS and RAS pumps
- Sludge scraper

**Energy-saving opportunities:**
Within the final clarification process, there is a requirement for return activated sludge (RAS) pumps and waste activated sludge (WAS) pumps. Return activated sludge (RAS) pumps continuously pump sludge back into the aeration lane as part of the treatment process, and waste activated sludge (WAS) is pumped to the sludge-handling process part of the plant. RAS pumping typically takes 5–10% of a sewage treatment works’ energy demand.

The required rate of RAS normally depends on the flow of sewage. However, other parameters such as the settleability of the sludge (commonly measured as SSVI) and the concentration of solids present in the sludge can be used to influence the RAS flowrate. These are often measured manually, but flowrates can be taken in as analog signals into the VSD/VFD and provide real-time speed control. By reducing the RAS pumping rate, less energy is used.

**Additional benefits**

**Potential savings:** **RAS pumping 50%**

**Potential payback period:** 6–36 months

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**OTHER APPLICATIONS**

Other applications in the wastewater treatment process include:
- SCREENING
- GRIT REMOVAL
- DISSOLVED AIR FLOTATION PLANT
- FILTRATION
- FLOCCULATION
- SLUDGE TREATMENT AND REMOVAL

These applications have limited energy-saving opportunities (mainly because of the power sizes) but still benefit from the application of VSD/VFDs for improved process control.
Wastewater process

Wastewater networks are designed to carry a predictable amount of wastewater from households, commercial buildings, industries and surface runoff. However, due to aging infrastructure, population growth and extreme weather events, the capacity of a wastewater process is often exceed or even underutilized, with a greater need for continual process variation.

In the past, investment in wastewater treatment and their networks has been driven by regulations, with the least priority given to control and monitoring. Pipelines are often reaching the end of their usable lifetimes, and treatment plants are nearing overcapacity. Some estimates state that wastewater networks are a decade behind in terms of control and monitoring against drinking/potable water networks.

Offsite assets such as pumping stations, pipelines and retention tanks often only have very basic control equipment mainly for levels, but sometimes include flow measurement devices as well. Monitoring is mostly local or offline, with basic alarms and a high reliance on customer feedback/complaints regarding leaks. Alarms, when present, are commonly set for any change to flow. The level and pressure are then linked manually to different outcomes such as duty and assist running in a multi-pump lift station.

Utilities that have implemented condition assessments of their assets have typically done it in sections, mainly due to the costs involved, meaning a large opportunity exists for improvement in control management for offsite assets.

### Wastewater treatment process benefits

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<tr>
<th>Benefit</th>
<th>Description</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced chemical use</td>
<td>Through process optimization and real-time wastewater monitoring, significant reductions in the amount of chemicals needed via accurate and frequent sampling are possible.</td>
<td></td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>Optimization of wastewater network pump operation, such as in wet wells/lift stations, has the potential for operational and energy cost savings reductions.</td>
<td></td>
</tr>
<tr>
<td>Flood protection</td>
<td>Combined sewers can suffer from periodic flooding events because of sudden changes in the weather. Network modeling aided by accurate flow and level information combined with weather updates can prepare utilities and allow them to mitigate the effects of flooding events through enhanced flow control.</td>
<td></td>
</tr>
<tr>
<td>Health and safety</td>
<td>Monitoring the physical pipe condition such as defects or the corrosion level, debris levels and obstructions when matched with flow and pressure data can mean early appropriate maintenance needs to be conducted, and risks to health and safety can be reduced.</td>
<td></td>
</tr>
</tbody>
</table>
Wet wells or sewer pumping lift stations

Wet wells or sewer pumping lift stations are where the sewage from the wastewater network is fed and stored. Flow is the main parameter required to be both measured and regulated in most countries. To improve the quality of incoming wastewater and enhance the aerobic digestion process, some utilities are now measuring additional parameters such as pH, conductivity, pressure, Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), and even ammonia to receive early warnings of harmful components in wastewater.

