

## Competence in Hydropower

Harness the full potential  
of hydroelectric power plants  
with process automation



# Pepping up plant productivity

Since its inception, hydropower has been appreciated as a clean, reliable and sustainable source of energy and continues to deliver with nearly a quarter of worldwide energy being produced by water. One of the overriding advantages is that hydropower plants can be used for storing electric energy.

Nevertheless, two thirds of the economically viable potential rivers provide is waiting to be exploited. In recent decades, however, investments in hydropower have lost focus. For whatever reason, hydropower is considered too decentralized, too traditional and too mid-scale to receive the priority it deserves. With the world clamoring for a serious reduction in CO<sub>2</sub> emissions, the time is more than ripe to rethink this perspective.

**The proficiency of process automation** Hydropower technology is not only dependable and time tested, its greatest strength is its ability to increase efficiency. Control over crucial parameters such as reservoir level or turbine supply means faster response times. Eliminating the

maintenance required for vulnerable mechanical control systems will reduce downtimes. By utilizing wireless technology maintenance staff will have more time to focus on core responsibilities. The examples are numerous.

## Endress+Hauser is your reliable process automation partner for all hydropower plant types

- Experience in modernizing hydropower plants
- Accessible point of contact – all over the world
- Expert advice on crucial checkpoints in the process
- Support throughout the whole operational life cycle
- Standardized technology and equipment
- Assistance in extracting the most out of cutting edge automation technology



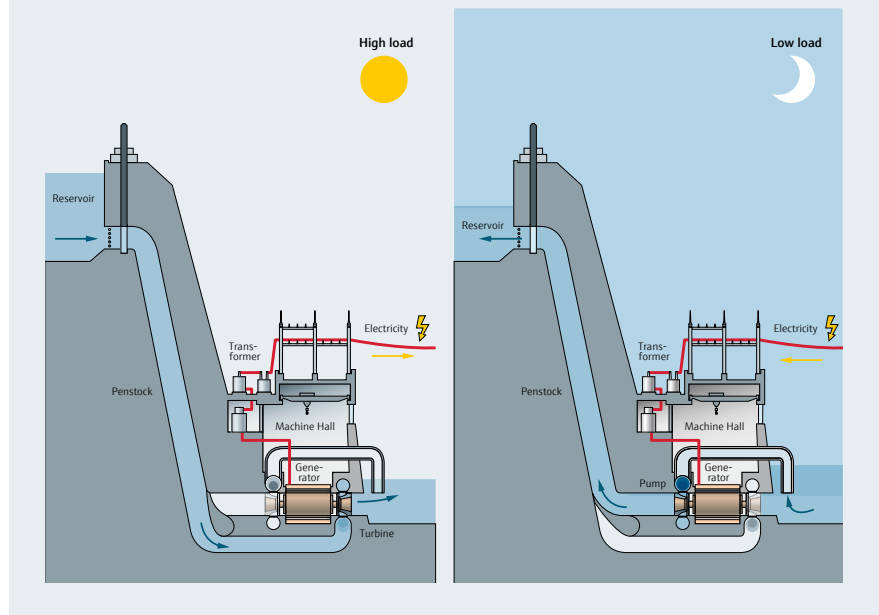
### **i** Crucial points in modernizing the hydropower process

