HYDRONEWS

Nº33

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INTELLIGENT MONITORING

Cover Story
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ANDRITZ

PASSION FOR HYDRO

All employees at ANDRITZ share the same core values that define how we act and what we stand for. We love what we do. Our ability to get the best out of ourselves and our technology is what makes us stand out. Times and technologies change, but our passion is always there.

ANDRITZ

ENGINEERED SUCCESS

Solving the challenges of the hydropower market

Dear Business Friends,

The energy market – and the hydropower industry especially – is facing many challenges with the growing demand for "base load renewables" and aging of much of the existing hydropower fleet.

As a result, new strategies are needed for successful hydro asset management and operation. One solution to reduce costs and improve operations is maintenance optimization to increase revenues. The new Metris DiOMera Platform, developed by ANDRITZ, is addressing these topics. Among recent project successes are the latest orders for Metris DiOMera, coming from the PresAGHO project in South America and Cerro del Águila in Peru.

Wolfgang Semper

Harald Heber

At a time when baseload power generation from fossil resources has to be replaced by a carbon-free renewable energy-based alternative, large-scale energy hybrid solutions offer a vital approach for the future. Hybrid solutions combine two or more power generation technologies with at least one renewable energy source, as well as a power and energy storage system. The Hatta project in Dubai is proof that ANDRITZ is a competent global partner for this evolving market.

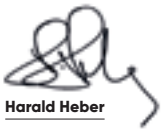
In addition to our large-scale hybrids, ANDRITZ has also developed a dedicated hybrid solution, which combines a battery with a hydropower unit – "HyBaTec". It increases hydropower asset lifetime by reducing mechanical stresses, triggers additional revenues by enabling participation in the short-term energy market, and opens up further opportunities to shift larger energy demands over the course of a day.

Along with these new technical solutions, several large project contracts have been recently awarded or are actively under construction. Major developments such as Xayaburi in Lao PDR, Laúca in Angola, Murkraftwerk Graz in Austria, or Hoa Binh in Vietnam are some highlights. There are also many interesting opportunities emerging for our small and mini hydropower systems in this growing market.

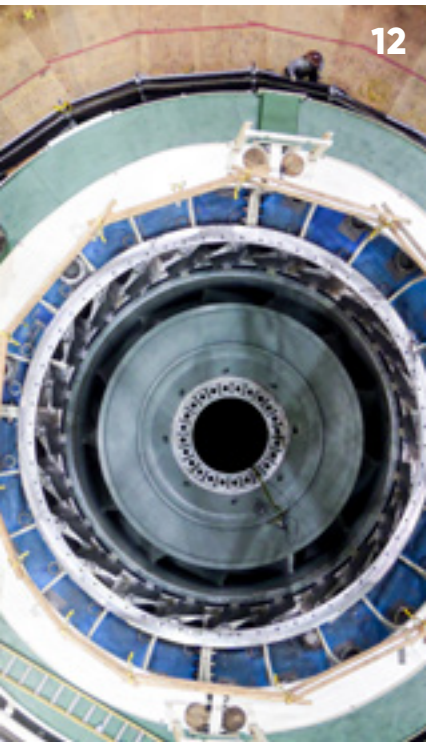
The energy industry is certainly facing many challenges, but with our technical abilities, the depth of our experience and our highly motivated staff, ANDRITZ is confidently looking forward to the future.

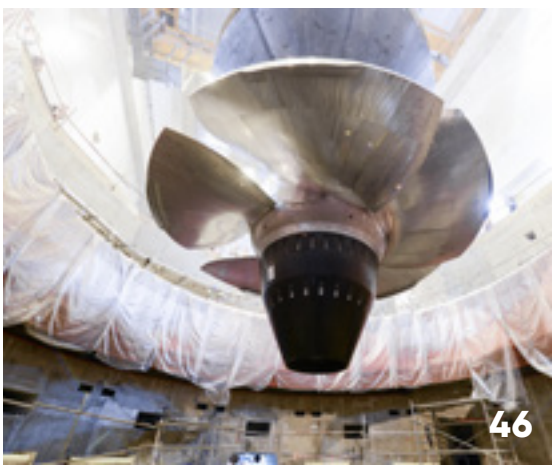
With kind regards, and sincere thanks for your continued trust,

Wolfgang Semper

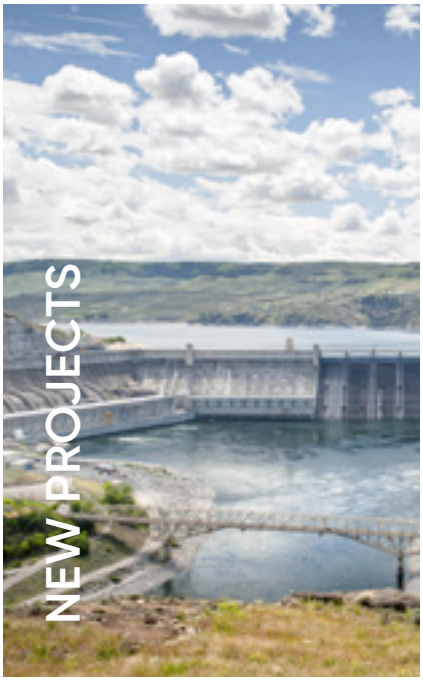


Harald Heber





OUR PROJECTS IN THIS ISSUE



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HYDRO PO
THE D

Dubai – The fascinating Emirate of Dubai, part of the United Arab Emirates, is about to turn a first-of its-kind hydro project into a reality.

THE CHALLENGE

The Dubai Supreme Council of Energy formulated a strategic objective to diversify the Emirate's energy mix and to enhance sustainability through a program of clean energy development. This plan envisages increasing the clean energy share of the generation mix to 7% by 2020, 25% by 2030, and 75% by 2050. To achieve this ambitious target the Dubai Energy and Water Authority (DEWA) decided to increase the power generation contribution from sources like photovoltaic solar and wind. But, in addition, to also create the necessary energy storage capacity required to balance these volatile renewable energy sources.

Further investigation determined that in regions with hot ambient conditions, pumped storage technology is superior to battery technology. Batteries are sensitive to heat and, as a result, a utility-scale battery storage facility would require a tremendous amount of electricity for cooling purposes.

THE CONCEPT

Near the community of Hatta, approximately 140 km southeast of Dubai in the Hajar Mountains on the northern border with the Sultanate of Oman, there is an existing reservoir created by the Sadd Hatta Al Awwal Dam. Together with the French consultant EDF (Électricité de France), DEWA developed a concept to create a new upper reservoir at a distance of 1.3 km and 150 m higher than the existing lower reservoir. The plan involved constructing two small dams with heights of 65 m and 30 m close to an old meander in the Hajar Mountains. A 1,300 m-long tunnel with some 7 m in diameter will connect the two reservoirs. With a capacity of approximately 200 m³/s and partially lined with steel, the tunnel is a key feature of the new Hatta Pumped Storage Power Plant.

WER FROM ESERT

"One third of the Earth's surface is arid or semi-arid. It is the world's major landscape type and is still suitable for hydropower development."

THE SOLUTION

For this challenging and unique project on the Arabian Peninsula, ANDRITZ Hydro formed a consortium with the civil works partners STRABAG and ÖZKAR. With support from the French consultant Artelia, the consortium was able to further improve the initial concept for the power plant and present a technically and commercially optimized offer to DEWA. This put the ANDRITZ Hydro-STRABAG-ÖZKAR consortium in a prime position once the tender opened. Following a series of rounds of technical and commercial clarification – during which all the specific details and benefits of the offer as presented were discussed with DEWA and the employer's engineer – the consortium was awarded the contract to realize this prestigious project on an EPC basis. This contract award took place in July 2019.

The final concept is based on a shaft-type powerhouse close to the existing reservoir. It will host two pump turbine and motor-generator units with a capacity of 125 MW each. Capable of producing a total net power of 250 MW over a six-hour generation cycle in turbine mode and a 7.4-hour storage cycle in pumping mode, the project provides an overall storage capacity of some 1,500 MWh.

Due to the relatively limited reservoir capacities, the available head will vary significantly, changing between 175 and 125 m during the charge-discharge cycle. To overcome this large head variation while keeping the units running at a high efficiency over the complete cycle, both pump turbine units are equipped with double-fed asynchronous motor-generators. They allow the units to operate at variable speed. ANDRITZ Hydro is one of the few global suppliers to have reference projects and appropriate expertise in the design,

→

The final concept is based on a shaft type powerhouse, hosting two pump turbine motor-generator units with 125 MW each.

With advanced technology by ANDRITZ, the project will provide an overall storage capacity of some 1,500 MWh.

→ manufacture and installation of such specific and challenging technology.

"This unique undertaking to generate electrical energy using pumped storage power technology in the desert has a signal effect for the future of clean energy in the generation mix. It's a flagship project not only in the Arabian Peninsula, but for every hot and dry region of the world."

THE SCOPE OF SUPPLY

STRABAG is acting as the consortium leader and joined forces with the Turkish ÖZKAR Group to execute the civil engineering elements of the project. STRABAG is a global leader in the execution of large infrastructure projects while ÖZKAR fields outstanding references in Rolled Compacted Concrete (RCC) Dams, the technology chosen for the Hatta Project. ANDRITZ Hydro will be the consortium partner responsible for the entire electro- and hydro-mechanical equipment for the Hatta Pumped Storage Power Plant.

ANDRITZ Hydro's scope of works to be engineered, supplied, installed and commissioned consists of two Francis-type pump turbines with double-fed generators and auxiliary systems including excitation, automation, as well as the control and protection systems. Furthermore, ANDRITZ Hydro will also supply the main power transformers, GIS switchyard and some 9 km of high voltage cables to connect the new power plant to the national grid.

In relation to the waterways, ANDRITZ Hydro will engineer, supply and install all gates and trash racks along with approximately 320 m of penstock steel lining. The company will also supply the main inlet valves at both the high and low pressure sides of the turbines.

Before initiating manufacture of the units, ANDRITZ Hydro will confirm the guaranteed characteristics of the

TO KNOW:

THE ARABIAN DESERT

The Arabian Desert has a subtropical, hot desert climate and is an extension of the Sahara Desert. Occupying most of the Arabian Peninsula with an area of 2,330,000 km², it is the fifth largest desert in the world. At its center is Ar-Rub'al-Khali (The Empty Quarter), one of the largest continuous bodies of sand in the world.

AL-HAJAR MOUNTAINS

"Hajar" means "Stone" or "Rock", so "Al-Hajar" would be defined as "The Stone" or "The Rock" – The Rocky Mountains of Arabia.

The Al-Hajar Mountains in northeastern Oman and the eastern United Arab Emirates are the highest mountain range in the eastern Arabian Peninsula. They separate the low coastal plain of Oman from the high desert plateau and lie 50–100 km inland from the Gulf of Oman. Measuring up to 50 km wide, the mountains begin in the Musandam Peninsula in the north, and extend about 440 km to Ras Al-Hadd in the east.

turbine through a detailed model test. Testing is to be conducted in one of ANDRITZ Hydro's own laboratories.

LIGHTHOUSE PROJECT

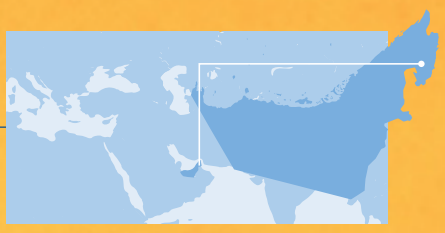
Considered a lighthouse project for our customer DEWA as well as other utilities and electricity producers across the whole region, this contract is a very important milestone for ANDRITZ Hydro and its consortium partners.

Upon successful completion of Hatta it is very likely that additional projects of a similar nature will be developed in the region to further improve the share of clean energy in the generation mix.

TECHNICAL DETAILS

Hatta:

Total output: 250 MW
Scope: 2 × 125 MW
Voltage: 15.5 kV
Head: 150 m
Speed: 285 – 315 rpm
Runner diameter: 3,800 mm



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MORE ENVIRONMENTALLY-FRIENDLY POWER


© UPM

TECHNICAL DETAILS

Kuusankoski:

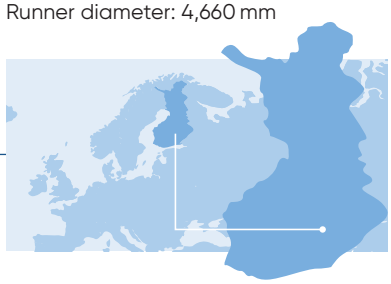
Total output: 37 MW

Scope: 3 × 12.33 MW

Head: 8.6 m

Speed: 107.1 rpm

Runner diameter: 4,660 mm



The small town of Kuusankoski has strong industrial roots. Three 10 MW turbines from 1950 will be replaced with modern, environmentally-friendly equipment.

Finland – Earlier this year, ANDRITZ Hydro was awarded the contract to refurbish one of UPM Energy's largest hydropower plants in Finland, the Kuusankoski project.

The order from UPM Energy is for the refurbishment of the turbines and generators at Kuusankoski, located in the town of the same name in southern Finland.

"After completion, the average annual electricity production is estimated to increase from the current 180 GWh to 195 GWh."

Awarded in February 2019, under the terms of the contract, ANDRITZ Hydro is to execute an extensive modernization of all three generating units at the hydro plant. First commissioned in the 1950s and with each unit rated at 10 MW, the major objective of the renovation and renewal program is to increase overall generation efficiency.

The ANDRITZ Hydro scope of the contract comprises the replacement of all three turbines with modern environmentally-friendly, oil-free runners. This will increase total plant output by about 19% to up to 37 MW. For one of the units a complete new stator will be delivered and for the other two generators there will be a basic overhaul. The new runners will be model tested in ANDRITZ Hydro's own hydraulic laboratory in Tampere, Finland.

With the refurbishment to be carried out one unit at a time to minimize the impact on the plant's operation, the first unit will be installed in 2020, with the other two following in 2021 and 2022, respectively.

UPM Energy is the second largest electricity producer in Finland and generates low-emission electricity from its own hydropower assets. UPM also owns shares in other electricity companies. Its total generation capacity is 1,500 MW.

ANDRITZ Hydro has successfully refurbished several hydropower plants of UPM in the past. Most recently, projects at Harjavalta, which is partly owned by UPM, and Keltti, which is fully owned by UPM. According to the customer, successful project execution in these earlier projects was one of the major success factors in ANDRITZ Hydro's latest Finnish project order at Kuusankoski.

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+30%

HIGH PERFORMANCE SUSTAINABLE ENERGY

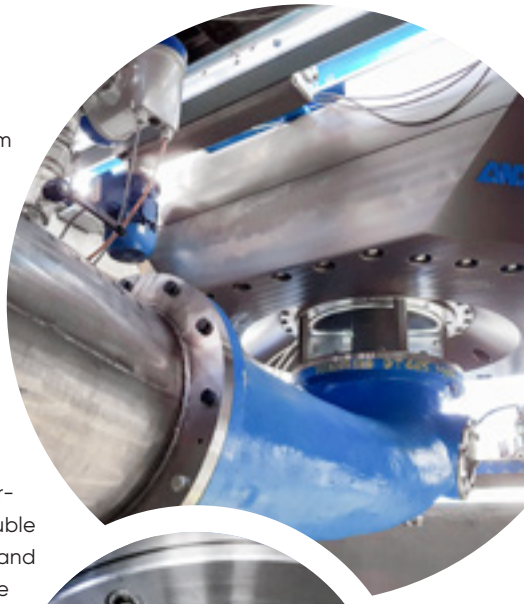
With a height of 200 m and spanning 626 m across, the Kölnbrein Dam is the largest dam in Austria. At peak, around 200 million m³ of water is impounded behind its double curved concrete dam. That's enough to fill a bathtub for 1.4 billion people, some 20% of the world's total population.

Austria – Malta Oberstufe and its Galgenbichl power station is a pumped storage hydropower plant located about 1,933 m above sea level in the mountains of Carinthia, Austria.

Equipped with two vertical pump units, construction began in 1974 and was completed in 1977. First commissioned in 1979, Malta Oberstufe features a 200 m-high double curved concrete dam. It is not only the highest dam in Austria, but also one of the highest curved dams in Europe. At peak capacity the lake produced by the dam has a storage volume of about 200 million m³.

After nearly forty years of service, the plant is now being repowered with new high-performance variable-speed pump turbines. The existing turbines had a rated capacity of 62.8 MW each. In pump mode, the units were rated at 21 MW at 375 rpm and 58 MW at 500 rpm. ANDRITZ Hydro will replace the existing units with turbines rated at 80 MW each in both pump and turbine operational modes.