### Wastewater treatment – Commonly monitored parameters – Wet wells and lift stations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow/Level</td>
<td>The level and flow in wet wells or sewer pumping stations/lift stations are an integral part of an effective sewage collection system and need to be monitored to provide an input for both the pump and operator.</td>
</tr>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>Total suspended solids (TSS) is a measure of the concentration of solid particles in wastewater that are suspended in the water and do not settle to the bottom of the container.</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>Chemical oxygen demand (COD) is a measure of the amount of oxygen that is required to chemically oxidize organic matter in wastewater. It is used as an indicator of the level of organic pollution in the water and is typically measured in milligrams per liter (mg/L) or parts per million (ppm).</td>
</tr>
</tbody>
</table>

**Wet wells or sewer pumping stations/lift stations are usually unmanned (due to their remote nature) and automated with a simple on/off switch for pump operation.** The monitoring often depends on the sophistication of communication infrastructure installed and the location of the site (deep in a valley with limited telephone signal limits connection capabilities). Smaller wet wells or sewer pumping stations/lift stations tend to have minimal monitoring, with utilities monitoring their stations remotely through their local treatment plants. Some stations are monitored through a telephone PSTN dial-up operation, and some use radio (UHF or VHF frequency) technology, which looks for alarm signals that are limited to much more. Remote telemetry units (RTUs) with a wireless 3G TSM capability are often installed and are starting to replace old telemetry systems. RTUs work by communicating with the central telemetry unit, which passes information to the utilities’ PLC. Larger utilities with larger wet walls and sewer pumping stations/lift stations use SCADA platforms dedicated to collecting information.

VSD/VFDs are more commonly found at larger pumping stations, providing pump reliability through reduced starts/stops and smoother ramps, reducing the wear of pumps and their seals. VSD/VFDs also reduce energy consumption by adjusting the speed of pumping according to the pressure at the pumping station or running at the best efficient speed (rather than full speed). Besides pressure, flow measurement can also be used to provide an improved flow and level control in the wet well.

**The pump cleaning function** in the ABB ACQ580 water dedicated VSD/VFD offers an intelligent way to resolve pump blockages/ragging. It has been designed to prevent solid particles becoming stuck in the pump impeller, featuring a programmable sequence of forward and reverse rotations to loosen solids and release them from the impeller. This prevents blockages, thereby reducing the frequency of manual cleaning.
Wastewater process – Aeration

Aeration basins are often the treatment plants’ most critical biological treatment process and are the highest energy consumers for most plants – accounting for up to 60% of a plant’s overall energy requirements.*

Common goals like ensuring adequate treatment, meeting regulatory requirements whilst optimizing energy use and reducing operational costs can become opposing goals. Over-aeration and overuse of chemicals upstream of the aeration process, often a consequence when better instrumentation and control, can improve biological activity and reduce energy.

Aeration provides the oxygen to the microbes for treating and stabilizing the wastewater as the bacteria needs oxygen to digest the waste and break down organic matter containing carbon to form carbon dioxide and water. Without sufficient oxygen, bacteria cannot biodegrade the incoming organic matter in the required treatment timescale. The aeration process delivers it to the basins, and the result is increased dissolved oxygen (DO) in the water. The optimal range of DO in aeration basins is decided based on the characteristics of the sewage influent and the sewage flowrate.

The process works by bringing water and air into close contact by exposing drops or thin sheets of water to the air or by introducing small bubbles of air (the smaller the bubble, the better) and letting them rise through the water. The efficiency depends on the amount of surface contact between the air and water, which is controlled primarily by the size of the waterdrop. Seasonal/situational operating conditions often show a clear diurnal pattern because of population activity, allowing periods of high and low load (low loading being typically from midnight to noon).

Using ABB ACQ580 VSD/VFDs and ABB dissolved oxygen (DO) probes, aeration operating costs can be greatly reduced by maintaining desired oxygen levels within aeration basins while reducing the airflow from the blowers.

Municipal plants that have to discharge liquid waste are required to prove to the relevant authorities that the biological content and volume discharged comply with environmental standards and do not exceed legal limits.

