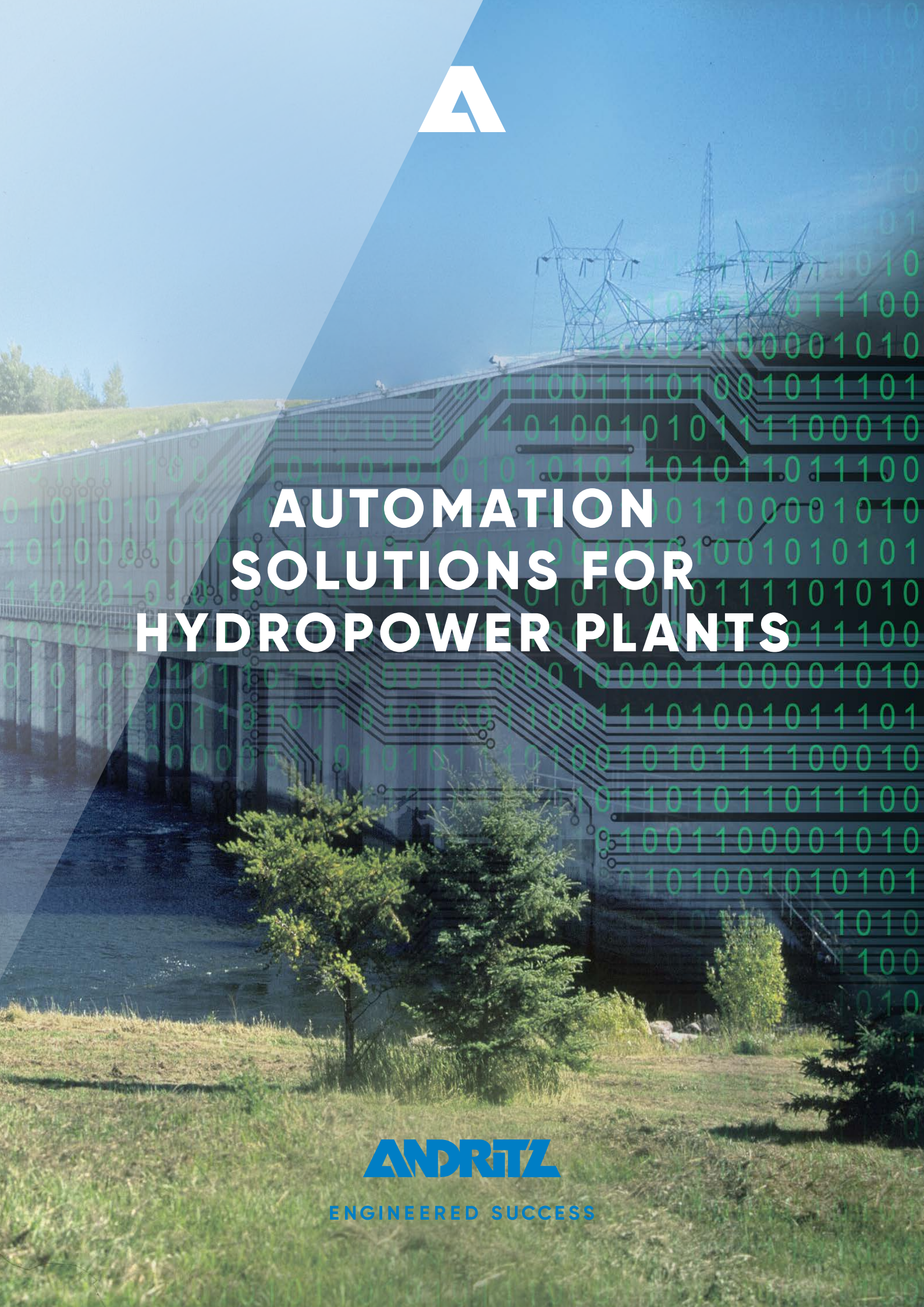


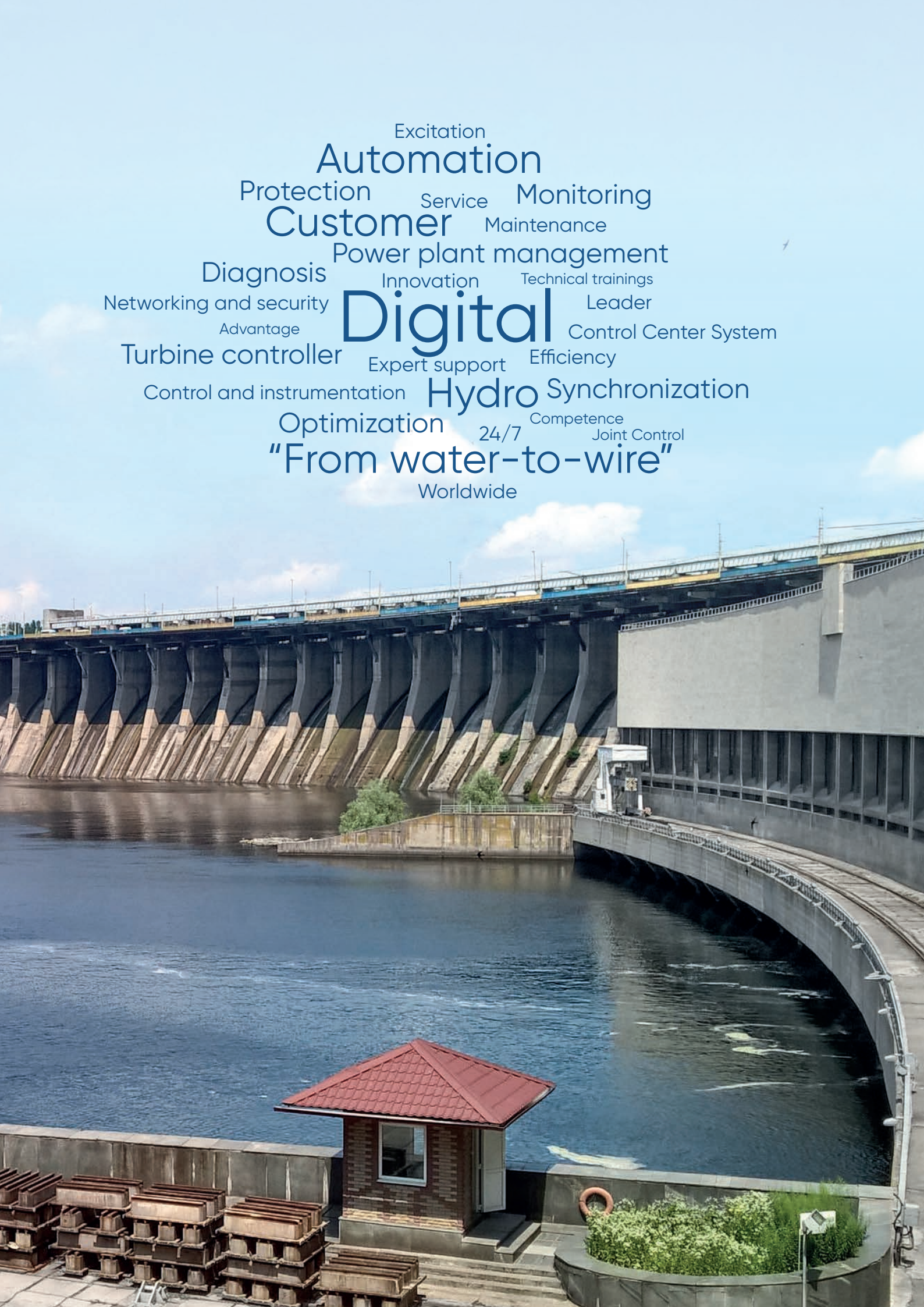
AUTOMATION SOLUTIONS FOR HYDROPOWER PLANTS

ANDRITZ

ENGINEERED SUCCESS

“Automation systems keep your hydropower asset running smoothly.”

DNIPRO 1
Ukraine


Excitation
Automation
Protection
Service
Monitoring
Customer
Maintenance
Power plant management
Diagnosis
Innovation
Technical trainings
Networking and security
Digital
Leader
Advantage
Control Center System
Turbine controller
Expert support
Efficiency
Control and instrumentation
Hydro
Synchronization
Optimization
Competence
24/7
Joint Control
“From water-to-wire”
Worldwide

A thriving market for hydro automation

Each hydropower plant has its own specific operational strategy, based on its age, energy market contracts, and manned/unmanned operations concepts. Today, a solution-oriented automation approach is needed to guarantee safe and secure operations, improve overall efficiency, reduce operational expenditures, and deliver an extended lifetime.

Hydropower currently meets about 16% of the world's electricity needs. Most mid-term future energy scenarios predict that power needs will be primarily met by a combination of various new renewable resources as well as fossil fuels. According to current forecasts, increasing awareness of global warming and the rising need for grid balancing services will also lead to continuous growth in demand for hydropower. Up to now, only about 30% of global hydropower resources have been developed and hydro is the best proven and most developed form of renewable energy generation.

The global potential for the hydropower automation market is also substantial. Demand for automation is widely forecast to grow in the future due to advances in digitalization and communications technologies. This will be driven by the development of new hydropower assets as well as the need to modernize the existing fleet as it ages.

MEGATREND DIGITALIZATION

Digitalization - also known as Industry 4.0 or the Industrial Internet - is one of the most important drivers for global economy. It has already a wide-ranging influence on our society. The value created with the help of technology, especially internet-based technology, is enormous. Automation, networking, cloud services, and Big Data will be decisive for the industry. Existing digital solutions for hydropower plants can be optimally adapted to customer needs already and are important components of a future-oriented asset strategy for the energy market of today.

ADVANTAGE OF PLATFORM CONCEPTS

All hydropower units are electrically protected, the generator voltage is regulated and the units are synchronized with the grid frequency. For nearly a century, this was done using specialized mechanical and electro-mechanical devices. Over recent decades though, the entire control, regulation and automation systems for hydro plants have been completely transformed. Providing different control and regulation devices on one common software and hardware platform is the next logical step in this transformation.