Brand new forged and welded pump turbine runners and a newly welded stay ring are at the heart of this upgrade, which uses existing cast-in spirals. The new pump turbines have a volute in which a double rotor composed of a Francis impeller and a radial pump impeller rotates. The direction of rotation is the same for both turbine and pump operation, though hydraulically the turbine and pump parts are independent of each other. To accommodate the significant variation in head produced by the Kölnbrein Reservoir, the Isogyre pump turbine sets have pole-variable motor generators and two speed settings.



The fully compliant model test was completed successfully in May 2019 at ASTRÖ Graz, Austria. Today, with an annual average production of about 37,870 MWh, Malta Oberstufe is supplying electricity for more than 8,300 households and is reducing Austria's annual CO_2 emissions by around 28,000 tons.

TECHNICAL DETAILS

Malta Oberstufe:

Total output: 160 MW
Scope: 2 × 80 MW
Head: 50 – 220 m
Speed: 560 rpm
Runner diameter: 2,400 mm

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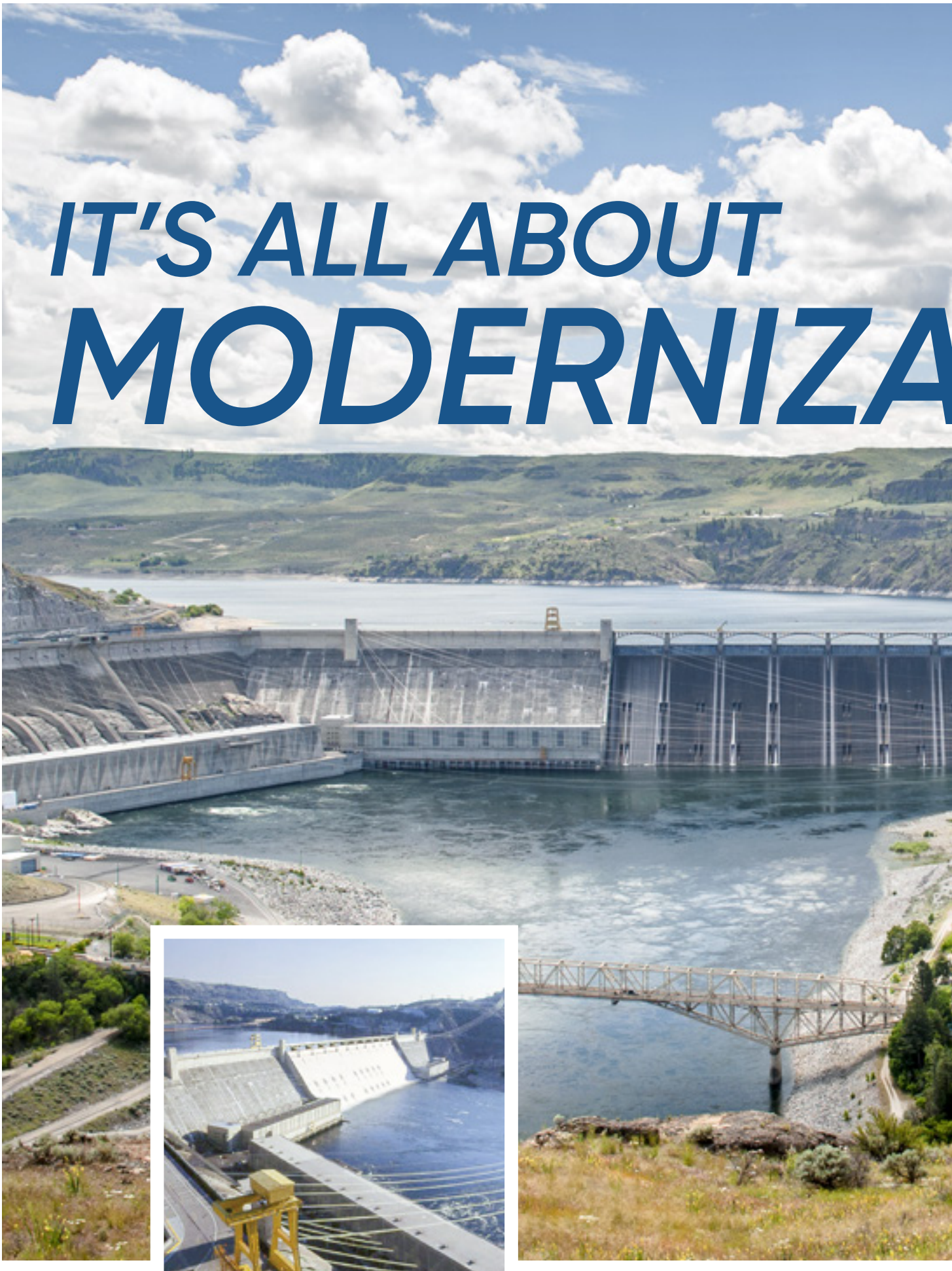
IT'S ALL ABOUT MODERNIZA



USA – On April 12, 2019, the United States Bureau of Reclamation awarded the Grand Coulee John W. Keys III major automation modernization contract to ANDRITZ. This award marks another milestone between the Bureau of Reclamation and ANDRITZ. We have been continuously working in various powerhouses at the Grand Coulee Dam for over 20 years with turbine and generator rehabilitations with great success.

Located on the Columbia River in Washington, and as the centerpiece of the Columbia Basin Project, Grand Coulee is the largest hydropower facility in the United States with a total of 36 units, including 24 conventional generating units, six reversible pump turbines and six pumps, in four powerhouses and a total capacity of 6,809 MW. The facility also supplies water for the irrigation to 2,700 km² (270,000 hectares) of farmland.

"John W. Keys III pump-generating plant is the largest automation order for ANDRITZ Hydro."

Under this new contract, ANDRITZ will modernize the entire automation systems at the John W. Keys III pump-generating plant with new digital excitation systems, protection

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TECHNICAL DETAILS

Grand Coulee:

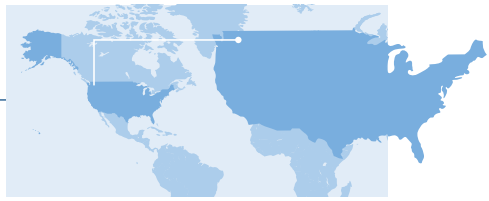
Total output: 6,809 MW

Output scope: 623 MW

Head: 90 m

Speed: 200 rpm

Voltage: 13.8 kV



relays, unit controls and turbine governor systems for all six pumping units and the six pump-generating units. The existing units were installed in the early 1950s (pumping units) and the late 1970s (pump-generating units) respectively with electro-mechanical or analogue controls. Spare parts for these old systems are no longer available and the maintenance is becoming more and more challenging.

The new systems will enable completely automated control and monitoring processes, taking advantage of the most advanced computerized data acquisition and control technologies. The contract also comprises the complete removal of the existing systems including the cable and cable tray/raceways, as well as the installation, commissioning and testing of the new systems. The first outage will start in November 2020 and the last two units will be completed in March 2026.

This order is the largest automation order for ANDRITZ Hydro in history and represents a significant award for ANDRITZ in the US market. It is the culmination of a great deal of work and cooperation between many areas within the company.

TO KNOW:

The Columbia Basin Project serves about 671,000 acres in east central Washington. The main facilities of the project include Grand Coulee Dam, Franklin D. Roosevelt Lake, three power plants, four switchyards, and a pump-generating plant. Primary irrigation facilities include the Feeder Canal, Banks Lake, the Main, West, East High, and East Low canals, O'Sullivan Dam, Potholes Reservoir, and Potholes Canal. There are over 300 miles of main canals, about 2,000 miles of laterals, and 3,500 miles of drains and wasteways on the project.

In addition to supplying water for irrigation, producing electricity, controlling floods, providing recreation, and regulating streamflow, the Columbia Basin Project also provides water for cities, industries, navigation, and endangered species.

Bureau of Reclamation

The scope for the upgrading contract comprises the complete dismantling of the turbine and the generator units, inspection of all components and refurbishment and reassembly of the units on-site.

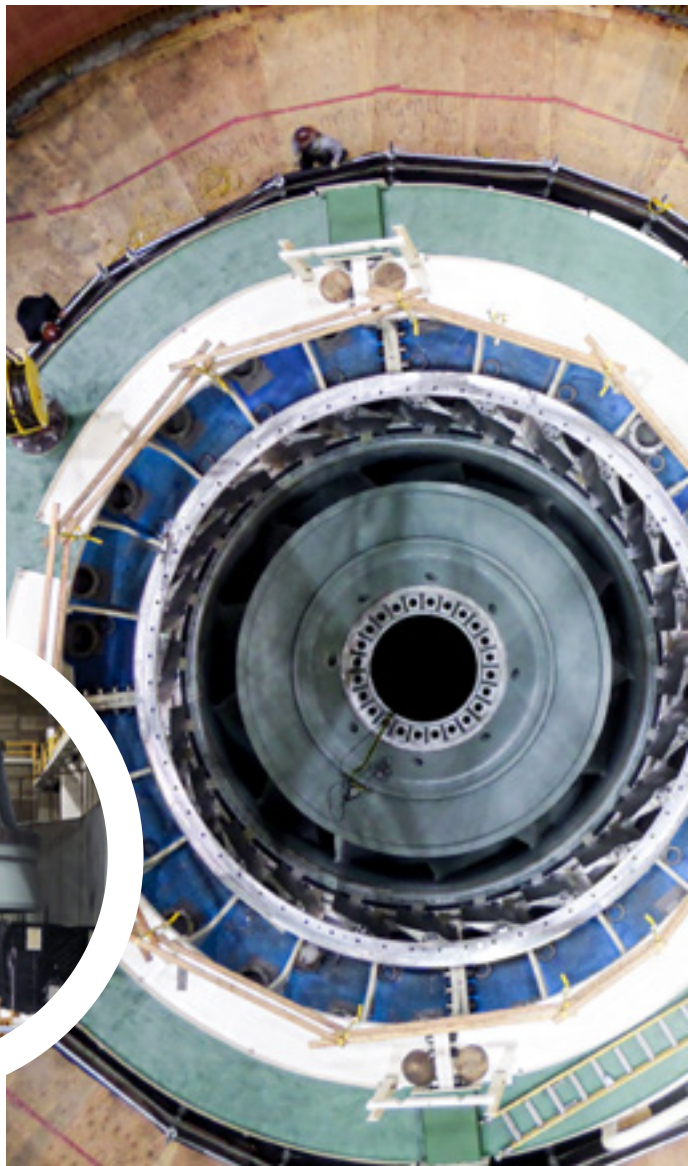
IMPORTANT TURBINE UPGRADE ORDER AT THIRD POWER PLANT

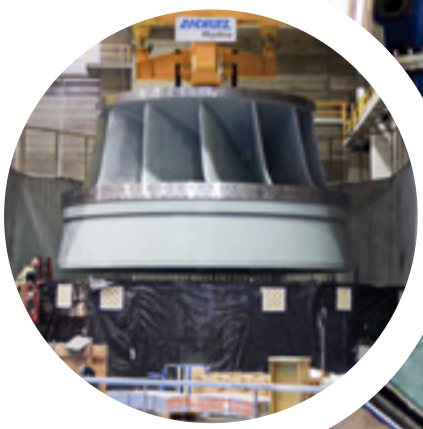
The US Bureau of Reclamation awarded a construction contract for the overhaul of three units, G22, G23, and G24 at the Grand Coulee third power plant to ANDRITZ Hydro in USA.

The scale of all of the components of the overhaul is enormous. The G22, G23 and G24 rotors are 61'6" in diameter and weigh 1,480 tons. The Francis runners are 32'6" in diameter, 18'4" in height and weigh 430 tons. The output of each unit is 805 MW.

We have completed the rehabilitation of two units (PAC) ahead of schedule, achieving early completion bonuses, and are in the process of disassembling the last unit for its rehabilitation.

With 6,809 MW and 36 units in four powerhouses, Grand Coulee is the largest hydropower complex in the United States.





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INTELL
MONIT

Digital O&M – from monitor

The new intelligent monitoring platform for hydropower plants by ANDRITZ.

Today's energy markets are undergoing major changes, all of which have a direct impact on hydropower asset management and operations. Energy price volatility is increasing together with the complexity of regulatory conditions and the need for flexible operations. New financing models are driving the need for more secure long-term reliability of equipment. There is continuous cost pressure. Meanwhile, maintaining technical know-how is becoming a challenge. The reality of hydropower operations and maintenance is changing rapidly.

Consequently, developing an O&M strategy suited to today's business environment offers considerable commercial benefits. The need for adequate information is key to help decision-making, risk assessment, and selecting appropriate maintenance strategies, such as deciding on a predictive or scheduled maintenance

IGENT ORING

ring to asset management

program. Assessing the condition of aging hydropower components is therefore a cornerstone of modern hydropower asset management.

OPERATION AND MAINTENANCE APPROACH

Aligning maintenance programs with effective operations is changing the focus from traditional, calendar-based scheduled maintenance. As a first step, operators must consider condition-based maintenance and adopt maintenance tasks that are appropriate to the effective status of components. Taking a second step on this path, operators are to move to a predictive maintenance posture by anticipating when any given inspection/maintenance task should be executed.

Applying predictive maintenance modeling allows hydropower asset owners and operators to optimize maintenance programs with the objective of reducing costs. However, improvements in operations that →

target increased revenues are also possible. Obviously, both issues must be addressed comprehensively if the challenges of aging components are to be mitigated throughout the asset's lifetime. Condition-based and predictive maintenance, optimization of operations, and follow-up on aging components is made possible by processing all operational data that are already available from hydropower plants.

Indeed, large volumes of data are already available. There are standard monitoring measurements, operations data, market data and maintenance records. However, this digital maze of information represents a challenge for hydropower operators. It cannot be addressed by the agnostic Big Data methods that exclude the engineering and operations expertise built-up by operators and manufacturers over many years. For hydropower, structured data processing is of critical importance.

"Operation and maintenance enhanced by digitalization will make your asset fit for the future."

Applying structured data processing to condition-based maintenance solutions relies on the development of Key Diagnostic Indicators (KDIs). These are equivalent to the fingerprints of the present status of a given parameter for a system or component and indicate its current "health condition level". For example, steadily increasing bearing temperatures may remain within admissible limits but are suggestive of a potential issue.

Similarly, predictive maintenance is built from Key Trend Indicators (KTIs) that define the future evolution of the health status of the said system or component. The KTIs give an indication of the residual service life before maintenance, inspection or replacement is required, depending on the client's specific maintenance strategy.

There are different approaches to establish these KDIs and KTIs, which are developed from different types of meta-models. As a first level, universal models are based on general physical laws and engineering knowledge are considered. For example, water density as a function of temperature or the residual life analysis of a turbine runner. A second level is based on models that require development over a reference period and represent a known physical context that is rooted in technical knowledge. An index of efficiency is a good example. Lastly, models purely based on data created from machine learning and unveiling specific behaviors are possible. Here the physical meaning of the model outputs is not immediately obvious. Big data mathematical approaches are applied here that can be used to monitor the evolution of vibration patterns in a Francis turbine at part load, for instance.

METRIS DIOMERA – THE NEW DIGITAL SOLUTION

A wealth of expertise, which takes in the full measure of ANDRITZ Hydro's nearly two centuries of experience, is embedded into the Metris DiOMera Platform. This software tool suite is dedicated to the optimization of operation and maintenance activities for hydropower assets.

The Metris DiOMera system can be installed on a computer located in the hydroelectric power station or preferably through a data concentrator (DC). The DC transmits the data to a remote server or to the cloud, which is then connected to the ANDRITZ Hydro Global Control Center (GCC). Metris DiOMera stores the signals data and offers a vision of specific plant behavior through a graphical user interface (GUI). It can run on any digital device using a web browser.

Metris DiOMera has no effect on the control system or on the operation of the hydroelectric power station. The intelligent monitoring platform performs continuous analysis of the data received from the hydroelectric plant and delivers results, trends, curves and other useful forecasts that enable optimization of the operations and maintenance activities for the full asset.

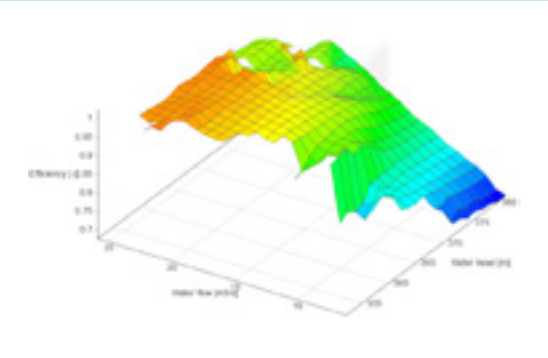
The meta-model technology developed within Metris DiOMera is generic and applicable to any system/subsystem provided some understanding of its operations and operational patterns is available. This makes Metris DiOMera an extremely flexible platform that is easily extended to meet the varied needs of our clients.