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Impact of reducing air supply

- Insufficient air for the bacteria to live
- Slow bacterial growth resulting in poor treatment

Impact of increasing air supply

- Complete treatment with optimized energy operation
- Complete treatment with poor energy operation
- Too much bacterial growth so bacteria gets hungry and dies

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Dissolved oxygen vs. process efficiency

- Poor efficiency
- Optimal efficiency
- High process efficiency

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Wastewater treatment – Commonly monitored parameters – Aeration basins

<table>
<thead>
<tr>
<th>Parameter</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen (DO)</td>
<td>Dissolved oxygen (DO) is the amount of oxygen that is dissolved in water. DO levels can be influenced by a variety of factors, including temperature, pressure and the presence of other dissolved gases.</td>
</tr>
<tr>
<td>Ammonia and Phosphate</td>
<td>Ammonia and phosphate are two important parameters that are commonly measured in wastewater treatment processes. Ammonia is a compound that is produced by the breakdown of organic matter and is commonly found in wastewater. It is toxic to many aquatic organisms and can cause problems in natural bodies of water if it is not properly treated. Phosphate is a nutrient that is essential for plant growth, but excessive amounts of phosphate in water can cause problems such as algal blooms and eutrophication.</td>
</tr>
<tr>
<td>Biochemical oxygen demand (BOD)</td>
<td>Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that is used by microorganisms to break down organic matter in water. It is an important parameter in wastewater treatment, as high levels of BOD can indicate the presence of organic pollution, which can lead to problems such as reduced water quality and the death of aquatic life.</td>
</tr>
</tbody>
</table>

Common aeration solutions

There are several approaches to aeration, with the energy requirement varying considerably for each setup and approach. Aeration using activated sludge uses the most amount of energy but treats far more cubic meters of waste per kWh (kilowatt hours) than the traditional and rural aerated lagoon approach.

A common aeration control strategy for a surface aerator can either include a DO (Dissolved Oxygen) probe and transmitter combination to measure the amount of oxygen in the basin or no DO measurement at all. The controller uses a DO setpoint, usually between 2.0 to 4.5 ppm (parts per million) and turns the aeration motor DOL (direct online or across the line) starter on or off, depending on the levels. Without the DO sensor, control is often just a timer control.

Stop/start control
A stop/start approach is inefficient in maintaining the DO value, and when the DO starts, it will cause high levels of inrush current/stress in the mechanical system.

Using process (PID) control is another approach, calculating the required control output via a flow control valve to regulate the amount of air flowing into the tank and thus changing the DO in the basin.

This is highly energy inefficient and again unlikely to achieve the process requirements – often leading to “Hunting” due to control valves in blowers fighting valves in the lanes, resulting in limited DO and ammonia control in the aeration basins. Innovations in process control using VFD/VSDs have allowed flow control valves and DOL starters to be removed.

Variable speed control
The VSD/VFD receives the speed demand output signal from the DO Sensor (usually 4–20 mA) and changes the speed of the blower/surface aerator. Using VFD/VSDs means energy savings can be as high as 50% of the electricity cost.

The same rules apply to positive displacement blowers (sometimes referred to as compressors) but with slightly less savings potential of around 20%.

The operation of the blowers will vary based on the plant’s loading, with treatment tank size, piping dimensions and HP/kW ratings all playing a part. Variables like operating temperature contribute to process control benefits from a VSD/VFD and DO sensor combination, for example, in worst-case summer conditions, when oxygen demand is highest or during heavy rainfall when DO levels can drop.

The ability to control the aeration process in response to actual oxygen demands, which are impacted by changes in temperature, volume, or waste stream characteristics, can make a big difference to overall energy costs.

With ammonium levels monitored at the output of a plant, the additional ability to link this back to the aeration basin (oxygen is used to transform ammonium to nitrate) enables even more process benefits.

