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No. 32

HYDRONEWS

PUMPED STORAGE FOR THE FUTURE

ANDRITZ

Photos © Paul Unmuth

ANDRITZ Hydro is sponsoring
a ten year exhibition at the

technisches museumwien

MARIAHILFER STR. 212, 1140 VIENNA
www.technischesmuseum.at

“ON / OFF –
The interactive exhibition all about the power grid”

Nowadays it’s hard to imagine life without electricity. Every day we automatically charge up smartphones, heat or cool homes, and switch on the lights whenever it gets dark. Electrical energy is a commodity – directly from the socket. The Technical Museum in Vienna has taken up the challenge to show, demonstrate and explain the backbone of Austria’s electricity production.

Since November 2017, the new permanent interactive exhibition “ON/OFF” looks at key aspects of Austria’s power grid, both now and in the future. The exhibition features nine sections explaining the pathways taken by electrical energy, from power plant to end consumer.

Within the exhibition these themed sections interconnect to create a symbolic electricity grid that can be monitored and regulated from a control center. The exhibition also shows that there are still many unanswered questions surrounding the topic of energy.

ANDRITZ Hydro is proud to be main sponsor of this exhibition and has also provided a Pelton runner, four Kaplan blades as well as an interactive Kaplan model. With this cooperation ANDRITZ Hydro supports the running activities of the Technical Museum to raise the public awareness for electrical energy and all related topics, like hydropower, wind and solar, sustainable and long-term solutions, storage and grid balancing.

New opportunities for pumped storage, development of the global hydropower market


Wolfgang Semper


Harald Heber

Dear Business Friends,

With a growing installed base of volatile wind and solar power plants, an economic solution for large-scale energy storage is becoming more and more important. Pumped storage power plants are currently the most economical way of efficiently storing large amounts of energy over a longer period. Indeed, this capability mean pumped storage power plants already play a significant role in stabilizing power grid frequency and voltage. Due to their black start capability, a pumped storage plant also acts as a safety line for supply security. ANDRITZ Hydro was and is one of the pioneers of this technology. The latest in a long line of project successes is the recent order for two variable speed pump turbines with asynchronous motor-generator units for what will be the world's largest pumped storage power plant – Fengning 2 in China.

Currently, the global hydropower market is stagnating, impacted by low electricity and energy prices. New green field and many modernization and refurbishment projects have been postponed and only a few larger projects were selectively awarded. Nevertheless, ANDRITZ Hydro has been successful in securing contracts for Abdelmoumen in Morocco, E.B. Campbell in Canada, Callahuanca in Peru, Alto Tâmega in Portugal, and of course Fengning 2.

Around the globe, several small hydropower project contracts were also awarded or are under construction, such as San Andrés in Colombia; the first Mini Compact Hydro in Brazil – Barrinha, Traunleiten in Austria, or the installation of two Compact Axial turbines integrated in the fish lock system of Xayaburi in Lao PDR.

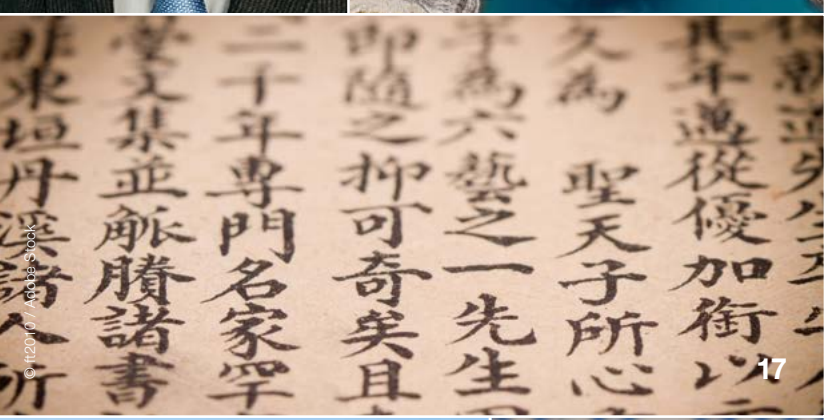
The global demand for water supply, irrigation, and flood control is growing. With highly specialized large engineered pumps ANDRITZ Hydro is able to offer outstanding solutions for these markets. Project examples are Kaleshwaram in India or Yen Nghia in Vietnam.