In parallel, in applying fault tree structures, Metris DiOMera supports asset management evaluations by

With the Global Control Center (GCC) ANDRITZ Hydro has established an advanced remote monitoring and control center for worldwide operations and maintenance.

using all the different KDIs that define and predict the risk-status of all the monitored systems. Examples of systems or sub-systems that are addressed by Metris DiOMera range from indexing efficiency to recording clogging of oil filters. In addition, aging of axial runner lever arms or damage in a Pelton runner due to hydro-abrasive water, as well as generator winding aging or any other component in the power plant can be encapsulated by Metris DiOMera to support rapid and data-led decision making.

The monitoring of the hydraulic efficiency of the units is also an aid to detect abnormal operating conditions by identifying abrupt changes in performance. It also acts as an indicator of aging or wear of the main hydraulic components by means of exploring long-term performance trends.



Example of performance analysis: hill of performance index 3D

In short, Metris DiOMera is the most advanced and intelligent hydropower assistance tool. It allows ANDRITZ Hydro to provide its strategic partners with added value assistance to maximize their generation output and optimize maintenance costs in addition to a continuous and comprehensive risk evaluation of the asset throughout its lifecycle.

ANDRITZ HYDRO'S GLOBAL CONTROL CENTER

A state-of-the-art system for monitoring our clients' plants has been set up in ANDRITZ Hydro premises located in Schio, Northern Italy. This Global Control Center (GCC) has been working for several years on different plants located all over the world, enabling their operators to monitor and optimize the functionality of the powerhouses concerned.

Cost reduction, prompt and punctual intervention in case of need, and maximized annual generation are some of the major advantages available for clients and their assets with the GCC

Based on our 24/7 service model, we deliver technical assistance on any issue the customer might face during daily plant operations. These include the collection of plant data, remote plant monitoring and plant operation, on-demand remote assistance and troubleshooting, computer-based maintenance management and generator and/or turbine, automation and BOP monitoring through specific technology modules.


Canada, Montrose | 88 MW

A GLIMPSE AT O&M DIGITALIZATION PROJECTS


Chile, Blanco | 60 MW


Colombia, La Insula | 18 MW


Peru, Santa Teresa | 104 MW

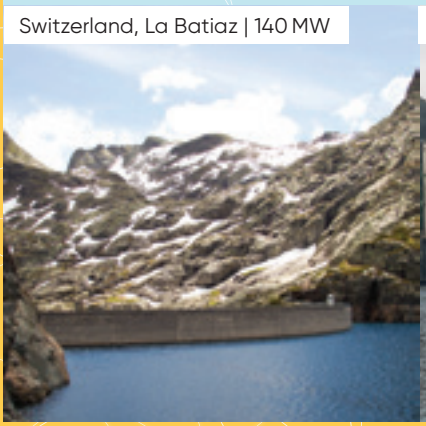
AN IMPORTANT STEP FORWARD

PresAGHO (9,000 MW) South America

ANDRITZ Hydro has been awarded a long-term O&M contract for the PresAGHO digital platform used by ENEL Green Power. The contract includes implementing predictive maintenance and digital services at ENEL's hydro fleet across Latin America in Brazil, Argentina, Chile, Peru, and Colombia. Applied to 44 hydro power plants, each with a rated capacity above 50 MW, the contract covers a total installed capacity of around 9,900 MW.

These services will set forth a game-changing review of O&M concepts and strategies, fostering a switch from a preventive approach to a truly predictive one.

A significant portion of the project will focus on the Metris-DiOMera digital platform, which will be installed in the ENEL cloud and connected to the hydro plants through a large database. The platform will monitor, manage and analyze the facilities' data in order to predict plant behavior and anticipate critical issues and help to increase performance.


Switzerland, La Batiaz | 140 MW


Italy, Gropello | 1 MW


Italy, ACEA | 45 MW


India, Testa III

A MILESTONE IN INNOVATIVE O&M APPROACHES

Cerro Del Áquila (500 MW), Peru

Cerro del Águila HPP was commissioned in 2016. During the warranty period and beyond, ANDRITZ Hydro was able to keep in contact with the owner and support them through remote assistance. This site support helps in dealing with minor troubleshooting and supports the transfer of solutions which generate added value for the client.

Under the long-term O&M contract, ANDRITZ Hydro is providing a Metris DiOMera platform and all related services. The ANDRITZ Hydro "Smart Spares" concept has been specified by the customer. This forecasts the delivery of a selected volume of spares which is kept available at the Cerro del Águila site and is available to be used on demand by means of an innovative "Use and Stock" mechanism.

The most relevant aspect of this O&M agreement is the implementation of an "Integrated Maintenance" concept. It helps to forecast rehabilitation works for major components such as all the plant units, valves and so on. It includes both major and minor rehabilitation works as well as repairs for worn components.

For the first time in the hydropower business, this new model provides a guarantee for defined key performance indicators in the period between major service intervals. ANDRITZ Hydro guarantees core client KPIs like annual water availability under well-defined and measured constraints such as limits on operations, sediment contents and so on. Digitalization is the key enabler for this new concept.

AUTHOR

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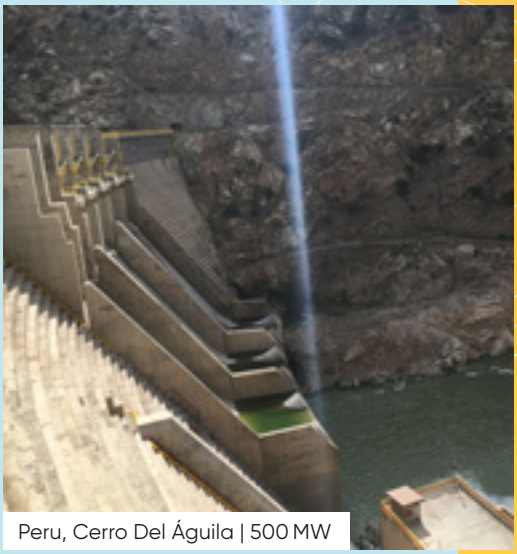
Chile, La Higuera | 180 MW

9,900 MW

South America, Enel PresAHGO



Peru, Cerro Del Águila | 500 MW

1,200 MW

Indonesia, Cianten | 19 MW

Germany, Goldistahl | 1,060 MW

Norway, Lysebotn | 370 MW

© Kristofer Ryde

BRING UP TO SHAPE

The pumps for the pumping stations of Amu Bukhara are highly technical units. Their development was carried out according to the project-specific requirements.

Uzbekistan – The Uzbek government is relying on ANDRITZ pump technology for the modernization of the country's largest pump irrigation system.

Uzbekistan depends heavily on artificial irrigation. One of the central economic sectors in Uzbekistan and essential for 90% of its agricultural production, it is the main source of income, especially in the rural areas and municipalities. Given the sector's importance, the government introduced two programs in order to significantly improve national agricultural productivity and sustainability, and thus raising overall living standards in rural areas. The goal is to modernize the irrigation and drainage systems to achieve higher productivity together with better environmental protection.

These plans include the country's largest pump irrigation system, Amu Bukhara. This plant supplies water to the Uzbek provinces of Bukhara and Navoi. The network was built in 1965 on the right bank of the Amu Darya River. It provides water for the irrigation of about 250,000 hectares of land, cities, local industries, and more than 1.7 million people.

"In Uzbekistan, systematic irrigation is based on seven natural oases and started more than 2,500 years ago. Today, the network relies on numerous pumping stations and canals and spans across approximately 196,000 km. It is one of the most complex irrigation systems of its type in the world."

However, after more than 50 years of continuous service, its major and minor channels are in desperate need of modernization. Irrigation efficiency is only 40% and thus represents a significant risk to agricultural production and the regional economy. Furthermore, the obsolete and energy-inefficient pump stations not only require large amounts of electricity, they also represent a large environmental impact, emitting some 758,000 to 935,000 tons of CO_2 emissions annually.

TECHNICAL DETAILS

Kizil Tepa:

Scope: 10 vertical volute pumps

Head: 75 m

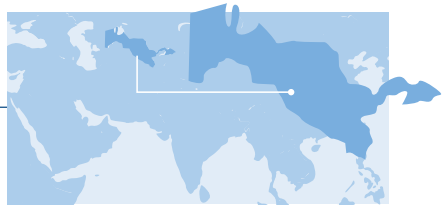
Flow rate: 440,000 m³/h

Kuyu Mazar:

Scope: 6 vertical line shaft pumps

Head: 24 m

Flow rate: 414,000 m³/h



The government, together with the support of the Asian Development Bank (ADB), is implementing a comprehensive overhaul and modernization program of the system. This includes the construction of a new pumping station as well as the modernization and refurbishment of four existing stations.

In the case of the Amu Bukhara project the Chinese infrastructure company Hebei Construction Group is acting as the Engineering, Procurement, Construction (EPC) contractor. With strictly defined awarding criteria, ANDRITZ was awarded the contract for the delivery of the core components. Accordingly, ANDRITZ is supplying a total of 16 custom-tailored pumps, including their respective spare parts, for two pumping stations.

The pumps for the two stations of Amu Bukhara are highly technical and whose development and production meet the detailed project-specific requirements. For the Kizil Tepa station, 10 tailor-made vertical volute pumps are being produced – each with an efficiency of up to 90%. They reach a head of up to 75 m and a flow rate of up to 440,000 m³ per hour.

For the second station, Kuyu Mazar, six customized vertical line shaft pumps with similarly excellent efficiencies are planned. They reach a head of up to 24 m and a flow rate of up to 414,000 m³ per hour.

These hydraulic machines are also designed to take into account the increasingly variable characteristics of the river. Equipped with a hydraulically adjustable mechanism to vary the impeller's angles by up to 15°, it is possible to respond reliably and promptly to changes in head and flow rate even during pump operations.

Additionally, by varying the impeller diameter and the trailing edge, an exact adaptation to achieve the desired operating points can be made and efficiency can be optimized. This mechanism demonstrates clear advantages where significant changes in the flow rate occur and is characterized by a long life with no requirement for any electronic components.

Alongside the design and delivery of the pumps and spare parts, installation and commissioning will be supervised by ANDRITZ personnel. Completion of the entire project is scheduled for June 2020.

Great hopes are being pinned on the success of this major infrastructure project. Harnessing sufficient water reserves for reliable irrigation of agricultural land is expected to bring about sustainable changes in terms of much-needed better living conditions for future generations in these Uzbek provinces.

AUTHOR

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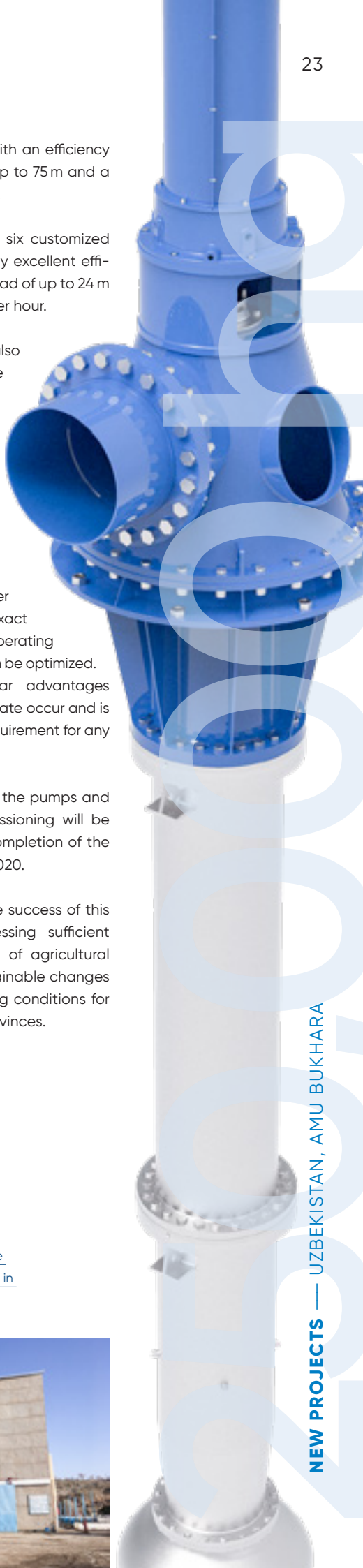
Amu Bukhara is the largest pump irrigation system in Uzbekistan supplying water for the irrigation of about 250,000 hectares of land in the provinces Bukhara and Navoi.



THE CHALLENGING PATH

New Zealand – New Zealand is fortunate to have a wide range of natural resources available for powering the country's industry and homes. Hydropower is the main renewable energy source in New Zealand, supplying 62% of the country's total, with wind turbines supplying 4% and geothermal 18%. The remainder is mainly supplied by gas and a small amount by a large coal-fired power station located near New Zealand's largest city, Auckland.

The two main islands are interconnected for electrical distribution by high voltage DC cables. Two thirds of the population live in the North Island, which is the main source of electricity demand, but electricity can be transferred in both directions depending on the hydrological situation.

New Zealand has committed to be 100% renewable by 2035 and the trend towards replacing fossil fuels and industrial heat with renewables is expected to lead to a doubling of electricity demand by 2050.

This poses a significant challenge for the development of new generation capacity. New Zealand's installed hydropower capacity of 5,437 MW is entirely conventional hydropower, with no pumped storage. Most of the hydropower plants in New Zealand were installed between the 1940s and 1980s. As a result, the bulk of recent capacity growth has been the refurbishment of existing hydropower plants along with the installation of smaller run-of-river schemes. With lower environmental impact, run-of-river schemes and small storage schemes continue to be the favored option for new hydro capacity in New Zealand. Consequently, uprating and refurbishment of existing hydro plants will also likely continue in the medium term.

In order to reach the ambitious national goals for renewable energy, much of the new capacity development will be focused on geothermal and wind energy. Nonetheless, such developments will require the higher performance, flexibility and reliability available from traditional sources of generation like hydropower to perform vital grid control and peaking power functions.

ANDRITZ HISTORY

ANDRITZ Hydro has contributed to the development of hydropower in New Zealand since its early beginnings. Some of the country's very earliest turbines, installed in Reefton in 1908, Akaroa in 1911 and Coleridge in 1914, all came from ANDRITZ Hydro. Subsequently, through the mid-20th century, ANDRITZ Hydro

supplied many large low-head vertical Francis and Kaplan turbines. From the large turbines in the underground powerhouse at New Zealand's largest hydro station at Manapouri (800 MW) to the brand new generators replacing existing units at Aratiatia in the North Island, more than 50% of the installed capacity in the country features either an ANDRITZ generator or a turbine.

The ANDRITZ Hydro team in New Zealand is passionate about delivering fit-for-purpose engineering solutions to our customers. Based on modern engineering solutions, the supply and installation of new equipment on a "from water-to-wire" basis is our core expertise. Naturally, major refurbishments of electro-mechanical equipment and valves, as well as turbine governing and excitation control systems are also part of our product portfolio. In addition, our services include condition assessment, spare parts supply and installation, detailed engineering calculation and advice on technical issues, and troubleshooting. ANDRITZ Hydro furthermore offers upgrade and refurbishment options and advice, as well as refurbishment and repair of all hydropower-related mechanical and electrical equipment.

NEW OFFICE

ANDRITZ Hydro has recently relocated to a larger office and warehouse facility in Christchurch in the South Island. The new office allows for business expansion, more storage on site, as well as a small workshop area for the growing service team.