Sensor choice and location play a part in reliable and constant DO readings. For surface aeration, sample flow can be volatile, so a dip system is a more stable solution. If you have a gentle sample flow without level changes, a floating ball is a good option. The location of blowers is also important, and they should be as close to the aeration tank as practical to minimize piping restrictions and friction (which can increase pressure demands by 20 to 30 percent). Elbows, valves and other design features also affect efficiency, as do check valves, which can require up to 20 percent more pressure (more hp/kW demand). Apart from the benefits of energy saving, which provides a return on investment (ROI) potential of 6 to 18 months depending on the plant variations, VSD/VFDs in aeration control can also lead to reductions in maintenance costs. By removing control valves (a high-maintenance component) and operating the blowers at lower pressure, stresses and vibrations in all mechanical system components are reduced. A lower speed also leans toward a lower noise level – important in some applications, especially plants running 24/7 in built-up areas.
Wastewater process – Clarification

Secondary or final clarifiers are used for solid-liquid separation of wastewater and are an essential step in the wastewater treatment process to remove suspended solids through gravity settling or mechanical means, providing a clarified liquid effluent.

### Wastewater treatment – Commonly monitored parameters – Clarifiers

<table>
<thead>
<tr>
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<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia and phosphate</td>
<td>In the clarification process of wastewater treatment, the goal is to remove suspended solids and other impurities from the wastewater. Ammonia and phosphate are two important parameters that may be present in wastewater, and that can be impacted by the clarification process.</td>
<td></td>
</tr>
<tr>
<td>Total suspended solids (TSS)</td>
<td>Total suspended solids (TSS) is a measure of the amount of solid material that is suspended in water. They can include a wide range of materials such as dirt, sand and organic matter. High levels of TSS can reduce the clarity of water and can have negative impacts on aquatic life and water quality. In the clarification process of wastewater treatment, the goal is to remove TSS and other impurities from the wastewater.</td>
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</table>

Secondary or final clarifiers feed into the sludge process through waste activated sludge pumps (WAS pumps) and divert sludge back into the aeration basin via the return activated sludge pumps (RAS pumps).

The purpose of the RAS pump is to prevent loss of microorganisms from the aeration tank and maintain an adequate level for the treatment of the wastewater. Pumping sludge from the secondary or final clarifiers to the aeration tanks maintains active biomass in the aeration tanks.

RAS pumps are usually designed for a flowrate of 100% of the average influent flow to the plant, and the control is therefore normally a proportion of the inlet flow with a simple PID control. By changing the control (RAS pumping typically takes 5–10% of a sewage treatment works’ energy demand), you can gain process benefits and energy savings.

Better control maintaining solids in the aeration basin while maintaining quality effluent from the clarifier is the gain. If the flow control of the RAS pump is inadequate, it can lead to insufficient Mixed Liquor Suspended Solids (MLSS) concentrations in the bioreactor and possible conditions, starting de-nitrification in the later stages of the process. By reducing the RAS pumping rate, less energy is used, which can result in potential savings of up to 55% of RAS pumping energy.

For retrofitting, studies of the installation are often needed to find out whether the appropriate pumps are installed and meet RAS return rates (30 to 75% of average daily flow (ADF)), i.e., studies will show the level of possible speed reduction and energy savings. Speaking to an ABB VSD/VFD expert will often help speed up the study and solution planning process.
Wastewater process – Sludge treatment

Advances in the measurement of the amount of waste and returned sludge accumulated at the bottom of the clarifier have led to better control. These real-time measurements allow cleaning based on the actual volume of sludge settled rather than a pre-set time. This results in lower energy bills and greater process efficiency by enabling more control of the quality, volume and consistency of the sludge that gets passed on to further treatment steps.

Sludge treatment has been a difficult place to install and use sensors mainly because of the varying consistency of the sludge but also due to the corrosive, toxic and dense environment. ABB’s innovation enables process managers to place sensors that enable plants to optimize the sludge treatment process, including sludge thickening and dewatering. For sludge dewatering and thickening, sensors for feed flow and the amount of feed sludge, and thickened sludge can measure and provide better controllability, enabling the reduction and overconsumption of polymers and deliver more consistent and reliable final sludge.

On sites with anaerobic digesters and where the utility also generates biogas for internal or external use, an additional level of instrumentation is required. For Anaerobic Digestion (AD), the utility would need to measure flow, level, temperature, pH, pressure and Oxidation Reduction Potential (ORP). For the liquid stream generated as a by-product of AD, the utility would also measure COD and ammonia. Utilities also measure the amount of biogas produced and its quality, especially its methane content.