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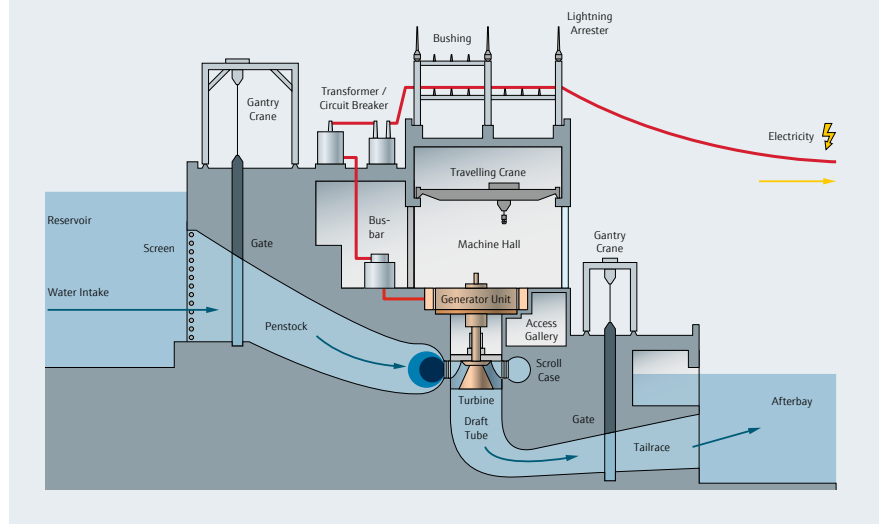
A case in point is represented by two Mexican hydropower plants (Infiernillo and La Villita) that Endress+Hauser helped to assess and modernize. These are typical reservoir plants, with structures and modes of operation as could be found anywhere in the world.

CFE (Comision Federal de Electricidad), the electric company owned by the Mexican state, generates power for more than 70 million people. Their goal is to achieve 25 % of their power from such renewable sources as solar, wind, geothermal and hydro by 2025.

### Pumped Storage Hydro Power Plant



### Hydroelectric Plant



The fully automated power stations CFE CH La Villita and CH Infiernillo have automated 15 units in five years using Endress+Hauser devices. This translates to approximately 12 Gwatts, which is half of the energy that the Michoacan, Jalisco, Colima and Nayarit States need.



# Endress+Hauser offerings

## Best in class on-site service support

Our highly trained services and sales staff partner with you to assess the potential to be gained by high-end measurement and automation to improve efficiency and minimize downtime.

Endress+Hauser project management and engineering staff accompany plant improvement from the outset – with experience and skills that go beyond instrumentation. Our experience in FNE (Field Networking Engineering) best demonstrates this. We design, build and commission fieldbus networks and integrate them directly into your control systems regardless of your choice of control system.

Endress+Hauser service personnel have expertise in on-site commissioning, training, calibration and maintenance right through the lifecycle of all your automation components.



## Selecting the best instrument for the job

All hydroelectric power stations face environmental and technical challenges. Regardless of where the plant is geographically located, whether close to the poles, in the tropics, or near the equator, the room housing the machine has to deal with high relative humidity, moisture, and water that can be acidic and may contain bacteria, sand and/or debris.

Endress+Hauser's network of engineering, sales and service staff has profound know-how on power production under every conceivable condition. This

knowledge serves to deliver the appropriate answer to your specific instrumentation, service or planning challenges. We probe down to the smallest technical detail (e.g. using ceramic pressure cells that withstand acids) to deliver process automation that allows you to work with ease.

In collaboration with you we will ensure that your plant is reliably and adequately equipped to achieve optimal performance through efficiency and functionality.