CONNECTIVITY AND CYBER SECURITY

Today, the need for easy accessibility, interconnection, and communication is enormous. All parts of the hydropower plant can be connected to a communication system and offer direct access to all process data and engineering settings. As a result, the development and deployment of effective cyber security is essential. Modern automation systems with global data interconnection to different kinds of systems have to protect data streams, device access, and communication channels against cyber attacks.

“The global potential for the hydropower automation market is substantial.”

MODERNIZATION MARKET

A hydropower plant consists of different automation components with varying lifetimes. More unit-related components, such as turbine governors, excitation or protection systems, have a longer lifetime than the more IT-related equipment, such as computers, routers, and communications tools. This equipment is mostly based on the consumer product market and is therefore subject to the extremely rapid technological development the sector is currently witnessing. Consequently, based on the specific technological age, accommodating a huge variety of physical interfaces is one of the most challenging aspects of such a project.

GREENFIELD MARKET

New large hydropower plants are designed to deliver maximum operating hours with minimal operational expenditure. Most hydropower plants also form one part of a set of assets, representing the installed fleet of an operator. Therefore, permanent data stream access is needed. Within the automation system, this need is reflected in the use of distributed function-related components, redundant communication structures, and overall optimization.

SMALL AND MINI HYDROPOWER MARKET

The market for small and mini hydropower is driven by simple and robust solutions using the minimum number of components. Whenever possible, a single component should cover several functions, such as turbine control and synchronization. User-friendly engineering and communication interfaces for unmanned operation are also preconditions for the success in this market.

Our global team delivering the best local solution

ANDRITZ

The ANDRITZ GROUP is a globally-leading supplier of plants, equipment, and services for hydropower stations, the pulp and paper industry, metalworking and steel industries, and solid/liquid separation in the municipal and industrial sectors. ANDRITZ is always close to its customers, with more than 280 production locations and service and sales companies around the world.