TO KNOW:

General data:

Population:	4.794 million
Access to electricity:	100%
Installed hydropower capacity:	5,437 MW
Share of generation from hydropower:	62%
Hydro generation per year:	25,304 GWh

ANDRITZ Hydro in the country:

Installed and/or rehabilitated capacity:	3,131 MW
Installed and/or rehabilitated units:	134
Location:	Christchurch
Mailadress:	contact-hydro.nz@andritz.com

Source: Hydropower & Dams World Atlas 2018

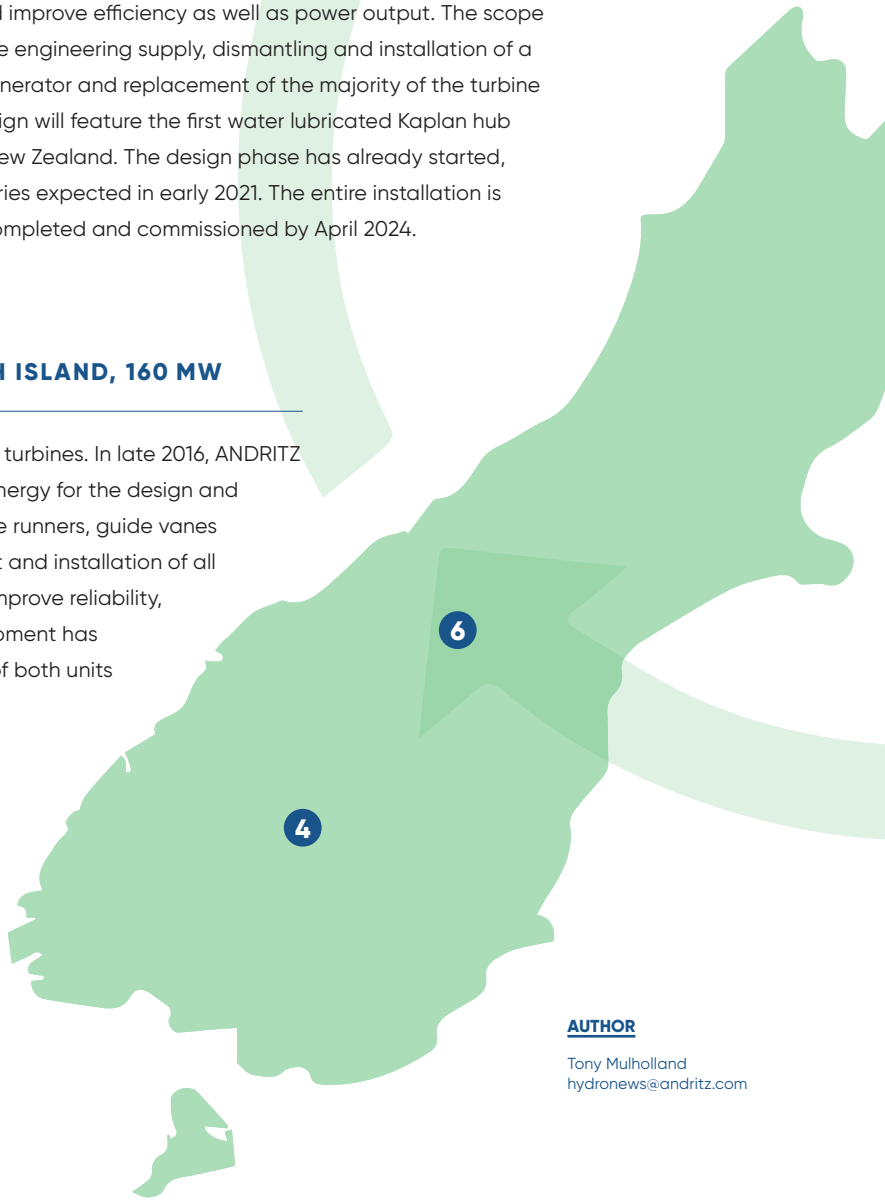
TO RENEWABLE ENERGY

5 KARAPIRO, WAIKATO RIVER, 90 MW

In January 2019, ANDRITZ Hydro signed a contract for the major refurbishment of the three Kaplan units with the main objectives to improve reliability, modernize the equipment and improve efficiency as well as power output. The scope of work includes the engineering supply, dismantling and installation of a completely new generator and replacement of the majority of the turbine parts. The new design will feature the first water lubricated Kaplan hub to be supplied in New Zealand. The design phase has already started, with the first deliveries expected in early 2021. The entire installation is scheduled to be completed and commissioned by April 2024.

6 TEKAPO B, LAKE PUKAKI, SOUTH ISLAND, 160 MW

The station contains 2 × 80 MW existing Francis turbines. In late 2016, ANDRITZ Hydro was awarded a contract from Genesis Energy for the design and model testing followed by supply of new turbine runners, guide vanes and associated parts, along with refurbishment and installation of all equipment on site. The project objective is to improve reliability, hydraulic stability and efficiency. The new equipment has been delivered to site in 2019, with installation of both units expected to be completed in 2020.



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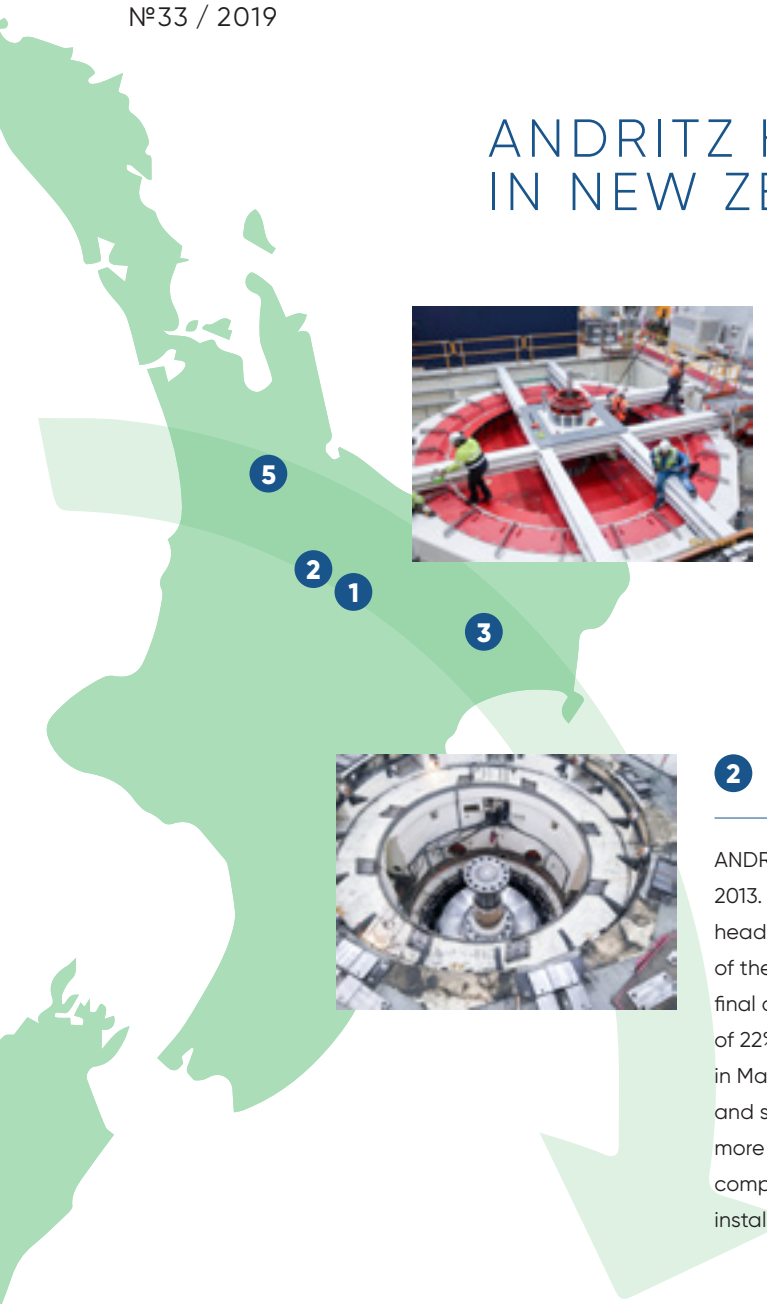
ANDRITZ HYDRO PROJECTS IN NEW ZEALAND



1 ARATIATIA, WAIKATO RIVER, 92 MW

ANDRITZ Hydro will design, deliver, install, and commission three generators, one Francis runner including model test, and three turbine governors for this plant, owned by Mercury NZ. After the refurbishment, the plant will have a significant increase in efficiency and reliability. ANDRITZ Hydro is currently implementing the site works and has already commissioned two units. The project completion is expected by mid-2020.

2 WHAKAMARU, WAIKATO RIVER, 128 MW

ANDRITZ Hydro was awarded the contract to upgrade the turbines in 2013. The agreed scope of supply included four Francis turbine runners, head covers, bottom rings, guide vanes, and the complete replacement of the governing equipment with a new high-pressure system. The final design has a turbine rated just under 32 MW – a rating increase of 22%. Installation and commissioning of the first unit was completed in May 2017. Site efficiency testing took place during commissioning and showed a significant gain in efficiency over the old turbine and more than had previously been expected. Two further units have been completed with the last unit already delivered and expected to be installed in the summer of 2020 to complete the project.

3 PIRIPAUA, LAKE WAIKAREMOANA, 42 MW

ANDRITZ Hydro has supplied two replacement butterfly main inlet valves. The existing slide valves from the 1940s were unreliable and the customer Genesis Energy awarded a contract in 2017 to ANDRITZ Hydro to design, supply, install and commission the replacement butterfly valves. Successful commissioning of the first unit was achieved in June 2019. The second replacement takes place from September to December 2019.

4 UPPER FRASER, FRASER RIVER, 8.1 MW

ANDRITZ Hydro has supplied one vertical, five-jet 8.1 MW Pelton compact turbine, main inlet valve, generator, excitation system and ancillary plant for this plant owned by Pioneer Energy. Civil construction by Pioneer and equipment installation by ANDRITZ was completed in June 2019, with the unit entering commercial service in July 2019. The scheme will produce an estimated 31 GWh of renewable electricity generation and is one of the highest head power stations in New Zealand with a gross head of 475 m.

PROJECT

LAÚCA, ANGOLA

Further milestones achieved

July 2019: The 72-hour reliability run of unit #5 at the Laúca HPP in Angola was successfully completed and the PAC (Preliminary Acceptance Certificate) for unit #4 was issued.

The scope of supply for ANDRITZ Hydro includes design, supply, installation supervision, and commissioning of the Francis turbines, generators, main transformers, isolated bus ducts, as well as control and protection systems. The security, access control and telecommunication systems for both the main and eco powerhouses are also included within the scope of supply.

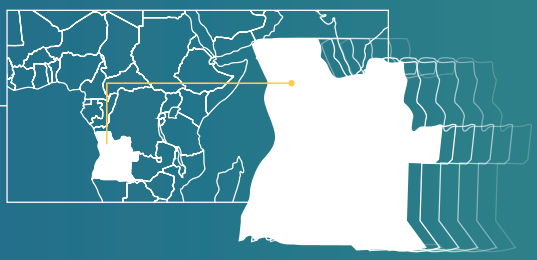
All units are scheduled to be completed and in commercial operation in 2020.

With a total capacity of 2,070 MW, Laúca will produce approximately 8,600 GWh of renewable energy per year, enough to supply about 8 million Angolan households, making a significant contribution to the rapidly growing demand of the country.

As Angola is a fast growing economy, the demand for electricity is constantly increasing. Laúca is an important step to improve the country's energy supply.

TECHNICAL DETAILS

Total output: 2,070 MW
Scope: 6 × 338 MW (Main) / 1 × 42 MW (Eco)
Head: 200 m (Main) / 118 m (Eco)
Voltage: 6 × 18 kV (Main) / 1 × 15 kV (Eco)
Speed: 200 rpm (Main) / 233.77 rpm (Eco)
Runner diameter: 4,790 mm (Main) / 3,220 mm (Eco)



UPDATES

YUSUFELI, TURKEY

Adding to the energy supply

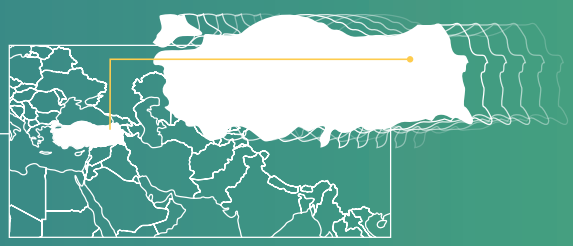
Mid-2019: The draft tube and spiral case installation, stator stacking and on-site rotor winding as well as engineering services are ongoing.

Scope of contract for ANDRITZ Hydro includes the design, supply, installation, and commissioning of turbines, generators and EPS equipment, as well as intake structure, penstock and gates and staff training.

Yusufeli Dam is the third highest arch dam worldwide and the highest in Turkey. Due to a delay of civil works, commissioning of the plant is postponed. As per the schedule the last unit will be handed over in December 2020.

TECHNICAL DETAILS

Total output: 558 MW
Scope: 3 × 186 MW (203 MVA)
Head: 191 m
Voltage: 14.4 kV
Speed: 214 rpm
Runner diameter: 3,500 mm



International teams from ANDRITZ Hydro are working on the project execution.

At 270 m, Yusufeli dam is the third highest double-arched dam in the world.

About 2,200 tons steel for the gates and about 3,800 tons steel for the penstocks will be used for Yusufeli.

The new Pelton turbine completes the existing reversible pump turbines and features extremely good part load behavior.

LA COCHE, FRANCE

The most powerful hydro unit in France

May 2019: The erection phase has been successfully completed at an accelerated time schedule. Quality and alignment tests during installation were successful and the customer, EDF, is satisfied with the quality of the equipment installed. After a smooth commissioning, the hydropower plant was officially inaugurated on October 14, 2019 with a big opening ceremony.

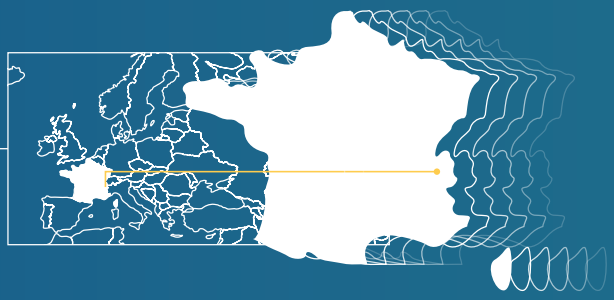
Scope of contract for ANDRITZ Hydro comprised the design, manufacturing, installation and commissioning of an additional turbine-generator unit. This included excitation for the extension of this pumped storage plant. Manufacturing and purchasing was solely done in Europe.

The new unit will be able to provide 240 MW and has a wide operational range. It has one of the most efficient runners worldwide produced with MicroGuss* technology and is the most powerful hydro unit in France. The turbine was coated with HVOF (SXH70) at ANDRITZ Hydro's manufacturing facility in Ravensburg, Germany.

Transfer of the unit after finalization of wet commissioning, efficiency tests and two phases of trial runs is expected for January 2020. Upon completion of the works the total power output of the hydropower plant will be increased by 75% from 280 MW to 520 MW.

TECHNICAL DETAILS

Total output: 520 MW
Scope: 1 × 240 MW
Head: 908 m
Voltage: 15.5 kV
Speed: 428.60 rpm
Runner diameter: 2,840 mm



Originally commissioned in 1963/64 the plant is located on the Sasketchewan River.

E.B. CAMPBELL, CANADA

Remarkable progress on a major refurbishment

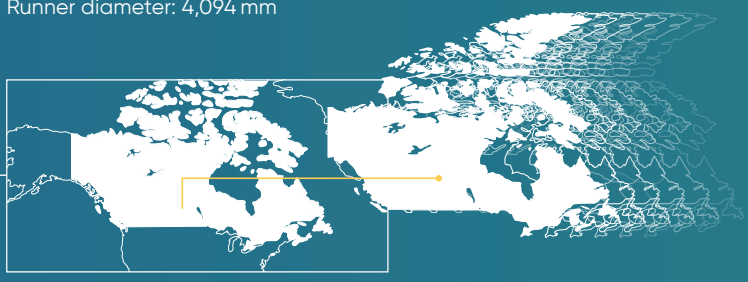
August 2019: The EB Campbell Life Extension project for SaskPower in Saskatchewan, Canada, is progressing very well. Engineering is completed and procurement is well underway. Site mobilization was achieved in July 2019. Outage and the start of work on the first unit (unit #3) occurred in August 2019. Dismantling of the first unit was completed in early September 2019. Removal of old hoists and head gates is already complete. They will be replaced with new components. New trash racks have also arrived at the site.

Scope of work for ANDRITZ Hydro includes refurbishment of six of the eight units, including model testing, condition assessment, design, manufacturing, transportation, installation and commissioning of new Francis runners with a 4 m diameter. In addition, a new complete distributor, new stator frame, core and windings, and a number of refurbished components, as well as gates, trash racks and hoists are also part of the contract.

Unit #3 is scheduled to be back in service in May 2020. The remaining five units will be refurbished, one per year, over the following years.

TECHNICAL DETAILS

Total output: 297 MW
Scope: 6 × 35 MW / 6 × 43.5 MVA
Voltage: 14.4 kV
Head: 32 m
Speed: 120 rpm
Runner diameter: 4,094 mm



This is one of the biggest refurbishment contracts for ANDRITZ Hydro in Canada to date.

Srinagarind is the first multipurpose dam under the Development of Mae Klong River Basin Project.

SRINAGARIND, THAILAND

Green energy for the Kingdom of Thailand

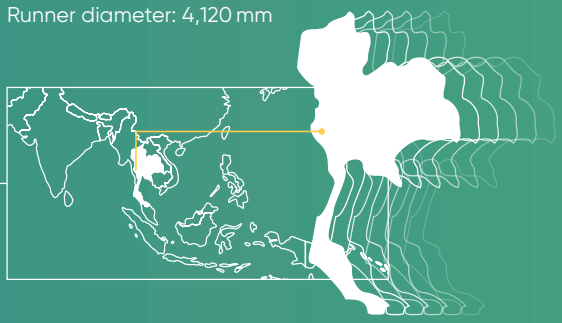
February 2019: The first unit for the Srinagarind project was completed, working together with the team at local utility EGAT. The unit is in commercial operation and operating successfully in the warranty period.