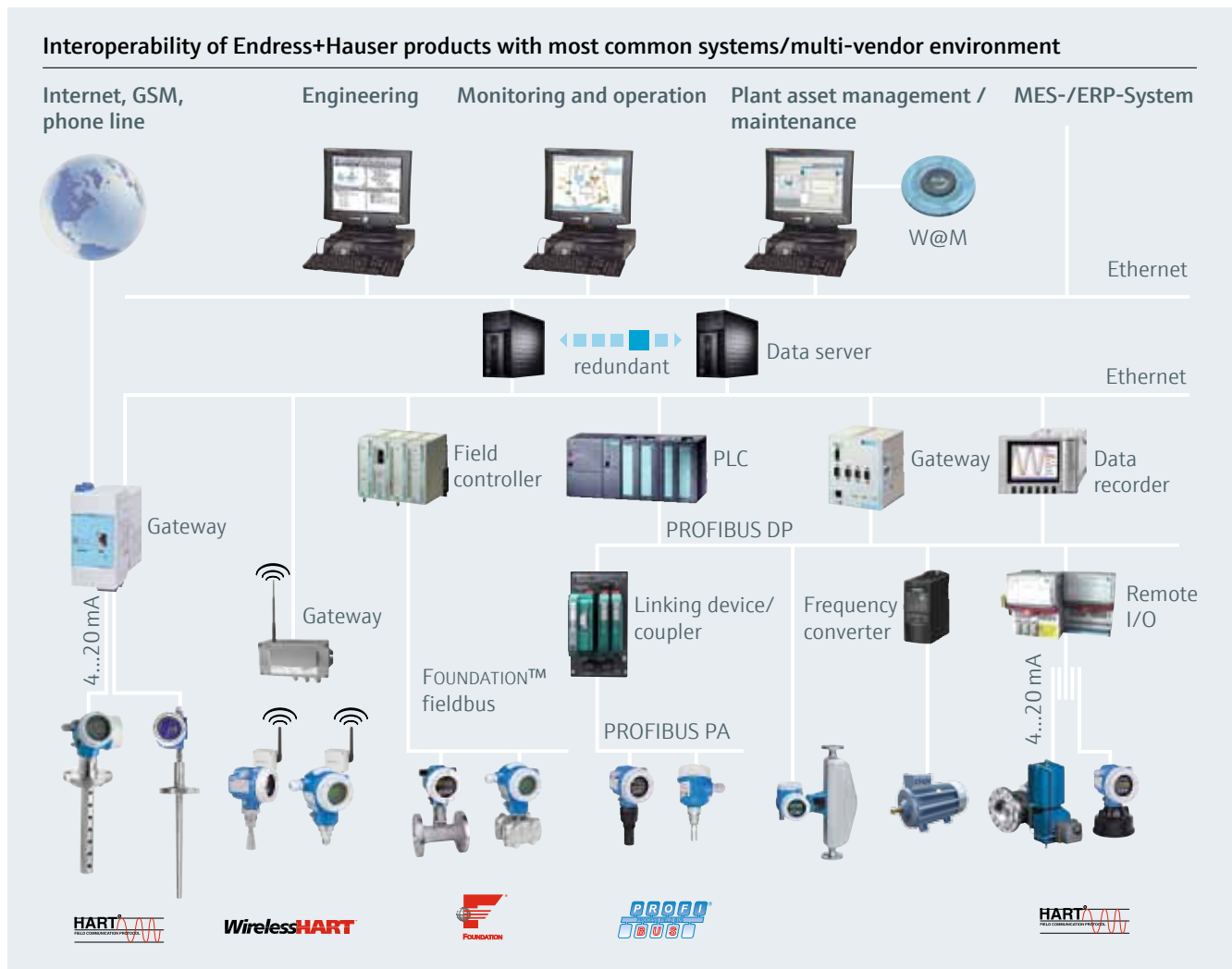
## Smooth operation

The luxury of best-fit instrumentation and best-fit technology: We offer a comprehensive portfolio of instruments, solutions and measurement technologies that guarantee you get the appropriate instrument for every requirement. No performance problems – no unnecessary fuss. We offer reliability.

Endress+Hauser instruments and solutions allow you to run your power station with high availability. We design instruments to meet the following maxims:

- Low maintenance requirements
- High accuracy
- Long term stability

Choose from “Easy to deal with” instruments based on friendly operation philosophy. The guided user menus are available in all major world languages.





# Monitoring and measuring

## Monitoring the reservoir level

In a hydroelectric power plant, measuring the reservoir water level is crucial as this information defines the reservoir's energy storing potential and also the hydrostatic pressure to which the turbine is subjected.

Various technologies exist for measuring this level, and the two most common and recommended ones are: Waterpilot – a hydrostatic pressure probe for precisely measuring the level using a capacitive ceramic cell that has these advantages:

- High resistance to aggressive media and overloading
- High accuracy, robust ceramic cell with long-term stability
- Weatherproof thanks to its completely encapsulated electronic insert and its double filter pressure compensation system
- Outlet signal between 4 to 20 mA with HART® superimposed
- Cable length of up to 600 m



Waterpilot can also be used in the oscillation well, thanks to its reduced diameter and the height of the measuring range, which can often be a problem when using ultrasonics.