ANDRITZ Hydro is part of the ANDRITZ GROUP and a leading global supplier of electro-mechanical equipment and services "from water-to-wire" for hydropower plants. With more than 175 years' experience in turbine technology and 120 years' experience in electrical engineering, over time, growth, mergers, and cooperation agreements have created today's state-of-the-art technology company. ANDRITZ Hydro has about 7,000 employees worldwide.

HYDRO AUTOMATION

The automation group within ANDRITZ provides comprehensive solutions for secondary hydropower plant equipment. All over the world, more than 500 employees have created an extensive knowledge base for secondary equipment within all types of hydropower plants. Decades-long experience of automation, protection, excitation, turbine control, and power plant regulation is combined to deliver an optimal solution.

PRODUCT AND SERVICE SCOPE

Our primary focus is excitation, protection, turbine control, synchronization, control and instrumentation, SCADA, monitoring and diagnosis, power plant management and networking, as well as security solutions. In addition, we offer a wide range of services for hydropower automation systems such as hardware and software design, erection work, start-up and operator training, as well as commissioning and engineering work for expansions and upgrades.

SYSTEM-BASED AUTOMATION

State-of-the-art automation and control systems have to guarantee the simple and safe operation of a hydropower plant at all times. Typically, hydropower plants are operated either locally with a unit control board, or remotely through a central control room and/or dispatching center. In emergency situations, the system has to ensure that the affected plant components are restored to a pre-defined, safe operating status. This requires a system which can be adapted easily to existing plant equipment and that can also be split into independent functional components. Any integrated control system for these functional components has to take into account both the primary systems and also the specific operational regulations within the country and region.

All process signals should be received and managed without requiring multiple inputs. In order to enable efficient short and long range communication, as well as facilitate future expansion, it is essential to apply international standards. Costs have to be reduced to a minimum by using one hardware platform and thus reducing spare parts inventory, and by applying integrated functions to keep maintenance and service activities to a minimum. Step-by-step expansion and integration of additional plant sections, such as the switchyard or station services, for example, should always be an easy, straight forward task.

YOUR BENEFIT

- More than 30 years of experience in digitalization
- +500 automation engineers worldwide
- +20 operating locations

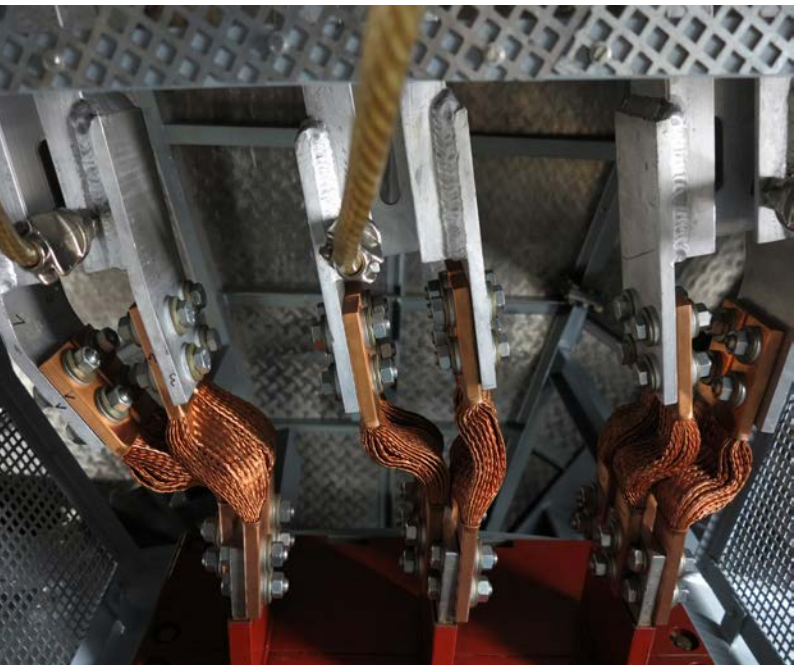
"The global ANDRITZ Hydro Automation teams are focused on optimized solutions for your asset."

Excitation – releasing power

The excitation system of a synchronous generator enables the energy produced by an engine (turbine) to supply the power grid.

The basic function of an excitation system is to keep the synchronous generator terminal voltage stable, either in stationary condition or during transient events. Superposed regulators are available to control reactive power output and power factors. Limiter functions are used to keep the synchronous machine within its safe operational range at all times. Different stabilizer functions can also be enabled to increase both unit and grid stability. Furthermore, independent hardware protects the excitation system against external and internal faults. The system is able to communicate with existing and modern plant control systems using different communication standards. Meanwhile, touch panels provide the human-machine interface with the excitation system.

Excitation systems are designed either as static type with direct connections to the rotor windings or as brushless exciters. This principle design choice depends on reliability, availability, performance, economic aspects, and grid operational requirements.



ANDRITZ provides solutions for both types of excitation system together with all power elements, such as fully controlled rectifiers, breakers and a de-excitation system if required.

Our automatic voltage regulator is suitable for all kinds and sizes of synchronous generator and motor. Based on a single unified platform it has a modular hardware and software structure and benefits from 50 years' of experience in design, commissioning and operation. The modular controller software includes all voltage regulator, limiter, and stabilizer functions and is based on the IEEE 421.5 standard.

The modular ANDRITZ Smart Bridge design for rectifiers is characterized by its easy maintainability, high availability and long-term spare part supply. The ANDRITZ Smart Bridge features a space-saving design for the rectifier bridges which allows for very compact solutions.

The modular design of the voltage regulator and power parts, as well as the high reliability of the equipment, makes it the optimal solution for every new and existing hydropower plant.

YOUR BENEFIT

- More then 50 years of experience
- Control and limiter functions acc. IEEE 421.5
- Smart Bridge

Electrical protection – safe operation

Electrical protection systems have to avoid any damage to the electrical power plant electrical equipment in the event of an overload or any other kind of fault.