The scope of the contract for ANDRITZ Hydro included rehabilitation of three Francis units including generator replacement, turbine upgrade with a new runner, replacement of the cooling water and mechanical auxiliary systems, as well as replacement of the electrical equipment, transformers, and SCADA system.

Unit #2 is also due to start operation in 2019. As per the schedule the last unit will be completed in 2020.

TECHNICAL DETAILS

Total output: 720 MW
Scope: 3 × 144 MW (150 MVA)
Head: 105 m
Voltage: 14 kV
Speed: 166.7 rpm
Runner diameter: 4,120 mm



SY-SIMA, NORWAY

World's largest MicroGuss* Pelton runner

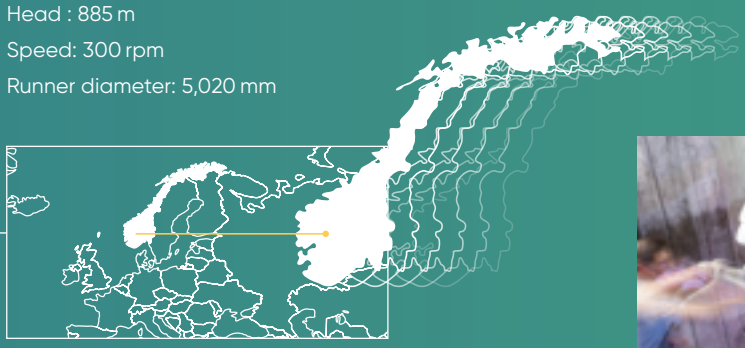
June 2019: The first out of two units have been successfully commissioned at Sy-Sima. Post commissioning on-site efficiency measurements show good results and confirm good margins beyond the guaranteed performance values.

Scope of contract for ANDRITZ Hydro included supply, design, engineering, manufacturing, installation, and commissioning of both Pelton runners, including a full homologous model test.

The full model test prior to manufacturing was completed in our laboratory in Vevey, Switzerland. Manufacturing was performed at the ANDRITZ Hydro workshop in Ravensburg, Germany. With an outer diameter of 5,020 mm, Sy-Sima has the largest Pelton runners manufactured with MicroGuss* welding technology in the world.

TECHNICAL DETAILS

Total output: 630 MW
Scope: 2 × 315 MW
Head : 885 m
Speed: 300 rpm
Runner diameter: 5,020 mm



Upper Tamakoshi is the largest hydropower plant in Nepal, important for meeting the country's growing energy demand.

UPPER TAMAKOSHI, NEPAL

Everything on track again

Mid-July 2019: Dry commissioning of all the six generating units has been completed at the Upper Tamakoshi HPP. Preservation activities for the installed units is now underway. Overcoming challenges such as building bypass bridges, equipment handling, storage and preservation at intermediate stores and convoy management to cope with poor road conditions, 49 over-sized consignments were successfully delivered to the site. All 18 generator transformers and the 220 kV gas-insulated switchgear have been successfully tested for power evacuation. Installation works of the 220 kV XLPE cable are underway. Until mid-Sept 2019, 14 ferrules at the lower penstock shaft were installed.

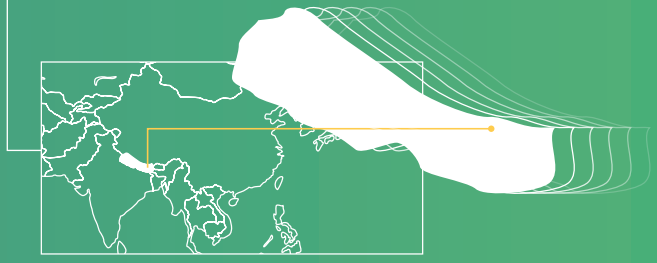
With a diameter of 2,500 mm and a pressure of 89 bar, one of the biggest spherical valves ever manufactured by ANDRITZ Hydro has been successfully assembled on site.

Scope of contract includes supply, installation, and commissioning of the entire electro-mechanical equipment. In addition, and based on the excellent performance of ANDRITZ Hydro on the electro-mechanical works, an additional order for the penstock installation and on-site repairs has also been received.

Upper Tamakoshi is the largest hydropower plant in Nepal with an underground powerhouse. It has a total capacity of 456 MW to meet the country's growing power demand.

TECHNICAL DETAILS

Total output: 456 MW
Scope: 6 × 76 MW
Head: 805 m
Voltage: 220 kV
Speed: 600 rpm




321MW

BEST PRACTICE EXAMPLE

An award-winning environmental, social and economically successful renewable energy development, Reventazón is the largest hydropower plant in Costa Rica. Today it is cleanly, sustainably and safely generating clean electricity for more than half a million of the country's homes.

TECHNICAL DETAILS

Reventazón:

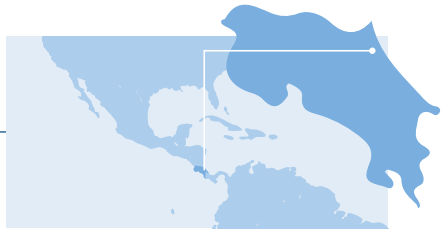
Total output: 321 MW

Scope: 4 × 76.5 MW (Main) / 1 × 15 MW (Eco)

Head: 130 m

Speed: 300 rpm

Runner diameter: 2,470 mm



Costa Rica – In February 2019, the Final Acceptance Certificate ("Finiquito") for the Reventazón main hydropower plant in Siquirres, Costa Rica, was mutually signed between Instituto Costarricense de Electricidad (ICE) and ANDRITZ Hydro.

With an installed capacity of 321 MW, Reventazón is the largest hydropower plant not only in Costa Rica, but across the whole of Central America. The contract was awarded in October 2011 with a project execution timetable of five years. All five turbine-generating units, including a special 'Ecological Unit', began commercial operations in 2016. Since then, the project has allowed Costa Rica to largely achieve its target of generating 100% of its electricity from renewable energy resources.

ANDRITZ Hydro supplied the electromechanical equipment for the project. Consisting of four Francis turbines and main inlet valves, penstock butterfly valve, four generators, mechanical and electrical auxiliary equipment, control, excitation and protection systems, as well as a turnkey 15 MW Eco unit in a separate powerhouse, the project featured ANDRITZ Hydro teams from both Italy and Austria.

ANDRITZ Hydro manufacturing team in Morelia, Mexico in front of the penstock valve for the Reventazón project. ANDRITZ Hydro teams from Austria and Italy supplied the electro-mechanical equipment for this outstanding award-winning project.

In May 2019, the IHA (International Hydropower Association) awarded the Reventazón hydropower plant with the Blue Planet Prize. Given to a hydropower project that demonstrates excellence across a range of social, environmental, technical and economic performance criteria, Reventazón and Costa Rica became the first Spanish-speaking nation to receive the prize and the second in Latin America, after Brazil.

"With the Blue Planet 2019 award, Costa Rica, in addition to being recognized for its natural wealth, is positioned as a global example for developers of clean and renewable energy."

The Costa Rica News

Reventazón demonstrates that hydroelectric projects can make a significant contribution, not only to the generation of energy in a country, but also in the application of international best practices for the technical, environmental, and social management of works regarding renewable energy.

ANDRITZ Hydro is proud to be part of this project and to support the Instituto Costarricense de Electricidad (ICE), Costa Rica's national electricity company, which built, owns, and operates Reventazón.

The successful execution of the important Reventazón project again underlines ANDRITZ Hydro's leading position in Costa Rican hydropower and strengthens our position for future projects with ICE across the entire Central American region.

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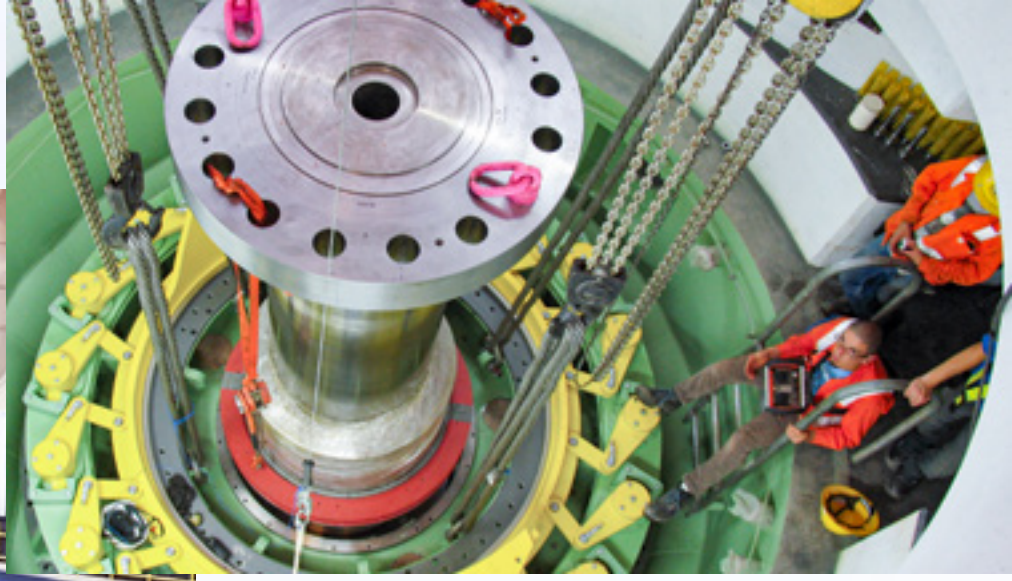
On receiving the award, Irene Cañas Díaz, President of ICE, stated: "This is an important award for ICE, its staff and Costa Rica, and an excellent example from the public sector of a small Latin American country to the world that we can do better hydropower, which is more inclusive and environmentally sensitive."

© IHA (International Hydropower Association)



Costa Rica already generates 99% of its energy from renewable sources. By 2050, the Central American country plans to be completely CO_2-neutral.

TO KNOW:

Costa Rica – Central America's Renewable Powerhouse
Hydropower is essential to the economic development of Costa Rica. Although the electrification rate of Costa Rica is about 99% and therefore is the highest in Central America, electricity demand is continuously increasing, currently estimated at 4% annually over the next decade.

Costa Rica has a total installed hydropower capacity of 2,328 MW, providing about 8,676 GWh/year according to data from 2017. This represents more than two thirds of the nation's total power production. In 2017 and 2018, the country ran solely on renewables for more than 300 days, making it a forerunner in renewable development across not only Central America but worldwide.

To meet the needs of an expanding population, increased rural electrification and growing demand for power, further development of Costa Rica's abundant hydropower resources is now being intensely promoted.

The country has drafted a detailed plan to decarbonize its economy by 2050, in line with the Paris Climate Agreement and the UN's' Sustainable Development Goals. In September 2019, the United Nations selected Costa Rica as its "Champion of the Earth" in the policy leadership category for its exemplary engagement against climate change.

SITE REPORT // AUSTRIA, MURKRAFTWERK GRAZ

RENEWABLE ENERGY

FROM THE HEART OF AUSTRIA

Austria – In March 2017, Austria's E-Steiermark awarded ANDRITZ Hydro a contract to supply two Bulb turbines for the Murkraftwerk Graz hydropower plant. The machines, with a rated capacity of 8.85 MW each, are destined for a plant located on the river Mur right in the heart of the Styrian capital of Graz. Alongside the turbines, the scope of supply includes speed controllers, generators, excitation and the entire control system. Murkraftwerk Graz, Errichtungs- und BetriebsgmbH, will build the plant.

Pre-installation works for the draft tube liners started in April 2018, one of the first major site activities executed by ANDRITZ Hydro. Following installation of the generator hatch frame in mid-2018, the bulb case was delivered to site in October the same year. As this is one of the heaviest components, a 500-ton mobile crane was required on site.

"Renewable forms of energy create added-value and jobs."

Anton Lang, Styria's Provincial Minister for Energy and Climate Protection

With the conclusion of all the pre-installation works, in March 2019 the main installation works began. Within a very short period all the main components, including the wicket gate mechanism, pre-installed shaft and bearing systems, runner, generator rotor and stator, were installed.

Wet commissioning of the first unit started in mid-June 2019. After five weeks, and after passing all required tests, in July this year the first unit was released for commercial operations and for the 30-day trial run period.

Immediately thereafter wet commissioning of the second unit began. In October 2019, the hydropower plant was officially put into commercial operation.

The Murkraftwerk Graz will provide enough electrical energy to supply about 20,000 households with clean, emission-free electricity, saving about 60,000 tons of CO_2 every year.

ANDRITZ Hydro is proud to be part of this important, sustainable clean energy project right here on our doorstep in the heartlands of Austria.

TECHNICAL DETAILS

Murkraftwerk Graz:

Total output: 17.7 MW

Scope: 2 × 8.85 MW

Voltage: 6.3 kV

Head: 9.65 m

Speed: 150 rpm

Runner diameter: 3,600 mm

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PROVEN SUCCESS

Vietnam – All eight units of the large Hoa Binh hydropower plant in Vietnam have been back in action since December 2018, now using ANDRITZ Hydro's cutting-edge automation technology.

With a total installed capacity of 1,920 MW, Hoa Binh is the second largest hydropower project in Vietnam and one of the largest hydropower projects in Southeast Asia. It is key to Vietnam's power system, playing a crucial role in the socio-economic development of the country.

The Hoa Binh Dam is located about 76 km west of Hanoi City on the final terrace step of the Da River. A multipurpose project, plant tasks include flood control, power generation, drought prevention, and ensuring navigation of the waterways. The hydropower plant was built in 1979 and the first unit began operations at the end of 1988. Last of the units began operations in 1994. As a result, although some individual equipment systems have been upgraded, the bulk of the equipment in the plant has been operating for over 25 years.

In October 2015, ANDRITZ Hydro received a contract from the Vietnam Electricity's (EVN) Hoa Binh Hydropower Company for the design, equipment supply and technical services for the upgrade. Denoted as "Project: upgrade of control, protection, signal and measurement system for eight generating units of Hoa Binh Hydropower Plant", the project scheduled an execution time of two years. This equated to a 'four-units-per-year' repair cycle ideally suited to large projects. Site works began in February 2017 and the last two paired units were completed in December 2018, 30 days ahead of the original schedule. Throughout the project all items were properly deployed per the schedule put into operation safely and on time.

Today, the Hoa Binh Hydropower Plant uses ANDRITZ Hydro's latest technologies to increase plant reliability and availability and, together with favorable hydrological conditions, this edge helped the plant achieve its highest ever annual power production last year – reaching 12,290 GWh in 2018. Hoa Binh continues to operate smoothly and safely, and will do so for years to come.

AUTHOR

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TO KNOW:

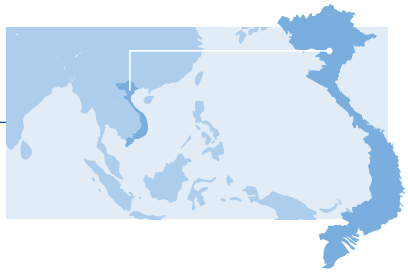
Inauguration Ceremony

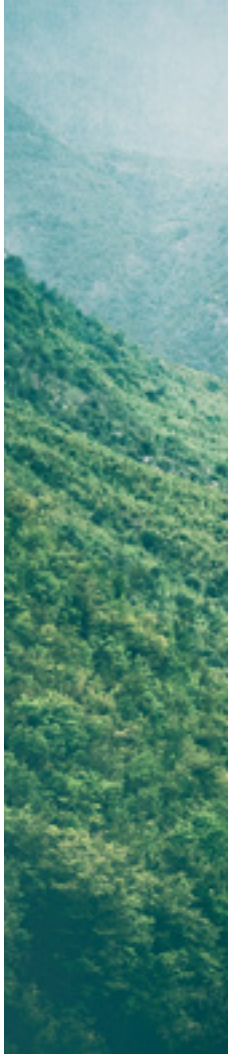
In August 2019, Vietnam Electricity (EVN) held a Project Acceptance Review and Inauguration Ceremony for the upgrading of the secondary systems of Hoa Binh under the presence of representatives of various member units of EVN, Hoa Binh Hydropower Company and the consortium ANDRITZ – Narime. In his speech, the CEO of EVN, Mr. Ngo Son Hai, expressed his delight to see immediate impacts of the newly upgraded systems, conveyed his compliment and thanks to the consortium on its performance, and appreciated the efforts of the whole project team.

TECHNICAL DETAILS

Hoa Binh:

Total output: 1,920 MW
Scope: 8 × 240 MW
Head: 109 m
Voltage: 15.75 kV
Current: 9,780 A
Speed: 125/240 rpm
Runner diameter: 5,672 mm





Interview *with*
Fatos Bundo

The backbone of Albania's power generation

Komani refurbishment project, Interview

In 2012, the Albanian state-owned utility KESH awarded ADRITZ Hydro a contract for the full-scale refurbishment of the Komani hydropower plant. Fatos Bundo is CEO Adviser to the Albanian Power Corporation, which is responsible for the overall energy supply in Albania. Hydro News spoke with him about his experiences during this important hydropower plant refurbishment.