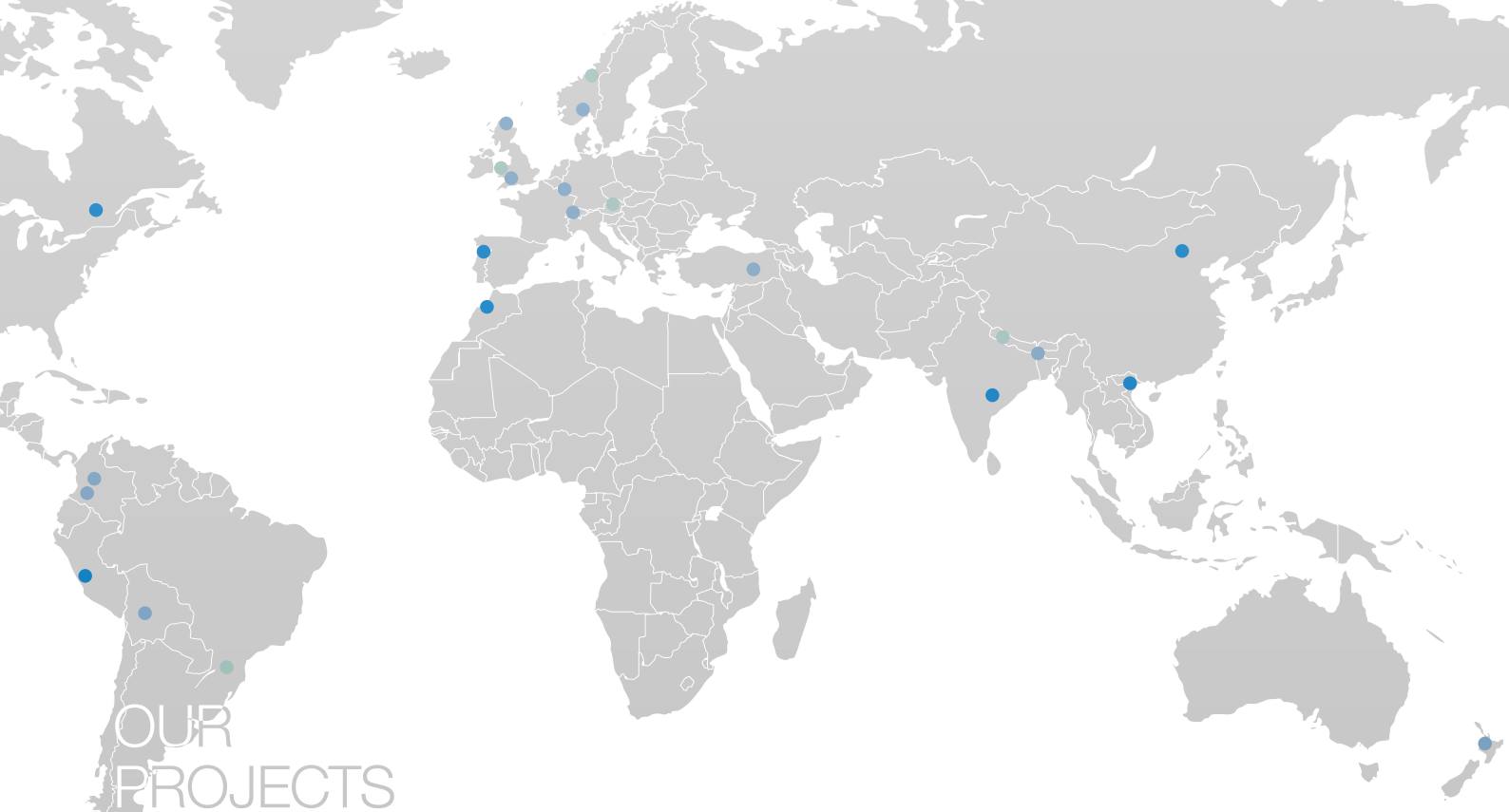
Despite some challenges, with the revival of pumped storage in combination with rapid growth in wind and solar, new technical solutions for existing demand, and interesting opportunities for the small and mini hydro sector, pump solutions, as well as hydropower refurbishment and modernization opportunities, ANDRITZ Hydro is confidently looking forward to the future hydropower market.