Today, a protection system has to be based on versatile and flexible equipment to provide safe solutions that are both technically and economically feasible. The aim is to use pre-assembled equipment and standardized solutions to guarantee high standards of safety throughout the entire plant. Power plants, electrical consumers, and transmission systems include various items of equipment with different levels of priority.

YOUR BENEFIT

- More than 50 years´ of experience
- Modular protection functions
- 50 Hz, 60 Hz, and 16.7 Hz

The experience and know-how of ANDRITZ protection engineers forms the basis from which to find the best possible protection "philosophy" for your power plant. Based on long-term experience with own digital protection relays, proven numeric algorithms are used and adapted to meet new requirements in power generation as they emerge. Generator protection requires numerous functions which are needed for advanced applications like pump turbines or large thermal blocks.

Our digital platform offers powerful generator and transformer protection solutions. The structure of the protection functions is modular and can be customized. The integrated engineering tools support the protection engineer during the entire engineering and commissioning process. It provides features such as a software trip matrix and test inputs for the protection functions and for simple interface testing.

Synchronization – perfect switching

Paralleling or synchronizing units with electrical grids is one of the most challenging tasks for hydropower automation systems. The basic requirement is to close the circuit breaker at exactly the right time in order to protect the lifetime of the unit.

Paralleling generators to power systems or synchronizing one power system with another is a particularly tricky technical challenge. Nowadays, this operation is performed automatically using state-of-the-art and technically mature electronic devices. ANDRITZ' synchronization equipment combines stringent reliability requirements with our experience of over 40 years in this sector.

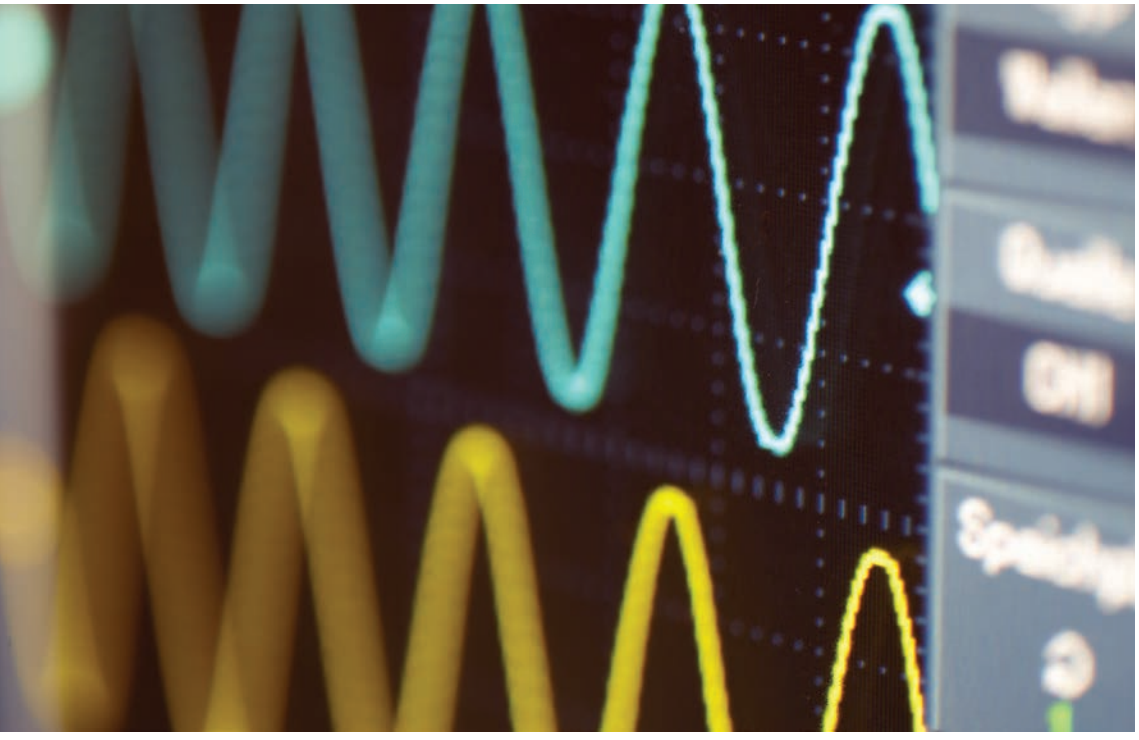
Our system guarantees smooth and efficient synchronization with the sound of synchronization coming from the machine room barely discernible. All data are logged, allowing you to analyze even the most complicated of sequences at your leisure.

SAFETY

Everything must run perfectly during synchronization. Requirements for real-time measurements and analysis in time for safety-critical control can only be met with reliable, and rigorously tested technology with additional redundancy features.

YOUR BENEFIT

- More than 40 years of experience
- Two-channel design with diverse calculation procedures
- Communication interfaces and data logging



Turbine controller – mastering speed

Modern turbine controllers have to meet the most stringent demands in terms of safety, economic efficiency, and availability. The basic requirement is a hardware platform suitable for industrial applications and using international standards.

With modern graphical digital interfaces, the operation of a turbine controller is relatively easy today. In addition, efficient remote functions allow fast and easy maintenance and service access. Operating reliability must be guaranteed under all service conditions and even the most difficult ambient conditions such as where high humidity and electromagnetic compatibility (EMC) are potential issues, for example.

For more than 150 years and all over the world, ANDRITZ Hydro has been providing leading turbine controller solutions. Our turbine governors are available for any type and size of turbine, for new installations as well as for refurbishment projects. Our governors ensure optimal operation under various grid conditions.

The digital controller is based on ANDRITZ' own in-house developed platform and has modular and unified hard- and software architecture. The software includes state-of-the-art signal processing logic, open and closed loop controllers, as well as limiters and more. Besides standard functions the system offers additional features, such as speed/load control, optimal load and frequency control for the grid, and penstock oscillation damping. Functions for flush control and adaptive cam control were also developed by ANDRITZ especially for double regulated turbines.