Albania – Albania's Komani hydropower plant is the second of three installations in the Drin River Cascade and the country's most powerful hydropower plant. Located in northern Albania, with a 96 m head the plant features four vertical Francis units with a capacity of 150 MW each. Construction began in 1980, the first turbine began operations in 1985, and the full 600 MW generation capacity was achieved in 1988.

After more than two decades of operations, in 2012 the state-owned utility Korporata Elektroenergjitike Shqiptare sh.a (KESH) awarded ANDRITZ Hydro a contract for a full-scale refurbishment. The scope of supply included rehabilitation of turbine and generator components, electrical power systems, control and monitoring, and related auxiliary systems. The refurbishment., executed by ANDRITZ Hydro teams in Austria and Switzerland, was completed in February 2019 with the recommissioning of unit #4. Today the plant is producing around a third of Albania's total electricity demand.

TECHNICAL DETAILS

Komani:

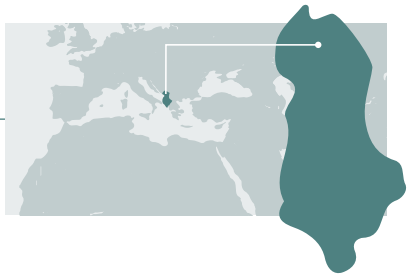
Total output: 600 MW

Scope: 4 × 150 MW

Head: 96 m

Voltage: 13.8 kV

Speed: 158 rpm



With 600 MW, Komani is the largest hydropower plant in Albania, producing more than 30% of the country's total electricity demand.

Why was a full-scale rehabilitation of the hydropower plant required at Komani?

By 2010, Komani had worked more than 20 years and rehabilitation is usually necessary after such a period. Inception study investigations showed that, with the exception of the runners, which were working smoothly, all the other mechanical and electrical components needed to be tested, measured and investigated to determine the need for repair, rehabilitation or replacement.

The aim was to improve the operational parameters of the units, bringing them back to the same level of performance as when it was constructed and increase readiness, efficiency and the life time of the plant. A partial rehabilitation would have only postponed a necessary full rehabilitation.

ABOUT:

Fatos Bundo is the CEO Advisor for the Albanian Power Corporation (APC) and Project Management Unit Director for Dam Safety. APC is responsible for overall energy supply in Albania. Bundo is the Project Manager for all dam safety contracts financed by the World Bank, KfW, EBRD and SECO for the Drin River Cascade. Among his responsibilities, he oversaw implementation of the electro-mechanical rehabilitation and installation of a new control and monitoring system at Komani.

Strict requirements and stipulations necessitated top tier expertise and experience for successful execution of the project.

→ What special or unique characteristics were encountered at this project?

Komani is one of the biggest power stations in the Balkans. Consequently there were very strict requirements with regard to quality of engineering and the implementation of mechanical and electrical works. A very high level of engineering knowledge and experience was a prerequisite to successfully reach the objective of achieving the operational parameters of the plant established with the original design.

In terms of achieving that goal, one of the most challenging issues was the large dimensions of the equipment that had to be transported to the site and installed, as well as the harmonization of the rehabilitation works with the schedule of operations in terms of power generation for KESH.

"With a rated capacity of 600 MW, Komani is the largest hydropower plant in Albania and produces a third of the country's total electricity demand."

How was the sustainability of this project ensured?

As a very important element of Albania's national infrastructure this EUR 35 million project was partially funded by a World Bank loan. Consequently, a critical aspect of this development was to meet the environmental requirements as set out in World Bank criteria. While no specific environmental key performance indicators have been applied for this project, the environmental requirements are in line with World Bank criteria standards for WB bid procedures.

Furthermore, the project itself has, for the first time, installed a system to drain the oil from the transformers. This is a new system that provides self-drainage and collection of oil in appropriate containers before further treatment off site. The main concern was that the oils were contaminating the waters of the Drin River.

What considerations were taken into account in selecting the technology used?

The rehabilitation strategy that we adopted was not to radically change the existing design. We hoped to keep to the original technology as much as possible and to see where it was possible to adopt more modern and improved solutions. For example, as one of the modernization measures, it was decided to install a new chlorination system to stop algae and mussels from building up inside water pipes within the power plant. Another important modernization saw the installation of a completely new digital controlling and monitoring system for the generation units which was integrated with Albanian Power System protocols, for example.

Why was ANDRITZ Hydro selected as a supplier?

ANDRITZ Hydro Austria was the primary contractor while the owner's engineering consultants were AF Consulting, Switzerland, and Junik sh.p.k. of Albania. We selected ANDRITZ Hydro to execute this very important project as they are very experienced and have specialist knowledge in the rehabilitation of hydropower plants. We have also had previous successful experiences in Albania with ANDRITZ Hydro, for example a transformer refurbishment project that was executed several years previously. Indeed, ANDRITZ Hydro submitted the only technically compliant offer received under this project tender.

Adapting the new equipment to the existing technology to achieve the best performance was a challenging task.

"The Drin River Cascade has a total installed capacity of 1,400 MW and is the backbone of Albania's power generation. The Cascade also plays an important role in moderating water flows on the Drin River, reducing the frequency and risk of flooding as well as creating opportunities for fishing, transport, and tourism."

Fatos Bundo, CEO Advisor for the Albanian Power Corporation (APC), Project Management Unit Director for Dam Safety.

How satisfied are you with the ANDRITZ Hydro offer and the execution of the project?

> **All activities performed by ANDRITZ Hydro were as per our expectations. They were very professional in their approach as well as in their project execution. In particular there were many challenges which emerged during the implementation phase. We raised a lot of difficulties related to the differences between the old technology which had been implemented in the past and adaptation of the new technology that had been proposed by the contractor. However, the ANDRITZ Hydro engineers and project managers have been very professional in accommodating all of these special requests and demands as they arose. This was a long-term project and took seven years from the date of the contract signature in July 2012. The commissioning procedure has been implemented as per time schedules agreed between all the concerned parties.**

Overall how was your experience of working with ANDRITZ Hydro on this refurbishment project?

> **The plant is still under the monitoring process following recommissioning but it is performing at a high level and is very productive. Following the refurbishment it is once again on track to produce some 1,800 GWh annually as per the original specifications. That constitutes about 45% of the total Drin Cascade Production. As well as on-the-job training of the local staff by ANDRITZ Hydro specialists, dedicated courses were organized at the Komani site with a predefined thematic, as well as training in Austria. We're currently recruiting local operations and maintenance staff and ANDRITZ Hydro operator training will enable us to continue training our staff. In addition, ANDRITZ Hydro is providing essential spare parts and all the technical documentation as per the contract agreement. We will certainly recommend further collaboration with ANDRITZ Hydro to our management.**

AUTHOR

Interview by David Appleyard
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BUILDING A SUSTAINABLE LIVELIHOOD

Turkey – One of the most impressive engineering projects in Turkey is the 1,224 MW Ilisu Dam on the Tigris River in South East Anatolia. In 2008, ANDRITZ Hydro received an order to design, engineer, manufacture, supply, install and commission the entire electro- and hydro-mechanical equipment for this major hydropower project.

TECHNICAL DETAILS

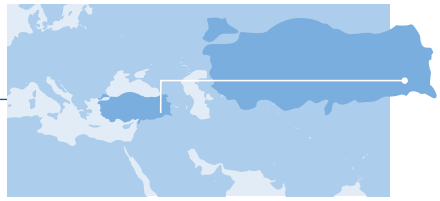
Ilisu:

Total output: 1,224 MW

Scope: 6 × 204 MW

Head: 110 m

Runner diameter: 4,200 mm

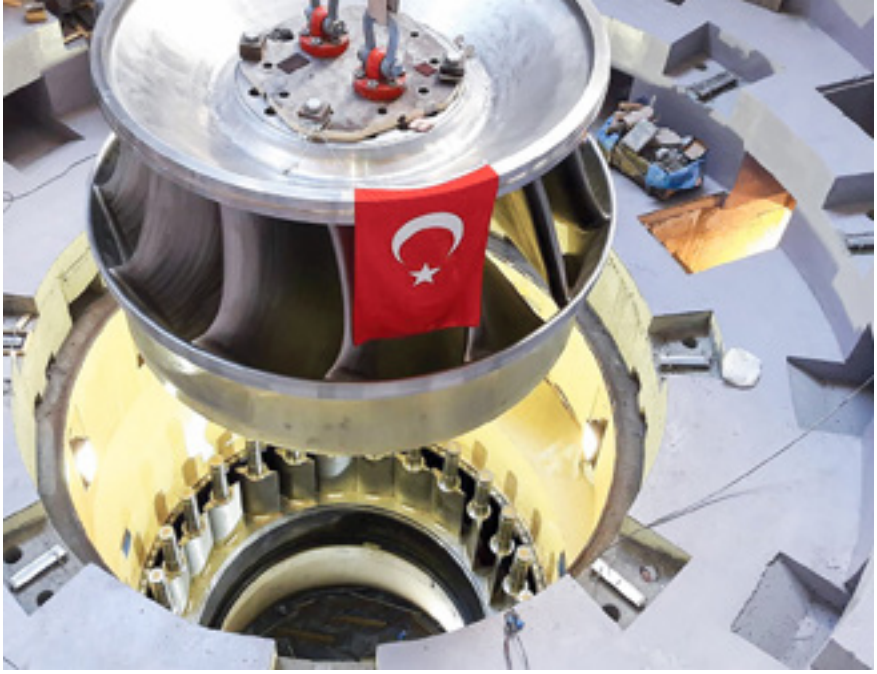


Starting in May 2008, the Turkish State Hydraulic Works, the Ministry of Energy and Natural Resources and others have expended a huge amount of energy and effort in supporting the project. Archeological and cultural works, resettlement, relocation of roads, environmental and social works are now close to completion. This will allow the Ilisu Dam to begin impounding water.

Turkey is remarkably rich in cultural heritage. Headline archeological and cultural conservation works have unearthed historical monuments and buildings at the ancient city of Hasankeyf that are being carried forward to future generations. Hasankeyf Ancient City is a centre of attraction for tourism. Under the Ilisu Dam and HEPP Project, following strengthening of the antique buildings they were transferred to the Cultural Peninsula in New Hasankeyf where restoration works are ongoing.

Resettlement of Hasankeyf residents has also been completed. All public institutions in the district including government offices, the Municipality Service Building, and District Police Headquarters have also been moved to their new locations. The Vocational School of Tourism started mobile teaching to develop cookery and tourism hotel management skills while three common schools are now teaching in their new location. The local library and mosque have started to serve the people as has the hospital. The Directorate of Museums has been moved and has started with a partial exhibition while 710 new houses have already been handed over to displaced citizens.

By 2011, New Ilisu Village houses had already been delivered to 48 owners. In addition, a village hall, primary school, mosque, health centre and 48 barns were also constructed. Similar construction measures for the resettlement of all the other villages that will be submerged under the new Ilisu Dam Lake have also been completed.



Runner lowering in 2018; with a weight of 41 tons, the last runner out of six was lowered and installed marking an important milestone of the installation works.

To address the economic concerns of local people ANDRITZ Hydro built a Vocational Education School in Mardin City where more than 150 local people were trained in welding, mechanics and electrical installation.

During execution of the project, ANDRITZ Hydro also addressed the economic concerns of local people by building a Vocational Education School in Mardin City. Austrian and Turkish teachers trained more than 150 people in vocational skills such as welding, mechanics and electricity. Designed to give local people with no college education the opportunity to gain occupational skills within just eight months, all of these trainees are now employed by local state and private organizations. Some preferred to work for ANDRITZ Hydro. By March 2015, the training centre, including all of its equipment, was handed over to the Governor of Mardin.

ANDRITZ Hydro provided the entire electro- and hydro-mechanical equipment for the Ilisu project as a "from water-to-wire" concept. All the turbines and generators, transformers and switchyard, the complete electrical and mechanical Balance of Plant equipment, as well as the penstock and gates for this project were manufactured in Europe and Turkey using cutting-edge ANDRITZ Hydro technology.

By June 2019, dry commissioning of all the hydro-mechanical and electro-mechanical equipment was completed. The hydro structures and related electro-mechanical equipment have been ready for impounding since December 2017. With the completion of final reservoir works, the impounding of water started in July 2019.

As a result, water will be available for wet commissioning by the beginning of 2020.

After the completion of the project, scheduled for the end of 2020, the six units with a capacity of 204 MW each will generate some 4.12 TWh energy annually. This impressive project will thus make a significant contribution to the stabilization and growth of the Turkish economy.

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With six powerful and top modern generation units and a total output of 1,224 MW, Ilisu will significantly increase the power supply in southeastern Turkey.

A MODEL FOR THE FUTURE

Lao PDR – Back in 2012, ANDRITZ Hydro received an order from Ch. Karnchang (Laos) Company Ltd. for the supply of electro-mechanical equipment for the Xayaburi run-of-river hydropower station.

Since then, major steps for the completion of this important hydropower plant on the Mekong River have been concluded. The electro-mechanical equipment consisting of seven 175 MW Kaplan units for EGAT, one 60 MW Kaplan unit for EdL (Électricité du Laos), as well as two Compact units with a capacity of 4 MW each, as well as all related and common auxiliary systems, have been designed, engineered, and transported, and installation has been completed.

After successful testing with the main stakeholders of the project – Ch. Karnchang Laos, Xayaburi Power Company (XPCL) and EGAT – all 175 MW units are now in commercial →

The oil-free Kaplan runners for Xayaburi are the largest and most powerful built to date.

Installation of the generator rotor into the generator pit requires absolute precision and know-how.

With 1,285 MW, Xayaburi is going to be the most important hydroelectric plant on the Mekong River.

"After completion Xayaburi will provide about 7,300 GWh per year of electricity for more than 3 million households."

operation. After wet commissioning, the 60 MW EdL unit is currently in the trial run phase. The trial run consists of continuous full load and start/stop sequences.

The non-unit related auxiliary systems are highly complex. Ranging from electronics systems such as telephone, video, and data transmission to mechanicals like waste and potable water supply systems they are being finalized with the installation and commissioning of Xayaburi.

From July 2019 onwards, important developments have been implemented with the finalization of the units #7 and #8, as well as all auxiliary systems. This completes the scope of the contract through to the Commercial Operation Date (COD), scheduled for the end of October 2019.

An important addition to the original scope of the contract for ANDRITZ Hydro was the auxiliary powerhouse with two 4 MW Compact units to facilitate fish upstream migration. This installation enables the upstream migration of fish through the Xayaburi Mekong River power station. With the local population largely relying on fishing, bypass facilities are an essential criteria for future Mekong River power plants. ANDRITZ Hydro makes a significant contribution to this

TO KNOW:

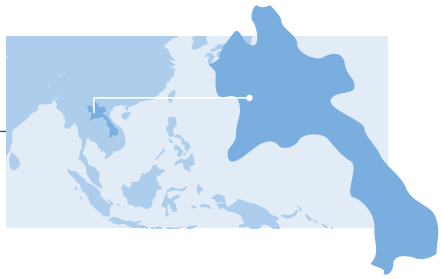
Cultural competences and the successful integration of different teams is of the utmost importance in big construction projects such as Xayaburi. ANDRITZ Hydro is working at this site with a global team of up to 1,200 employees from many different nations. To emphasize these strong relationships, local festivities and social needs are respected and celebrated together.

In July 2019, CK Power and XPCL together with CH Karnchang Laos, the local government, religious representatives and the public joined ANDRITZ Hydro staff at the Xayaburi site to hold a celebratory opening ceremony for the Buddha Pavillion on the upstream side of the power station.

TECHNICAL DETAILS

Xayaburi:

Total Output: 1,285 MW
Scope: 7 × 175 MW / 1 × 60 MW / 2 × 4 MW
Voltage: 16 kV / 13.8 kV
Head: 39 m
Speed: 83.33 rpm / 150 rpm
Runner diameter: 8,600 mm / 5,050 mm / 1,600 mm



important part of the Xayaburi Station. The auxiliary units, which create attraction flows for upstream fish migration, also produce the electrical energy required to run the complete station services, including seven large 1 MW pumps.