If a non-contact measurement can be utilized then we recommend our Prosonic S, which uses ultrasonic technology for level measurement, providing the following advantages:

- Measurement range of up to 70 m
- Display the envelope curve on the local display for easy diagnosis
- Outlet signals for integrating into control or monitoring systems via HART® or PROFIBUS DP
- Integrated temperature sensor for correcting time-of-flight
- The sensor can be installed up to 300 m from the transmitter
- Dam ultrasonic time-of-flight level measurement with Prosonic S at CFE CH El Caracol, Guerrero, México



Dam ultrasonic time-of-flight level measurement with Prosonic S at CFE CH El Caracol, Guerrero, México

**i Solutions for La Villita and Infiernillo** The projects focused on two main objectives: 1. Process protection. Introduce process automation that ensures safe running of the plant along with the ability to rapidly shut down a unit if a parameter gets out of range. 2. Process performance. Precise and continuous monitoring that assures the plant is run under optimum conditions whilst reducing and optimizing maintenance efforts.

Endress+Hauser not only supported CFE in evaluating the automation potential and in realizing the most efficient production, we were also on hand for the installing and commissioning.

Project implementation included a Profibus PA fieldbus network that forms the basis for a system architecture that saved infrastructure costs.

Thanks to investments in process automation black outs in the power station due to warming up and faulty signals have been reduced considerably.



## Measuring the flow in the penstock

Measuring the flow in the supply pipe is important for quantifying the amount of water that is supplied to the turbine.

Due to the size of these pipes, the suggested technology to be used are flow indicators with non-intrusive clamp-on type ultrasonic sensors. In other words, attached on the outside without having to open the pipe. Based on good engineering practices, it is important to always check that the straight sections established for this technology are provided.



Clamp on ultrasonic flow measurement in the main pipe.  
CFE CH La Boquilla, Chihuahua México





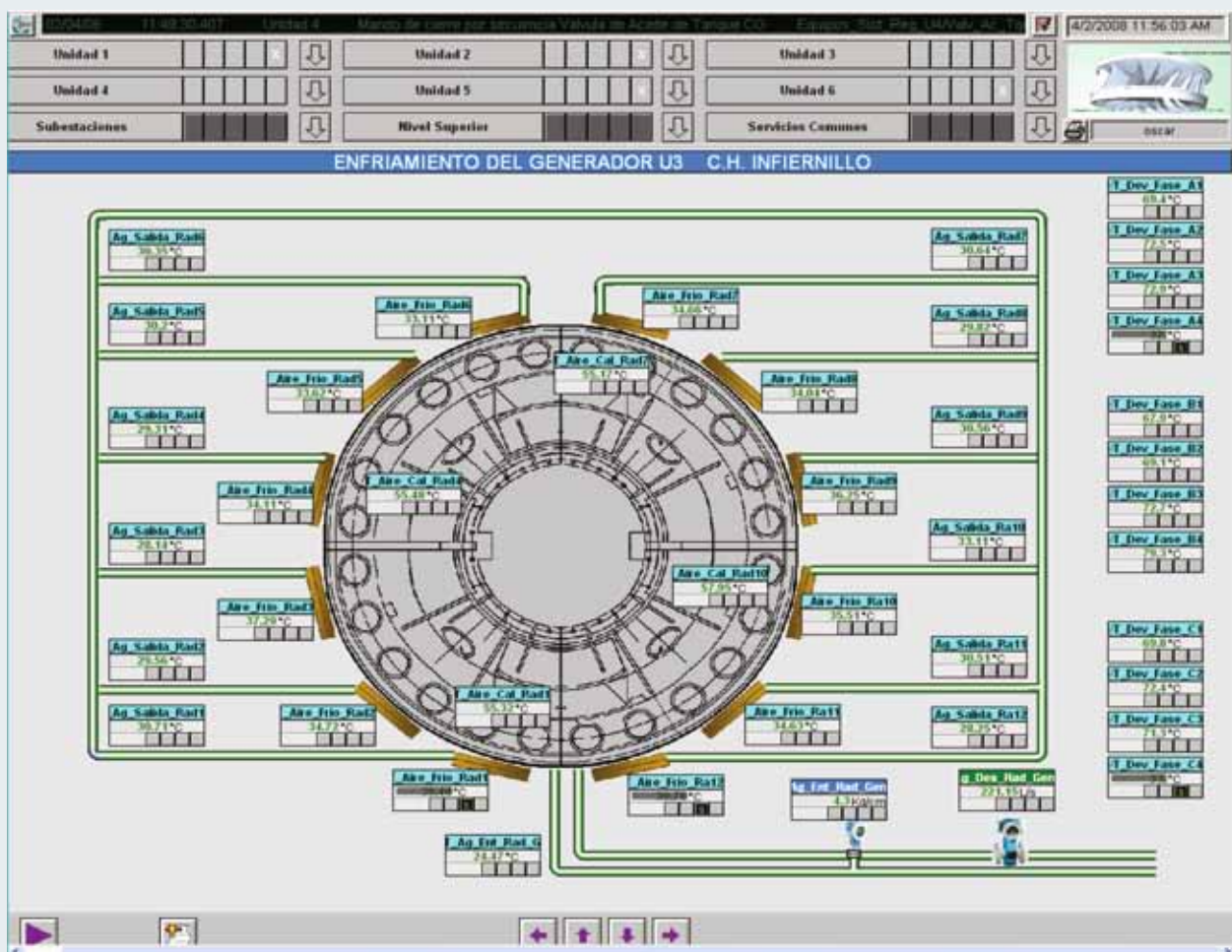
## Measuring the temperature of the bearings in the turbine, generators and guides