ADAPTIVE CAM CONTROL

Kaplan and Bulb type turbines with adjustable runner blades are able to operate under all discharge and head ranges with very high efficiency. To increase the operating efficiency the relationship between the opening of the wicket gate and runner blades can be optimized. This can be achieved under actual operating conditions by means of an automatic real time procedure.

SENSORS

The sensor technology required to detect field signals is designed to meet the highest standards. The speed sensors, some of which are redundant, and the drift-free positioning of the servo-motor have to guarantee low error and maintenance-free operation. In order to guarantee easy maintenance the mechanical design should feature a modular structure that can also be extended.

YOUR BENEFIT

- More than 150 years of experience
- For all types of turbines
- ACC module for double regulated turbines

Control Center Systems – process vizualizing

A state-of-the-art SCADA system provides all necessary functions for operation, supervision and control of plant processes. Its scalability allows its use at all automation levels - from the turbine controller and unit controls right up to large central control rooms.

Optimized ergonomic control and display concepts guarantee a quick and reliable process overview. Our product line ranges from touch panels for a turbine- or machine controller with a singular compact system, through redundant compact systems and up to distributed client/server configurations in multi-hierarchical systems.

The SCADA system can be configured as a compact or a multi-user system with redundancy. Drawing upon our many years of project experience, we can easily adapt the control center system to your operational requirements, modifying elements such as process displays, user guidance, alarm alerts, reporting, and the format of other parameters.

Based on a defined purpose, our system can be used as a local user interface at the turbine controller, gate controller or unit control boards. But, by simply expanding the functionality, the same system is able to cover all demands from a power plant controller or central control room.

YOUR BENEFIT

- **Innovative human-machine interface**
- **Distributed redundancy**
- **Microsoft Windows and Linux (Red Hat)**

Monitoring and Diagnosis – permanent care

Nowadays every power plant must maximize revenue and minimize expenditure. Advanced monitoring and diagnosis systems have to supervise indicators of condition changes, analyze trends and provide warnings and/or maintenance instructions if alarm or pre-set levels are reached.

Even under normal operating conditions all components of a hydropower plant system - such as turbine, main shaft, bearings, generator and auxiliaries - are subject to aging and damage. Advanced monitoring and diagnostic systems have to watch for changes in condition, analyze the trends and provide warnings if pre-set alarm or reaction levels are reached. They should support the rapid diagnosis of the causes behind any deviation, such as abnormal aging, before any serious damage occurs. These analytical and diagnostic results can then assist plant operators, technical specialists and asset owners in making informed decisions. For example, the results may be used to anticipate damage and support decision-making with regard to inspection recommendations and planning predictive maintenance.

The early identification of faulty components, a reduction in unscheduled outages and shorter repair times are major objectives of today's operational processes. Data is permanently sampled and stored upon every excursion, which reduces the need for storage capacity and yet makes all the relevant data available for 'life'. This unique feature enables users to access data over longer periods with user friendly graphical displays. Our in-house developed monitoring and diagnosis system continuously incorporates the experiences of ANDRITZ Hydro, as well as those of our customers and international electric generating utilities. The hard- and software solution is based on state-of-the-art system concepts and is able to accommodate future developments or additions. The system supports the easy integration of existing monitoring components, as well as any add-ons specific to the operator's own processes.

YOUR BENEFEIT

- **Predictive maintenance**
- **Dedicated digital solutions for the entire asset**
- **24/7**

Control and instrumentation – everything connected

Secondary technology represents an area of mandatory key competence for any global solution provider operating in the hydropower market.

INTEGRATED AUTOMATION SOLUTION

The development of an integrated and seamless automation system is an important influence on the secondary technology solutions for hydropower plants. The ANDRITZ hydro automation system includes all the secondary functions and components of a hydropower plant, including turbine governors, excitation and protection systems, synchronizers, gate controls, and substation automation, as well as local and superordinating automation and control systems.

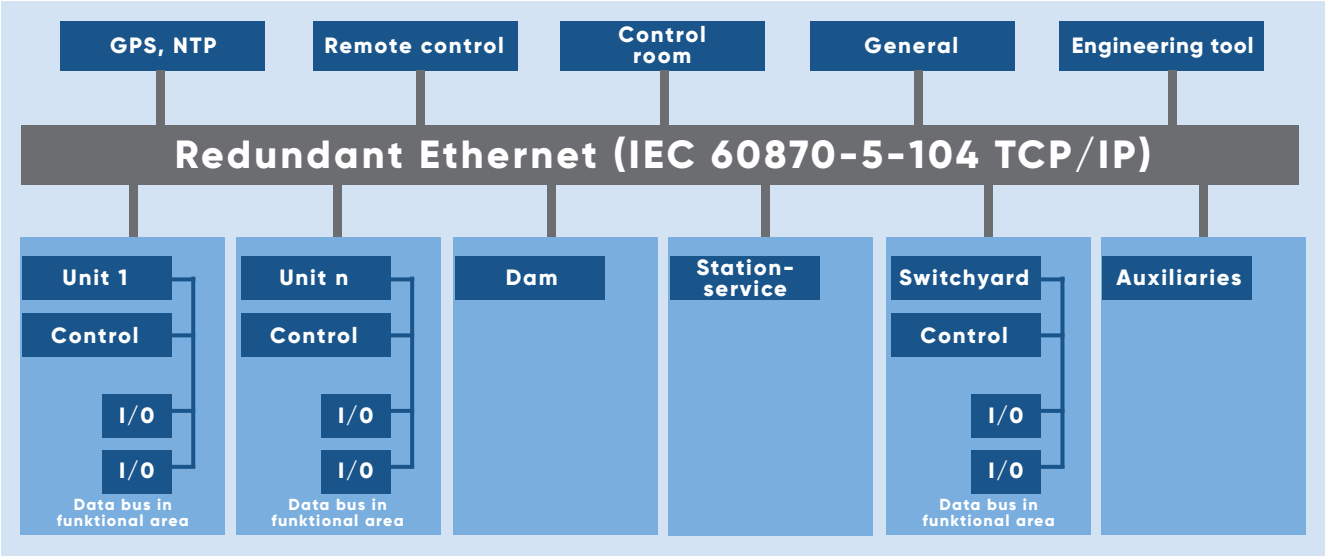
Close attention is paid to the systematic application of international standards and seamless system functions, while individual requirements of stand-alone devices are also taken into account. The system platform also guarantees straightforward integration into existing control concepts and solutions.