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Pictures courtesy of XPCL

ELECTRICITY FOR MORE THAN 3 MILLION HOUSEHOLDS

SMALL & MINI HYDRO HIGHLIGHTS

RANNEY FALLS

Update | Trent River, Northumberland | Canada
Successfully put into commercial operation
Output: 1 × 10.5 MW
Scope: "from water-to-wire" package
Highlight: largest ECOBulb turbine worldwide

TRAUNLEITEN

Update | City of Wels | Austria
Successfully put into commercial operation
Output: 2 × 8.75 MW
Scope: Compact Bulb turbines
Highlight: Replacement of existing power plant

METLAC

New | State of Veracruz | Mexico
Output: 3 × 2.45 MW
Scope: "from water-to-wire" package
Highlight: Upgrading the existing hydropower plant with new equipment

→ More on Page 52

DIETIKON

Update | Dietikon | Switzerland
Commercial operation since October 2019
Output: 2 × 1.75 MW / 1 × 0.68 MW
Scope: Complete electro-mechanical supply
Highlight: Redevelopment of the existing two Kaplan turbines and one new reserved-flow turbine

SAN ANDRÉS

Update | San Andrés River | Colombia
Commissioning expected beginning of 2020
Output: 2 × 11 MW
Scope: W2W package including 2-jet Pelton turbines

BARRINHA

Update | Santa Catarina | Brazil
Commercial operation since June 2019
Output: 2 × 1.8 MW
Scope: Compact Axial Turbines
Highlight: First Mini Compact in Brazil

EMBALSE DIGUA

New | Digua Reservoir | Chile
Commissioning expected 4th quarter of 2019
Output: 2 × 10 MW
Scope: "from water-to-wire" package
Highlight: 91 GWh per year of clean energy to the Chilean Central Interconnected System (SIC)

→ More on Page 52

NKUSI

Update | Nkusi River | Uganda
Commercial operation since October 2018
Output: 2 × 4.8 MW
Scope: Complete electro-mechanical supply
Highlight: Showcase for a privately developed small HPP in Africa

Small and mini hydropower continues to serve as a key element to increase access to electricity, rural electrification and industrial energy supply. While the global market is still below recent peaks, the outlook remains positive. Declining feed-in tariffs demand joint approaches by both supplier and investor to optimize returns.

BREIVIKELVA

New | Beiarn municipality | Norway
Output: 1 × 9.9 MW
Scope: W2W package including vertical Pelton turbine
Highlight: Additional 27 GWh renewable energy per year for Northern Norway

→ More on Page 53

KAMOLOT

New | Chirchik-Bozsu Canal | Uzbekistan
Output: 4 × 2.13 MW
Scope: Complete electro-mechanical equipment
Highlight: First order for Compact Hydro in Uzbekistan

→ More on Page 54

SELTI MUSRANG

New | Himachal Pradesh | India
Output: 3 × 8 MW
Scope: "from water-to-wire" package
Highlight: Benchmark project for Compact Hydro in India

→ More on Page 53

PHA CHUK

New | Uttaradit Province | Thailand
Output: 2 × 7 MW
Scope: Electro-mechanical package
Highlight: Meeting the government's policy of Alternative Energy Development Plan (AEDP 2015)

NAM KONG 3

New | Attapeu Province | Lao PDR
Output: 3 × 18 MW
Scope: Electro-mechanical equipment
Highlight: A new contract for Compact Hydro in Lao PDR

UPPER MALADUGAO

New | Bukidnon | Philippines
Output: 3 × 3.12 MW
Scope: "from water-to-wire" package

→ More on Page 55

CIKANDANG

New | West Java | Indonesia
Output: 3 × 2 MW
Scope: Complete electro-mechanical equipment
Highlight: Additional 35 GWh stable power supply per year for West Java

→ More on Page 54

UPPER FRASER

New | Fraser River | New Zealand
Output: 1 × 8.1 MW
Scope: Vertical Pelton turbine

→ More on Page 27

HOSHAN

New | Yunlin County | Taiwan
Output: 1 × 1.96 MW
Scope: Complete electro-mechanical equipment
Highlight: Turbines for existing irrigation structures

→ More on Page 55

CHICHI NANAN 2

New | Nantou County | Taiwan
Output: 2 × 1.97 MW
Scope: Complete electro-mechanical equipment
Highlight: Turbines for existing irrigation structures

→ More on Page 55

METLAC, MEXICO

Environmentally-friendly beer production

Cerverceria Cuauhtemoc Moctezuma SA de CV is a beer factory in Mexico. It is part of the Heineken Group. In June 2017, the factory received a prize for environmental excellence based on its consumption of renewable energy. Some 20% of the factory's electricity demand comes from its own hydropower plant, Metlac.

Because of its long-held expertise in small hydro and its important local presence and support network in Mexico, ANDRITZ Hydro received a contract to refurbish the plant. The scope of the contract comprises supply of three generating units including Francis horizontal turbines, butterfly inlet valves, synchronous generators, a cooling water system, automation, and complete electrical power systems. The contract also includes removal of the old equipment and installation and commissioning of its replacement. Executed in an open consortium between the ANDRITZ Hydro locations in Grenoble, France, and Morelia, Mexico, this order again shows the competence of ANDRITZ in the small and mini hydropower market, as well as the strong international cooperation between all our locations.

AUTHOR

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TECHNICAL DETAILS

Total output: 7.37 MW
Scope: 3 × 2.45 MW
Head: 125 m
Speed: 900 rpm
Runner diameter: 618 mm

EMBALSE DIGUA, CHILE

91 GWh per year of clean energy

ANDRITZ Hydro has signed an important contract with Chile's Besalco Energia Renovables (BSER) for the supply of the electro-mechanical equipment for a small hydropower plant. The contract is for the Embalse Digua plant in the Maule Region of Central-Southern Chile.

ANDRITZ Hydro's scope of supply comprises the complete electro-mechanical equipment for the hydropower station, as well as additional equipment required for the by-pass irrigation system. The contract includes turbines, generators, butterfly valves, Howell Bunger discharge valves, mechanical and electrical auxiliary equipment, and the complete control and protection system. In order to take full advantage of the system's seasonal variations in head and flow rate, two additional turbine runners with a design especially suited to usage in the dry season are also part of the contract.

Commissioning and hand over of Embalse Digua is scheduled for the last quarter of 2019. It will provide about 91 GWh per year of clean energy to the Chilean Central Interconnected System (SIC).

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TECHNICAL DETAILS

Total output: 20 MW
Scope: 2 × 10 MW
Voltage: 6.6 kV
Head: 71.4 m
Speed: 428.6 rpm
Runner diameter: 1,450 mm

BREIVIKELVA, NORWAY

Additional power for Northern Norway

At the beginning of 2019, ANDRITZ Hydro was awarded a contract for the development of the Breivikelva hydropower plant in the Beiarn municipality in Norway.

The contract is a "from water-to-wire" complete solution and includes a vertical Pelton generating unit with 9.9 MW capacity, generator, automation, electrical power system, transformer, main inlet valve, inlet pipes and auxiliaries.

TECHNICAL DETAILS

Total output: 10.3 MW
Scope: 1 × 10.3 MW
Head: 269.9 m
Speed: 500 rpm
Runner diameter: 1,340 mm

After completion of Breivikelva in 2021, it will provide an additional 27 GWh of renewable energy per year to the Norwegian grid. This corresponds to the electricity consumption of about 1,360 households.

The owner is Salten Kraftsamband AS (SKS), a private limited company owned by municipal authorities in the county of Nordland, together with the energy companies Bodø Energi AS and Jämtkraft AB (SWE). Stein Mørtsell, CEO of SKS Produksjon AS, states that the power development is positive for SKS and is in line with their strategy for increased production of hydropower. The project is also a good case for the Beiarn municipality with regard to local effects and the activity the project will bring.

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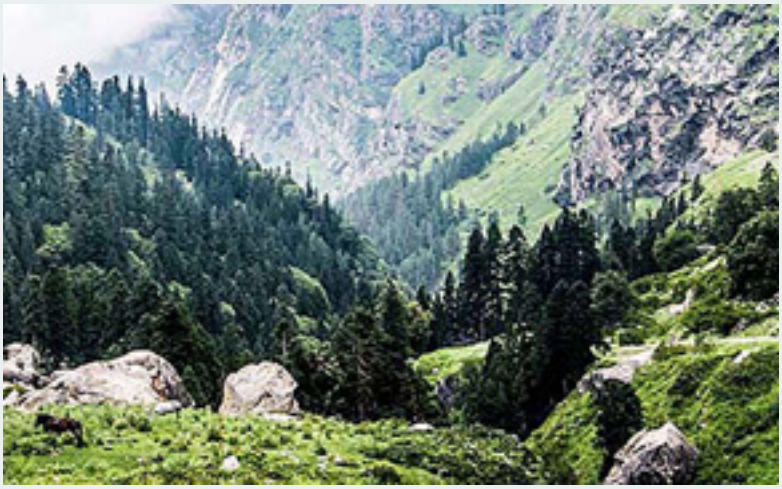

SELTI MUSRANG, INDIA

Benchmark project for Compact Hydro

ANDRITZ Hydro has received an order for the small run-of-river hydropower plant Selti Musrang on the river Bhaba Khad in Himachal Pradesh from the private developer Ramesh Hydro Private Limited.

The scheme envisages a diversion of the Bhaba Khad inflow through a conveyance channel/tunnel to a surface desilting tank via a crested-type diversion weir. This flow will subsequently pass through a power tunnel and up to an underground forebay where it leads to an underground powerhouse through a surface penstock. It will feed three horizontal Francis turbines driving generating units rated at 8,000 kW each.

ANDRITZ Hydro's scope of supply is a complete "from water-to-wire" solution including turbines, generators, balance of mechanical package, balance of electrical package and the entire automation system of the hydropower plant. Our team has elaborated a complex package and good cooperation with the customer during the development phase made this project a benchmark for Compact Hydro. ANDRITZ Hydro has again proved itself the market leader by offering the best technical solution for this project.

TECHNICAL DETAILS

Total output: 24 MW
Scope: 3 × 8 MW
Head: 219 m
Runner diameter: 740 mm

The duration for the completion of the project is 24 months from the commencement date starting June 2019.

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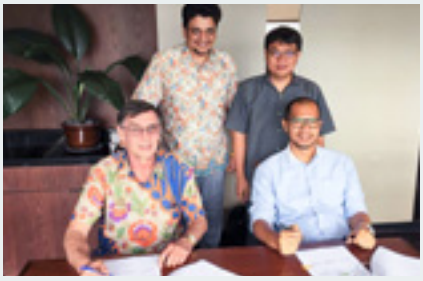
CIKANDANG, INDONESIA

An additional 35 GWh of stable power per year for West Java

ANDRITZ Hydro has signed a contract for the electro-mechanical equipment for the 6-MW Cikandang hydropower project in Indonesia. The contract is with PT Republika Mandiri Energi, a special purpose company of PT Bukaka Teknik Utama, a renowned limited company listed on the Indonesia Stock Exchange (IDX). This company already runs several hydropower plants in Indonesia.

The scope for ANDRITZ Hydro for Cikandang includes design, engineering, manufacturing and supply, as well as supervision of installation and commissioning of the complete electro-mechanical equipment for the plant. A consortium of ANDRITZ Hydro Indonesia and ANDRITZ Hydro India will execute the project. Cikandang is scheduled to commence commercial operation in September 2020.

The Cikandang project is located in Garut Regency, West Java, Indonesia, and will utilize the Cikandang River to produce electricity. A 20 kV transmission line from this plant will be interconnected with the JTM PT PLN (Persero) network and to the Garut Regency of Indonesia. Estimated annual energy production of the plant is 35 GWh with a 67% plant capacity factor. Indonesia's government has projected



electricity demand growth of 6.87% per annum. During the next decade, the government aims to add 56,024 MW of power plants, where the renewable energy contribution would be 23% of the total.

ANDRITZ Hydro will continue to contribute to the stable power supply in Indonesia and to expand the supply of high-efficiency power generation systems. With this order, ANDRITZ Hydro has once again strengthened its leading position in the Indonesian hydropower market.

TECHNICAL DETAILS

Total output: 6 MW
Scope: 3 × 2 MW
Voltage: 6.3 kV
Head: 45.38 m
Speed: 600 rpm
Runner diameter: 878 mm

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KAMOLOT, UZBEKISTAN

First order for Compact Hydro in Uzbekistan

Uzbekistan has a wide network of irrigation canals, which were built at the beginning of the 20th century. It represents a significant untapped hydropower potential. A plan for a hydropower station to use this potential was formed early last century and in 1939 some basic structures for the powerhouse of Kamolot were built. In 1982, further construction measurements were implemented, but the power station was never completed.

ANDRITZ Hydro has now received the order from the Chinese enterprise group Dongfang Electric International Corporation (DEC) for the complete electro-mechanical equipment of this plant. DEC is acting as the main contractor for the end customer, JSC Uzbekgidroenergo, an Uzbek state-run utility.

The scope of supply for ANDRITZ Hydro comprises four identical Bevel Gear Bulb turbines with a runner diameter of 2,150 mm and a rated power output of 2.13 MW each. The contract also includes synchronous generators, hydraulic power units, cooling water system, as well as a package of controls and automation. Transportation to site, supervision of installation and commissioning are also part of the contract.

The first two of the four turbines were commissioned in October 2019.

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TECHNICAL DETAILS

Total output: 8.5 MW
Scope: 4 × 2.13 MW
Head: 7.77 m
Voltage: 6.3 kV
Speed: 217 rpm
Runner diameter: 2,150 mm

CHICHI NANAN 2 AND HOSHAN, TAIWAN

Turbines for existing irrigation structures

The government of Taiwan is pushing forward with its ambitious plans for the development of renewable energy, in particular small hydropower at existing drinking-water-reservoirs and irrigation canals.

In April 2019, ANDRITZ Hydro was awarded two new orders, both with the Nan Dao Engineering Corporation based in Taipei. Nan Dao is acting as the EPC-contractor for the project owner (Taiwan Power Corporation).

At the project site of ChiChi Nanan 2 an existing irrigation canal will be equipped with two identical low head Bevel Gear Bulb turbines. At Hoshan, which is located at an existing water dam, one horizontal Francis turbine will be installed.

Both projects are scheduled to be completed by March 2021. Following the successful PaTien project in 2012, these two small hydropower projects for Taiwan Power mark a further step into this small hydropower market. It proves the competence and excellent technology solutions available from ANDRITZ Hydro.

TECHNICAL DETAILS

ChiChi Nanan 2

Total output: 3.94 MW
Scope: 2 × 1.97 MW
Head: 10 m
Speed: 269 rpm
Voltage: 6.6 kV
Runner diameter: 1,770 mm

Hoshan

Total output: 1.96 MW
Scope: 1 × 1.96 MW
Head: 59.41 m
Speed: 720 rpm
Voltage: 6.6 kV
Runner diameter: 747 mm

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UPPER MALADUGAO, PHILIPPINES

Further success in the Philippines

Located in Bukidnon in Mindanao, Upper Maladugao is the first project from the Philippine Independent Power Producer United Holding Power Corporation. ANDRITZ Hydro Germany was awarded the contract for the supply of the entire electro-mechanical "from water-to-wire" package with three Compact Francis units. Local erection infrastructure, manpower and commissioning services for the equipment round out the contract.

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TECHNICAL DETAILS

Total output: 9.36 MW
Scope: 3 × 3.12 MW
Head: 39 m
Speed: 450 rpm
Runner diameter: 1,155 mm

REALIZING NEW POSSIBILITIES

Modern hybrid solution for hydropower

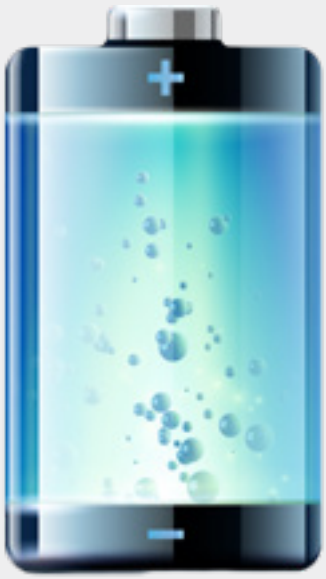
At a time when power generation based on fossil resources is being replaced by a carbon-free renewable electrical energy production, a compromise between the needs of the present and responsibility to future generations has to be found. In addition to structural changes, there are many market challenges to address. Issues such as market liberalization, energy prices, base- and peak-load capacity, the impact of weather, and smart metering technology must all be resolved.

How can we solve these challenges? The ideal approach is a combination of the best features of all systems – a hybrid solution. Today, examples of hybrid solutions include smart watches (IT and the mechanical wristwatch) or hybrid cars (battery and internal combustion). For the bulk power industry, hybrid solutions are defined as a combination of one or more generation technologies involving at least one renewable energy source and an energy storage system. This ensures maximum supply reliability and security of energy supply.

In addition to the large-scale hybrid solution, ANDRITZ Hydro is implementing hybrid approaches for our core products and services. For low-head hydropower plants, a reconsideration of the traditional operation approach is necessary. New demands require fast response times, frequent load changes, frequency regulation, and extended operational ranges. ANDRITZ Hydro is now offering a new hybrid solution that integrates a battery storage system into a hydropower plant – HyBaTec.