Temperature measurement is essential to ensure that the plant works properly. Any hot point in the bearings must be identified so that appropriate action can be taken to prevent heat loss through friction, wear and tear or possible equipment destruction.

Both the oil and the metal temperatures are measured. This application requires temperature elements such as the iTHERM® StrongSens RTD sensor that are reliable and can withstand high vibrations >60 g. The bores available in these applications are not very wide, and response time is critical. Therefore for these applications we recommend

high quality sensors with a protection tube instead of a solid barstock thermowell. This allows small diameters of 3 to 12 mm that adjust to the bores in the metals and the bores for measuring the temperature of the oil in the bearings. Also protection tubes are thin walled which considerably decreases the response time in the temperature measurement. In order to augment measurement reliability and availability, we also suggest using duplex sensors in the same protection tube so that in the event of a faulty sensor a substitute sensor is available and online, eliminating turbine shutdown.

### Water cooling system, temperature monitoring and control. CFE CH Infiernillo



## Monitoring turbine pressure and temperature

Monitoring the turbine pressure provides information such as whether the turbine is full or empty, the actual pressure it is operating under, and/or if the turbine is ready to start operation or if it must be shut down.

In many instances the water in the turbine contains suspended solids and/or sulfuric acid due to the water reservoir's organic content. Pressure measurement equipment in these areas are also often subjected to pulsating flows and water hammer. For all these reasons, we recommend using our capacitive ceramic pressure sensor technology. It is ideal for accurate and dependable pressure measurements.

- High vibration resistant duplex RTDs monitor the temperature in the turbine or generator bearings. Two sensors in the same insert prevent faulty signals which can cause unwanted shutdowns.
- Dual channel temperature transmitters make it possible to connect two sensors in redundant mode. If one sensor breaks the other automatically takes over and the transmitter issues a maintenance alert. This also ensures no unnecessary shutdowns.



Bearing temperature measurement (vertical unit)  
CFE CH El Encanto, Veracruz, México

## Cooling water system



This system is necessary to keep all the rotary systems working within their designated temperatures, usually in these cases a branch of the main supply pipe is used, and so it is necessary to measure the amount of water for this system and the branches to the cooling system of the turbine, generator and bearings.

Promag, our electromagnetic flow indicator, provides the following advantages:

- Empty pipe detection
- ECC – Electrode Cleaning Circuit to remove undesired coatings i.e. magnetite from the electrodes
- Diameters from 2 to 2200 mm
- No moving parts or obstructions (reduce maintenance costs)
- Self diagnosis (reduces idling time due to faults)

In addition, measuring the temperature and pressure of the cooling water is also important, because the cooling system efficiency depends on this, and also, the pressure measurement signal can be used to identify leaks and obstructions in the system filters.