SEAMLESS ENGINEERING TOOL

The Engineering Tool distinguishes itself through its future-oriented user interface and work-oriented menu structure, providing exceptional user-friendly operation. It is optimized for user requirements and needs. All engineering phases of a project can be managed with this tool.

SECURITY

"Cyber Security" is increasingly important in the modern energy market. Thanks to a comprehensive, consistent and hardware-supported security architecture, the ANDRITZ solution provides robust protection against unauthorized external and internal access. The core elements are the internal firewalls in the devices that strictly separate the application processing from the communications interfaces.



NEPTUN – SEAMLESS ARCHITECTURE

NEPTUN is the integrated solution for hydropower plants. It connects all secondary technology components seamlessly into one system – from the turbine governor up to the SCADA. The core features of NEPTUN are: one communication, one hardware platform, and one engineering tool.

FUNCTIONAL AREAS AND ISLANDS

Functional areas are defined according to the primary systems and structural conditions, increasing the availability of the entire hydropower plant. In normal operations, the functional areas reliably control and monitor the respective plant components. In emergency situations, they are responsible for guaranteeing the safe operating status of the primary systems. The availability of a functional area can be increased further by splitting it into functional islands. Direct process and transformer signal interfaces (binary 220 V DC; transformer 220 V AC, 5A) eliminate the need and the substantial costs of a further layer of interfacing.

YOUR BENEFIT

- Integrated scalable architecture
- Huge library of communication protocols
- One homogeneous system for the whole plant

POWER PLANT MANAGEMENT

Both, single power plants and power plant cascades have to maximize energy production and minimize operational costs. Modern power plant management systems have to handle these tasks safely and efficiently.

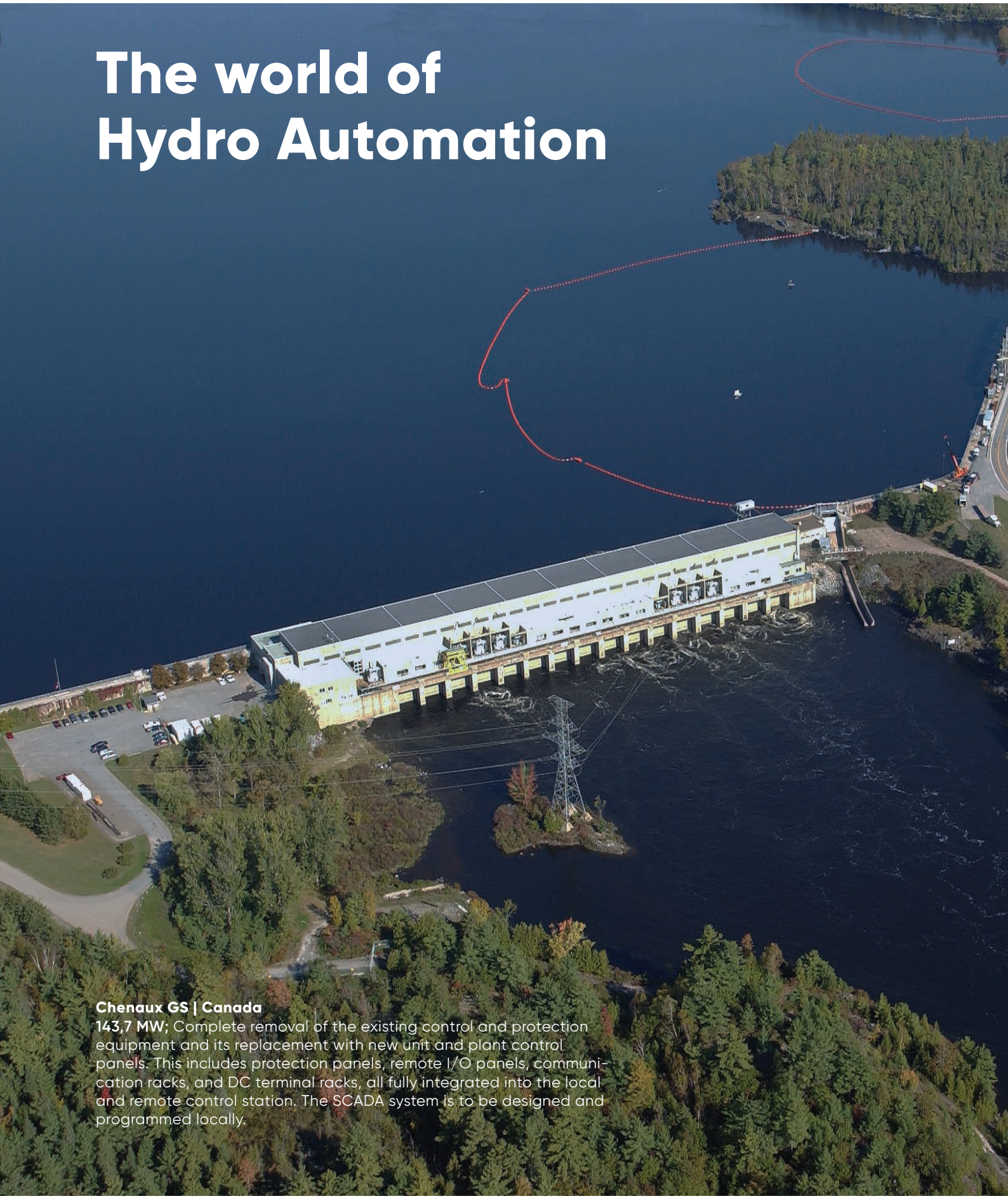
JOINT CONTROL

A joint controller optimizes the operation of a power plant by dividing and distributing overall energy production to individual units. Depending on the hydropower plant, the joint controller supports different operational modes such as active power control, flow control, reactive power control, pump mode operation, and condenser mode operation. Under special operational conditions, such as during floods, a dedicated gate controller is used for the operation of the spillway. With the level controller the operation of a power station can be achieved automatically. The controller varies the outflow of the reservoir according to level measurements in the reservoir so that both the optimal operation of the power station in terms of energy production is achieved as well as meeting any obligations to the authorities on reservoir usage.