Using variable speed control in digesters
An anaerobic digester uses microorganisms to break down biodegradable material such as sewage waste. A digester tank has pumps that, when run at full speed, can cause foaming of the liquid in the tank, making it difficult to both control the sludge level and the digestion.

The foaming can also interfere with the volume of methane produced. Fitting a VSD/VFD to the digester tank pumps gives the ability to reduce the motor speeds to avoid foaming, and it also offers substantial cost savings through a reduction of the energy used by the motors.

<table>
<thead>
<tr>
<th>Wastewater treatment – Commonly monitored parameters – Sludge treatment</th>
<th>Check</th>
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</thead>
</table>
| Sludge quality for biogas production | • Sludge is the solid or semi-solid material that is produced during the treatment of wastewater. It is composed of a mixture of organic matter, inorganic matter and microorganisms.  
• Various factors can impact the quality of sludge for biogas production. An important factor is the content of organic matter, as this is the primary source of energy for the anaerobic digestion process. Sludge with a high organic matter content is generally more suitable for biogas production than sludge with a low organic matter content. Another factor that can impact the quality of sludge for biogas production is the presence of contaminants such as metals, pathogens and other harmful substances. These contaminants can interfere with the anaerobic digestion process and reduce the biogas yield. | ☑ |
| Oxidation reduction potential (ORP) | • Oxidation-reduction potential (ORP) is a measure of the potential for a chemical reaction to occur in a solution. It is expressed in millivolts (mV) and is used to measure the effectiveness of the treatment process and to ensure that the water is safe for reuse or discharge into the environment.  
• It is important to accurately measure ORP in wastewater to ensure that the water is safe for reuse or discharge and to help identify any potential problems with the treatment process. Monitoring ORP can also help optimize the use of disinfectants and other chemicals in the treatment process and can help reduce the overall cost of treatment. | ☑ |
Education and development

ABB offers a wide range of training from Lunch 'n' Learn sessions to hands on, instructor-led skills development courses. A range of e-learning modules is also available.

Previous knowledge
There are no prerequisites for these training topics. However, it would be helpful if the student had a basic understanding of water industry applications.

Objectives
To alert energy managers of the merits of using VSDs/VFDs to improve process efficiency, reduce energy use and lower carbon dioxide emissions.

Location
The courses can be presented at customer premises or an ABB facility. Online content can be served using online conferencing software.

Booking
To book training, or for more information, contact your local ABB office.

Bespoke training courses
Contact your local ABB office for any training opportunities tailored to your custom needs.

<table>
<thead>
<tr>
<th>Lunch 'n' Learn topics</th>
<th>Duration</th>
<th>Reference</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drives Basics – Theory</td>
<td>15 mins</td>
<td>EN154</td>
<td></td>
</tr>
<tr>
<td>Pumps Basics – Theory</td>
<td>15 mins</td>
<td>EN155</td>
<td></td>
</tr>
<tr>
<td>Best Efficiency Point Pumping</td>
<td>20 mins</td>
<td>EN156</td>
<td></td>
</tr>
<tr>
<td>Wastewater – Wet Wells – Understanding the application</td>
<td>20 mins</td>
<td>EN157</td>
<td></td>
</tr>
<tr>
<td>Wastewater – Headworks – Understanding the application</td>
<td>20 mins</td>
<td>EN158</td>
<td></td>
</tr>
<tr>
<td>Wastewater – Aeration – Understanding the application through energy case studies</td>
<td>20 mins</td>
<td>EN159</td>
<td></td>
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<tr>
<td>Clean water – River Abstraction – Understanding the application through energy case studies</td>
<td>20 mins</td>
<td>EN160</td>
<td></td>
</tr>
<tr>
<td>Clean water – Groundwater abstraction – Understanding the application through energy case studies</td>
<td>20 mins</td>
<td>EN161</td>
<td></td>
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<tr>
<td>Clean water – Distribution network – Understanding the application through energy case studies</td>
<td>20 mins</td>
<td>EN162</td>
<td></td>
</tr>
<tr>
<td>Clean water – Reservoir – Understanding the application through energy case studies</td>
<td>20 mins</td>
<td>EN163</td>
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