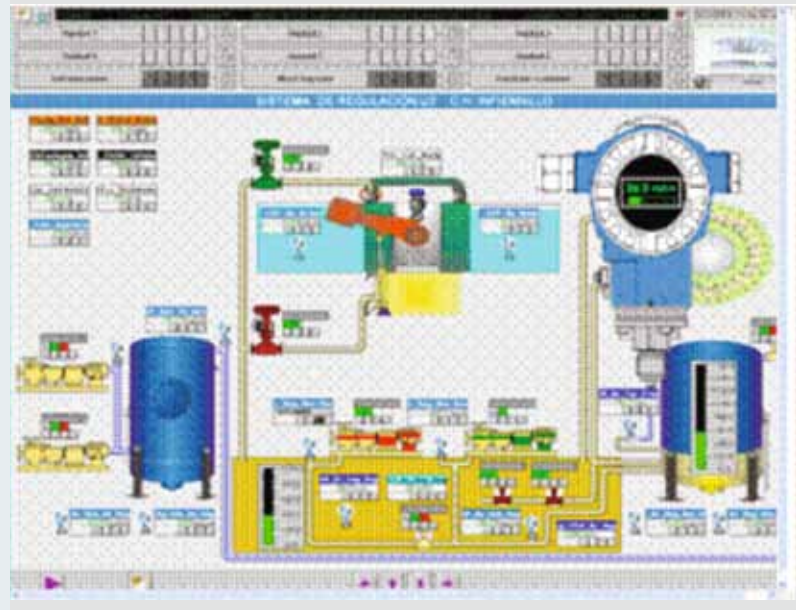
## Pressurized oil system

This system includes the speed control system, the braking system, and also the gate control system.

Endress+Hauser pressure transmitters assure long-term stability and reduced maintenance on these applications.

Measuring level in the pressurized air-oil tank can be achieved either by using differential pressure transmitters or by using a guided wave radar mounted directly in the tank or in a bypass.

Monitor view of the pressurized oil system



## Monitoring ambient temperatures in high voltage areas



High ambient temperatures in high voltage areas are dangerous, and therefore they must be monitored continuously. These areas can be, for example: conduction bars, thyristor bridges.

The ambient temperature must be measured in these areas, and fire detectors should be provided as a safety precaution. The ambient temperature sensor Omnigrad T has been designed specially for this purpose, and it can include a temperature transmitter assembled in the head.

## Lubricating oil systems

The lubrication system is an essential part of the turbine because if the oil is dirty or insufficient, it can cause damage to the rotary parts.

Cleaning the oil and identifying leaks in the system is critical to ensure that the system is functioning properly. Often times separate systems are supplied for each thrust bearing in the hydroelectric turbine.

In order to prevent leaks, the oil pressure must be monitored and this requires reliable pressure transmitters that can withstand upwards of 600 psig.

Guaranteeing the correct oil levels is also quite essential and Endress+Hauser's Deltapilot is an ideal choice for this application. Some Deltapilot advantages are:

- A hermetically sealed measurement cell, CONTITE™
- Condensate-resistant and climatic-proofed
- Reference accuracy:  $\pm 0.1\%$
- Quick commissioning thanks to easy to understand configuration menus
- Configuration using a local display and its configuration keypad
- The sensor can be remotely coupled to the transmitter to enable easy access to the transmitter in hard to reach areas.

This application can also be accomplished using Endress+Hauser Liquicap, our continuous capacitive level transmitter.

Oil density and viscosity are some other critical values that need to be monitored as a decrease in viscosity can have a major impact on the wear and tear of mechanical components. Both these measurements can be accomplished with one device, our Promass I Coriolis type flowmeter.



Pressure devices to monitor lube oil pressure as well as the air pressure for the air-pressurized lube oil tank. CFE CH Malpaso

# Reliable and robust communication networks

Endress+Hauser skills have grown from experience: Our combined installed base of HART®, PROFIBUS® and FOUNDATION™ fieldbus instruments is one of the largest in the world. We will help you to choose the most appropriate process communication technology for your hydropower plant.

The design processes and choice of networking components, combined with your choice of plant asset management software, ensure that the wealth of information available today from modern field instrumentation devices can be applied to reduce your operating costs.