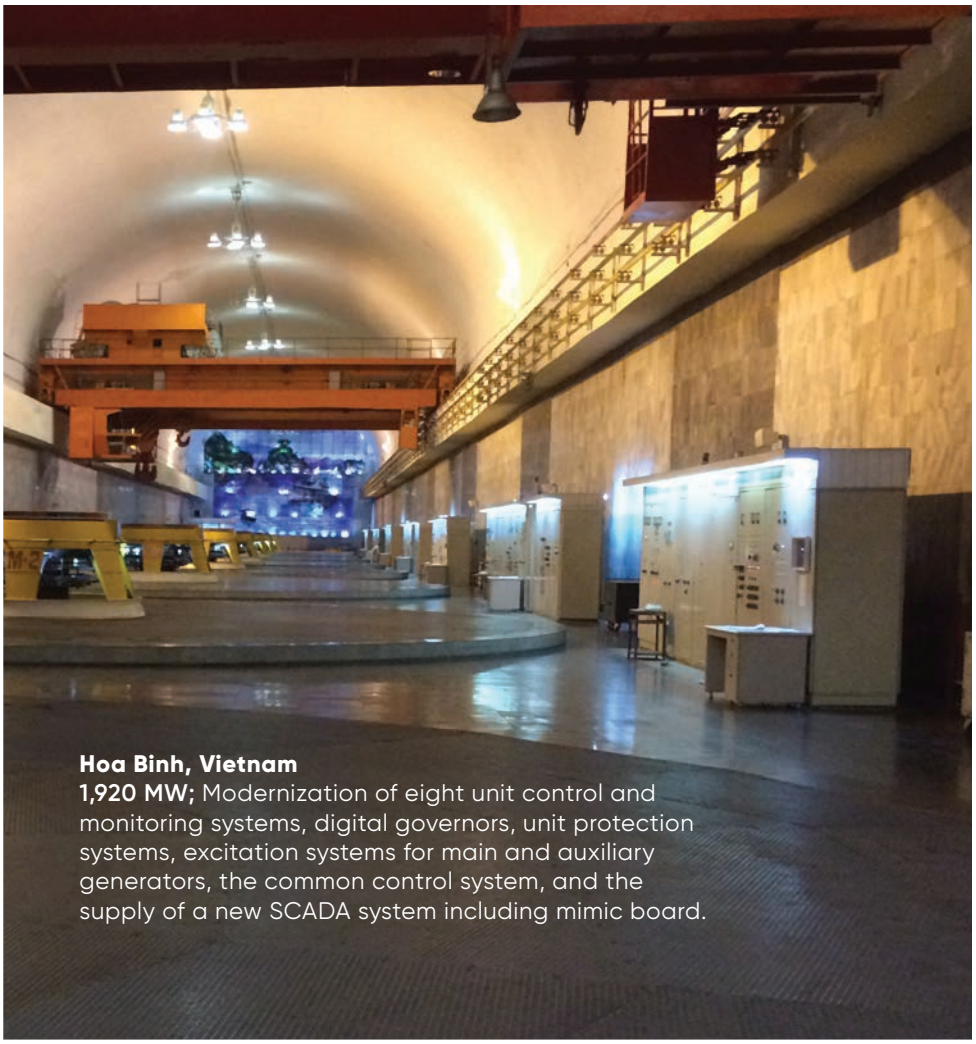
CASCADE CONTROL

To optimize a set of hydropower plants or a hydro power cascade an additional overarching controller is required. It takes into account the capabilities and current situation of all involved assets, optimizes discharge and energy production, and guarantees that all legal and environmental regulations and parameters are met.