HYBATEC – THE SOLUTION

HyBaTec is a hybrid energy solution combining a hydro turbine generator unit with a battery. Compared to a conventional hydro application – and depending on the size of the battery – the operational range can be extended up to +/- 25%.



Along with the existing run-of-river operation mode, other operational modes and additional grid services are possible using the HyBaTec solution. Faster response times and very flexible operation due to the interaction of the generation unit and the battery will be available without restrictions resulting from electrical, mechanical or hydraulic limitations.

The battery can be either installed in a container in order to be mobile or can be integrated in cubicles directly within the hydropower plant buildings. In any event, the battery will be integrated into the electrical

TO KNOW:

A hybrid energy system provides:

- Better energy security
- Improved grid support by providing/releasing storage capacity to compensate for variable output resources
- New opportunities for energy market participation such as base load, peak load and balancing markets
- Extension of equipment lifetimes by reducing mechanical stress

power plant as well as in the control system to optimize revenue from the system. The ANDRITZ Station Controller (ASC) includes the energy management system and manages both the turbine and the battery.

"HyBaTec is offering new possibilities to improve the economic feasibility of your hydropower asset."

The system can be applied to "greenfield" applications as well as retrofitted to existing facilities, covering battery capacities from 100 kWh up to 10 MWh. Our hybrid solution is able to increase or keep the operational flexibility of your hydropower plant with no or reduced storage basins.

Over recent years some hybrid projects have already been realized using different combinations of wind, solar, hydropower, or batteries.

Gorona del Viento, Spain – For this Canary island, which is home to about 5,000 families, an 11.5 MW wind farm was combined with a hydropower plant to compensate for the short-term volatility and guarantee a carbon-free energy supply. ANDRITZ Hydro provided the Pelton turbines for this project.

Kidston, Australia – This installation features a 270 MW solar farm combined with a 250 MW pumped storage plant to compensate for any volatility in output as well as up to eight-hour of night time operations in the absence of sunlight. ANDRITZ Hydro is supplying the electro-mechanical equipment for the pumped storage elements of this plant.

Hornsdale Power Reserve, Australia – A 100 MW battery plant will compensate for grid volatility and provide energy for 30,000 homes for about one hour. The battery plant was built by Tesla over a period of just 100 days.

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ANDRITZ Hydro experts during on-site inspection using HPP Assessment Tool on dedicated tablets

PERFECTLY DEFINED SERVICE

Accurate hydropower plant assessment with new software tools

With the number of aging power plants increasing worldwide, the effective assessment of hydropower assets is gaining ever-greater importance. Owners and operators of older facilities still need to ensure and improve the long-term value, safety and operating results of these assets. In parallel, there is a considerable and growing shortage of experienced hydropower plant staff.

To meet today's client needs and changing market requirements, highly-skilled ANDRITZ Hydro engineers have developed a new software tool to facilitate the rapid and professional assessment of key plant components. It also provides a detailed diagnosis of the equipment, which aims to support customers' planning process to identify and design the rehabilitation scenario with the highest return.

The HPP Assessment Tool is a software platform supporting the execution and documentation of hydropower plant inspections. It consists of a set of so-called "know-how databases" that cover each plant system, such as the turbine or generator. Each database is structured with details of the core components and the related inspections that should be performed. The status of all HPP systems and components are assessed in terms of production maximization, reduction of maintenance costs and improved reliability. The results of the inspection are documented in a report, which includes a full status of the equipment, detailed risk and potential analysis as well as proposals for improvement. This provides a strong basis for the operator in his selection and decision process for the optimal rehabilitation scenario.

The most recent success story for the HPP Assessment Tool comes from the Aconcagua hydropower complex in Chile. Located near the Argentinian border and consisting of five plants with a total capacity of 215 MW, this complex is a strategically important power-generating asset. As a service provider, ANDRITZ supported the customer with the advanced HPP Assessment Tool diagnostics for most of the core components and could provide suitable guidance and prioritization for the next major rehabilitation activities.

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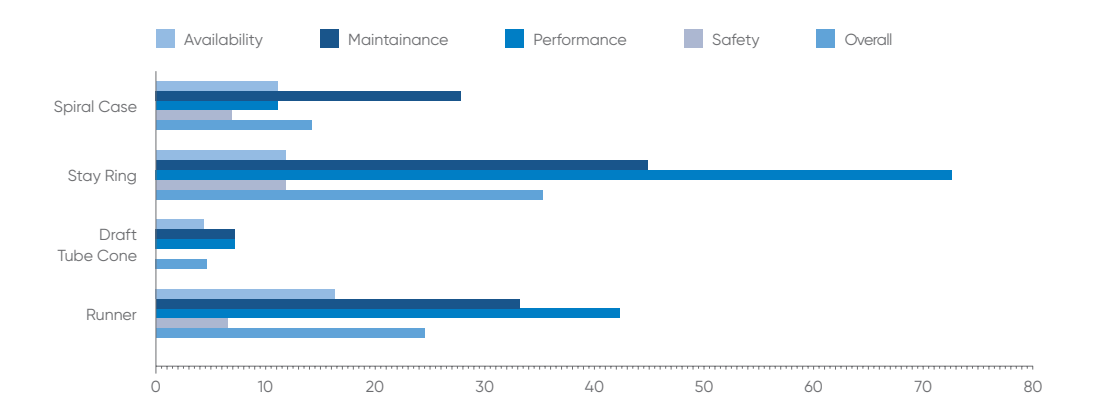
COMPONENT CONDITIONS



Example of detailed risk analysis evaluation performed on 4 criteria: Availability, Maintenance, Performance, Safety

EMBRACING THE DIGITAL AGE WITH ANDRITZ HYDRO CUSTOMER CARE

Enhancing worldwide service quality with modern technology

Many hydropower plants around the globe are located in remote areas. If customers are facing operational difficulties, this remoteness inevitably poses a challenge for service and maintenance in terms of reaction time.

BEING APART – WORKING TOGETHER

In the event of a breakdown or other failure, rapid troubleshooting at a hydropower plant is one of the most important benefits for any hydropower plant operator. Currently, tasks in remote areas are typically associated with extended travel times for expert maintenance teams to reach the power plant adding costs and typically extending outages.

To address this industry challenge and deliver an extremely rapid first assessment, ANDRITZ Hydro has developed a technical solution establishing synergies between on-site employees and plant operators and owners, as well as technical experts at potentially distant ANDRITZ Hydro expert locations. Without being physically present, our deeply experienced team can deliver an immediate first impression with guidance on the root cause and advice on the course of action. This enables even the farthest flung hydro plant operator to benefit from the expertise of a dedicated engineering knowledge base. By quickly accessing that core knowledge, this solution delivers a significant enhancement to the quality of ANDRITZ Hydro service in terms of both time and costs.

MAVIS – MOBILE AUDIO VISUAL SUPPORT IN SYSTEM

MAViS combines different technologies to support bidirectional audio-visual communication via mobile/internet systems with people on-site and ANDRITZ Hydro experts. The MAViS kit fits in one carry case and enables direct contact with an expert team of ANDRITZ Hydro with on-site staff. The two parties could be located in different countries or continents but are able to clarify questions in real time, take advice on-site via video conference, and be guided – via communication and visualization – through the entire fault-finding process if necessary.

Customer benefits include an extremely rapid solution for fault diagnostics, saving both downtime and additional travel expenses. ANDRITZ benefits too. On-site appearance of experts is only necessary where very serious or complex problems have developed which cannot be addressed remotely. The result is a win-win, low-cost and easy-to-deploy solution.

The MAViS development team is located in Weiz and Vienna, Austria, and combines the expertise of our service business and IT specialists. MAViS 3.0 is now in the final testing phase and will be available soon for worldwide commercial use. MAViS will be available as a service package with expert support, including rental of the necessary equipment.

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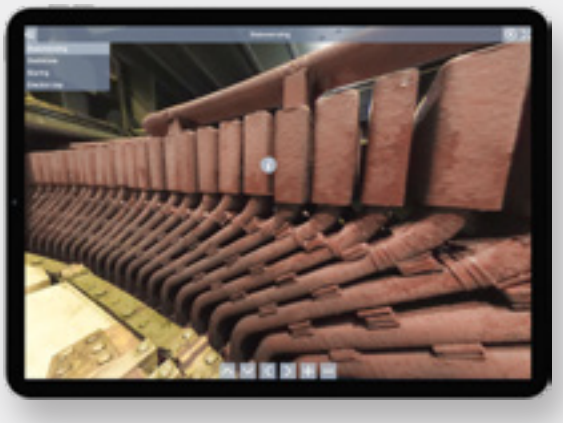

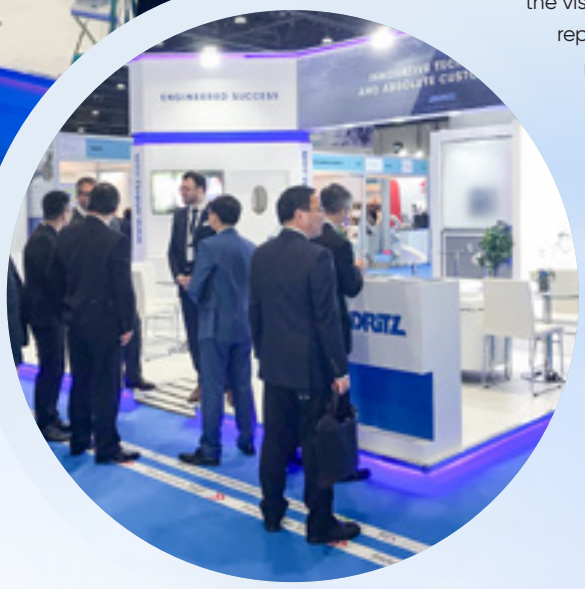

A2B – ANDRITZ GETS DOWN TO BUSINESS AT WFES 2019

Abu Dhabi, UAE – January 14-17, 2019

The 12th annual World Future Energy Summit (WFES) hosted over 850 exhibiting companies from 40 countries earlier this year. This high-level exhibition is the world's leading specialist event in showcasing the latest and best of the world's clean and sustainable energy technologies.

As the only pump manufacturer and supplier exhibiting, ANDRITZ took a leading part in WFES Water, an essential platform for governments and businesses to discuss critical water supply and use concerns. It's a major platform for the promotion of the sustainable production, treatment, and supply of water in arid regions.

An outstanding booth design in an excellent location offered the best opportunities to attract participants. Among the visitors were many high-level representatives of governmental institutions from across the Middle East, such as the United Arab Emirates, Saudi Arabia, and Oman. Throughout the four-day exhibition, the ANDRITZ booth was a highlight on the guided VIP tours through the exhibition center as well as featuring in the daily local TV news coverage of WFES.

"WFES proved once again to be a highly valuable resource for further strengthening regional brand awareness the Middle East. We had very inspiring and exceptionally intensive four days full of meetings, from a host of visitors from different authorities to in-depth discussions with experts and innovators from the water and energy sector. By presenting the company's technological know-how and comprehensive portfolio of high efficiency pumping solutions and services we are committed to helping to solve the Middle East's significant water scarcity challenges," Muhammad Abou Daoud, Regional Sales Representative of ANDRITZ.

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AFRICA 2019 CONFERENCE AND EXHIBITION

Windhoek, Namibia – April 2-4, 2019

AFRICA 2019 offered the year's best opportunity to bring together industry professionals and policymakers for high-level discussions on the water and energy issues that are central to African development.

Held just outside the center of Windhoek in Namibia, the country has plenty of hydro experience and a variety of significant hydraulic works to its credit. A number of neighboring countries also have major hydro development programs underway.

AFRICA 2019 is the leading African hydropower conference and technical exhibition and remains a superb platform for all the various partners interested in the hydropower industry to come together. Utilities, suppliers, investors, project developers, policymakers and operators – every sector was amply represented. More than 500 delegates came from across Africa and from all over the world to attend this key event.

ANDRITZ Hydro has been active in the African hydropower market for more than 100 years and has supplied about 40% of all the turbines installed across the continent to date. To emphasize this long and enduring relationship, this year – alongside our continued booth presence – ANDRITZ Hydro also presented papers on African small hydropower projects, leading generator technology, and outstanding engineered pump solutions for irrigation, drinking water supply and flood control. ANDRITZ Hydro also co-hosted the opening reception. This was a special opportunity for the communication between all participants.

Once again, AFRICA 2019 offered many opportunities for the promotion of our comprehensive product, solution, and service portfolio. In parallel, ANDRITZ Hydro demonstrated its long standing competence in advanced processes and technology, as well as project delivery. Importantly, we also improved our existing customer relations and identified further potential success stories in the promising African hydropower market.

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CUSTOMER DAY INDONESIA 2019 – ANOTHER OUTSTANDING HYDROPOWER EVENT

Jakarta, Indonesia – March 15, 2019

In another successful event, more than 180 experts from government institutions, hydropower plant operators and private investors participated in the ANDRITZ Hydro Customer Day Indonesia.

Opened with a traditional Indonesian dance performance and welcome speech from Mr. Josef Ullmer, President Director of PT. ANDRITZ Hydro, special keynote speeches were delivered by leading local figures. Mr. Ullmer was joined in speaking by the Ambassador of the Austrian Embassy to Indonesia, Mrs. Helene Steinhaeusl, the Director of Various New and Renewable Energy, Ministry of Energy and Mineral Resources of Indonesia, Mr. Harris Yahya and Mr. Michael Lederer, Special Attaché for Transport, Innovation and Technology to the Austrian Embassy to Indonesia.

This year the presentations were somewhat focused on the small and mini hydropower market, including some dedicated product highlights featuring Compact generators and "Large Compact" solutions. Special papers on operations and maintenance, low head applications, and pumped storage solutions were also presented. Alongside the interesting technical presentations, the day also offered an ample opportunity for the intensive exchange of information between all of the participants.

Our Customer Day Indonesia is becoming one of the most important hydropower events in Indonesia and underlines our leading position in the local hydropower market. Thank you to all among the ANDRITZ Hydro team who contributed to realize this successful event. We are already looking forward to the next Customer Day Indonesia and seeing all of our hydropower friends in 2020!

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HYDRO AUTOMATION DAY 2019 A SPECIAL EVENT – A UNIQUE PRODUCT

Vienna, Austria – May 14, 2019

More than 180 experts, hydropower plant operators, private investors, and partners from at least 15 countries accepted our invitation and joined us at this year's HYDRO Automation Day.

Held in May 2019, the event was opened by a welcome speech from Mr. Wolfgang Semper, Member of the Executive Board of ANDRITZ and Managing Director of ANDRITZ Hydro.

Special customer keynotes were also given by Mr. J. Lackner (VERBUND/Austria), Mr. S. Jäger (KW Birsfelden/Switzerland), and Mr. Rieckmann (Schluchseewerke/Germany). Their comments considered a range of projects and highlighted their recent first-hand experience of the continued and excellent levels of cooperation between ANDRITZ Hydro and all our customers.

This year, one highlight was a presentation of the next phase of HIPASE. Comprising a dedicated paper on the HIPASE concept, as well as an impressive HIPASE product show, the event showcased the latest developments in our globally unique product.

Additional special papers in the technical section of the event included those on subjects focused on market need and featured large comprehensive automation architectures, automation solutions for hydropower cascades, cyber security, Metris DiOMera, and modelling.

In addition to the varied and interesting technical presentations, the day offered multiple opportunities for further in-depth and intensive exchange of information between all the gathered participants.

After a long conference day with its range of top-tier presentations, HYDRO Automation Day participants were able to enjoy a delightful gala dinner whilst reviewing the day. This, of course, offered many more opportunities for additional discussion and networking.

The HYDRO Automation Day is an important event for our hydropower automation customers and underlines our leading position in this market. Once again we were delighted to receive and host so many guests.

Thank you to the whole team who contributed to the realization of this successful event. We are already eagerly looking forward to welcome you all to the next HYDRO Automation Day.

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MODERN HYBRID SOLUTION FOR HYDROPOWER

HYBATEC

ANDRITZ Hydro is a global supplier of electro-mechanical equipment and services ("from water-to-wire") for hydropower plants. With over 175 years of experience and more than 31,600 turbines installed, we are constantly striving to create up-to-date technological innovations to meet our customer's needs and requirements. Utility companies from all over the world value our know-how and commitment, and trust in the safety and reliability of our tailor-made energy generation solutions.

HyBaTec (Hybrid Battery Technology) is a hybrid energy solution combining a hydropower unit with a battery. Compared to a conventional hydro application and – depending on the size of the battery – the operation range can be extended up to +/- 25%.

We focus on the best solution – "from water-to-wire".

ENGINEERED SUCCESS

ANDRITZ HYDRO GmbH / www.andritz.com/hydro

ANDRITZ