Our harmonized processes and procedures ensure:

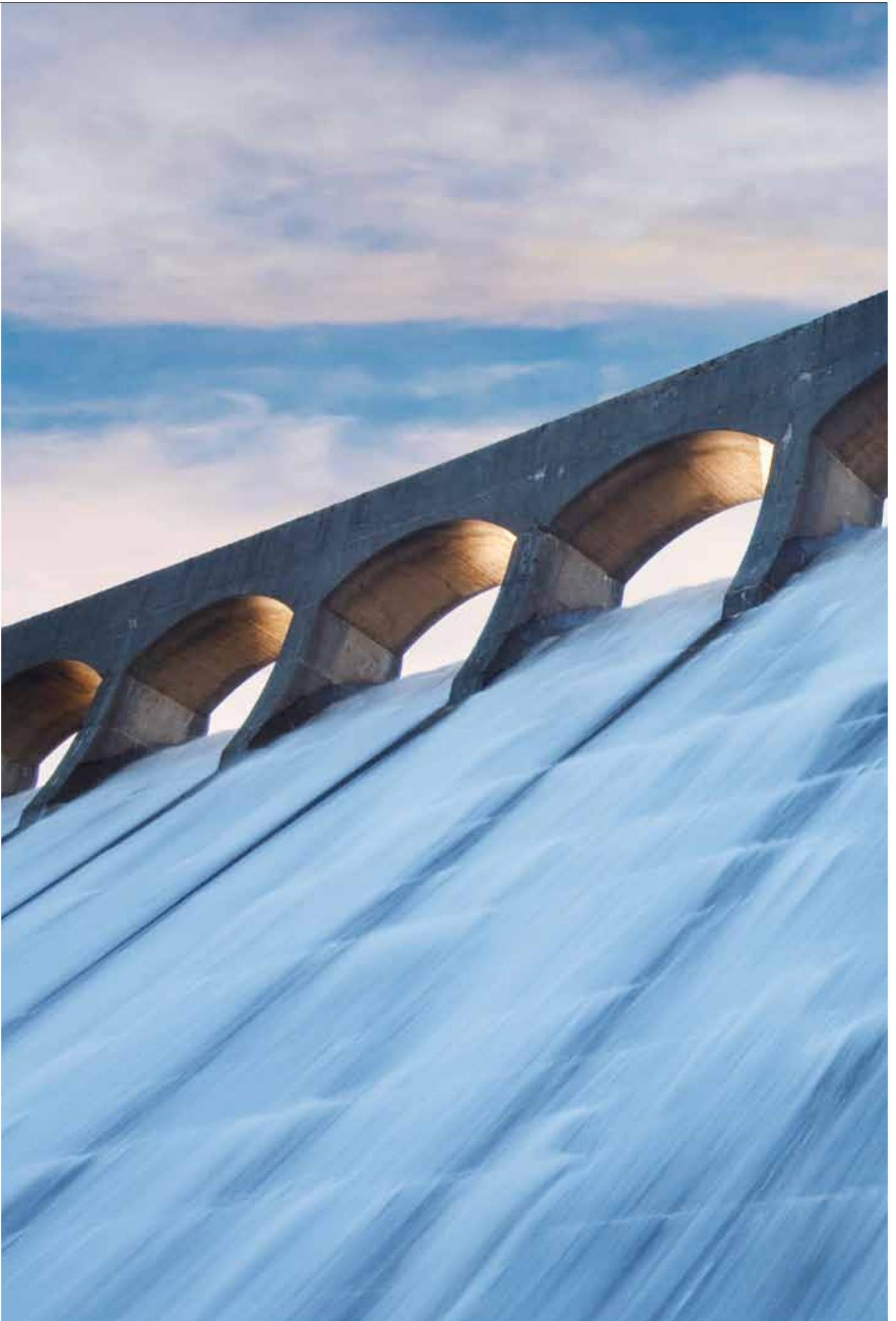
- Clear communication and reliability
- Guaranteed quality
- Reduced risk

**WirelessHART**

**PROFI**  
PROCESS FIELD BUS  
**BUS**







**Instruments International**

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