The world of Hydro Automation

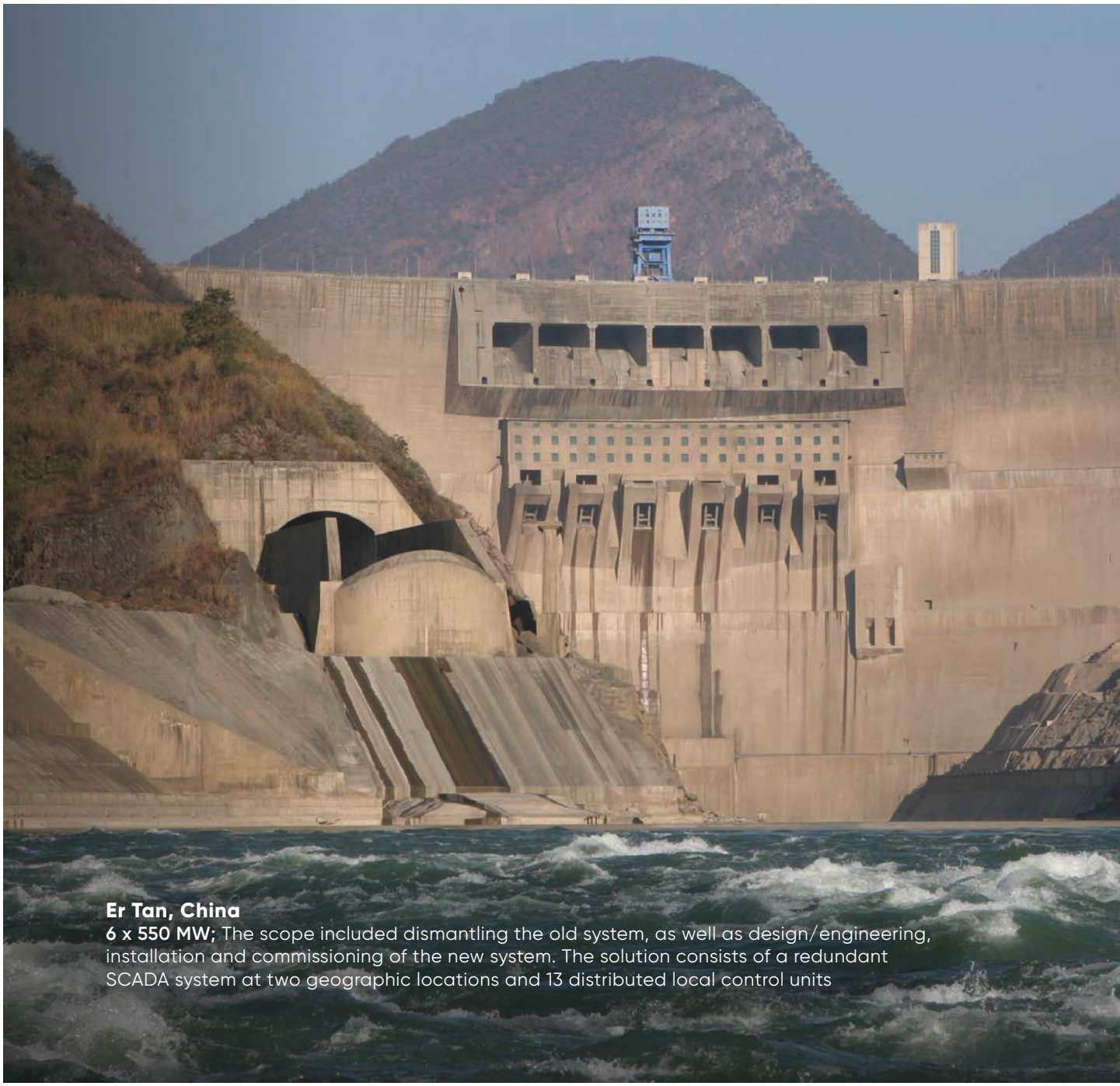


Chenaux GS | Canada
143,7 MW; Complete removal of the existing control and protection equipment and its replacement with new unit and plant control panels. This includes protection panels, remote I/O panels, communication racks, and DC terminal racks, all fully integrated into the local and remote control station. The SCADA system is to be designed and programmed locally.



Hoa Binh, Vietnam
1,920 MW; Modernization of eight unit control and monitoring systems, digital governors, unit protection systems, excitation systems for main and auxiliary generators, the common control system, and the supply of a new SCADA system including mimic board.

Group Dispatch Center Landshut, Germany
Complete system, SCADA, regional dispatch center for 110 HPP´s owned by UNIPER, six operator stations, and two engineering stations.



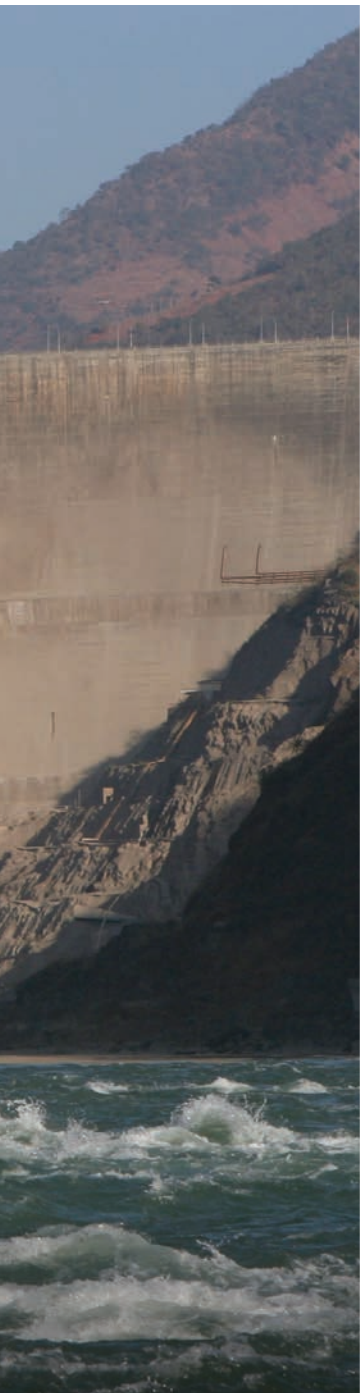
Er Tan, China
6 x 550 MW; The scope included dismantling the old system, as well as design/engineering, installation and commissioning of the new system. The solution consists of a redundant SCADA system at two geographic locations and 13 distributed local control units

Santo Antonio, Brazil
3,568 MW; full automation system for one of the largest HPPs in Brazil

Small hydropower market
THYNE1 compact excitation system for the small hydropower plants

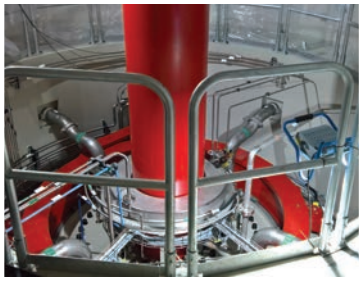
Langenprozelten, Germany
94 MW; HIPASE-E excitation for the world's largest single phase generator

Simon Bolivar, Venezuela
805 MVA; large excitation system; highest voltage level, THYNE 6 solution



Lauca, Angola
2,070 MW; Complete system, main transformers, isolated bus ducts, as well as control and protection systems, security, access control and telecommunication systems for both the main and eco powerhouses

Reisseck II, Austria
2 x 240 MVA; Complete system for pumped storage power plant; design, installation and commissioning of automation systems (control, excitation and protection)



Búrfell, Iceland
110 MW, Electrical Power Systems (EPS), control and protection system

Small hydropower, Turkey
+100 automation systems for small hydropower plants over the last 10 years

Shawinigan, Canada
5 x 18 MW; first HIPASE-E excitation project in Canada

Nant de Drance, Switzerland
6 x 174 MVA, first HIPASE-P protection for Swiss asynchronous generators

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ANDRITZ HYDRO GmbH
contact-hydro@andritz.com

ANDRITZ.COM/HYDRO

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