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


Wolfgang Semper


Harald Heber





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NEW PROJECTS

SITE REPORTS

SMALL & MINI HYDRO

OCEAN ENERGY

CONTACT US:

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KEY INVESTMENT FOR RENEWA ENERGY

NEW PROJECTS
ABDELMOUMEN

MOROCCO – In a bid to reduce its dependence on foreign imported hydrocarbons, Morocco has set itself the ambitious objective of increasing the share of renewable energy to 42% of the country's total power generation through 2020. The Abdelmoumen Pumped Storage Power Plant (PSPP) is a crucial element in meeting this goal.

Leading global construction company Vinci Construction and ANDRITZ Hydro have forged an EPC consortium (Engineering, Procurement and Construction) for the design, construction, manufacturing and commissioning of the 350 MW Abdelmoumen project. L'Office Nationale de l'Électricité et de l'Eau potable (ONEE) awarded the contract to the consortium based on its technically and commercially competitive offer, after a thorough evaluation.

Located on the river Issen in the Taroudant Province and close to the existing Abdelmoumen reservoir, the project is situated approximately 140 km southwest of Marrakesh. Construction will start early in 2018 and is due to be completed 48 months later.

PSPP Abdelmoumen will be used to compensate for natural variations in the production of wind and solar power. This role will place specific technical demands on the project. For example, a high number of start and stop cycles in both pump and turbine mode may be required on any given day, while the need to react quickly and switch from one mode to another is needed to respond to rapid drops or increases in wind speed. (⟶ see Cover Story on page 18)

With two 175 MW pump turbines robustly designed to accommodate 20 rapid mode changes per day, PSPP Abdelmoumen will cover peak-load energy demands and provide rapid response power to regulate the Moroccan grid.

In addition to the works inherent to the PSPP Abdelmoumen - such as reservoirs, waterway, plant and substation - the project also includes the creation or rehabilitation of many access roads, and the installation

of supplementary pumping equipment. All of this while respecting the environment and the surrounding population.

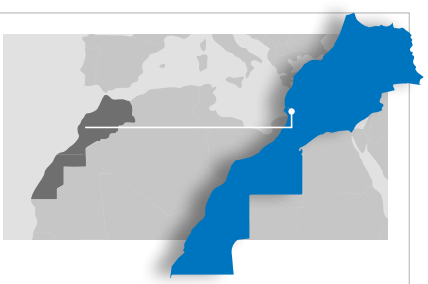
Vinci Construction is acting as the consortium leader and will execute all the important civil engineering elements of the project. ANDRITZ Hydro's scope of supply comprises design, manufacturing, delivery, installation, supervision and commissioning of the reversible pump-turbines, motor-generators, and electrical power systems.

Combining their expertise, Vinci Construction and ANDRITZ Hydro are jointly realizing the technically challenging 3 km steel-lined waterway. This consists of a 2 km-long penstock, more than 700 m of tunnels made of sections of between 3.5 m and 5 m in diameter, and three shafts up to 60 m high.

To provide a reliable base for the design of the pump-turbines broad research and model testing activities have been accomplished by ANDRITZ Hydro's test laboratory. Operating under the outstanding high net head of about 555 m, the designs assure the two pump-turbines are able to meet both the high efficiency and reliability requirements for years to come.

PSPP Abdelmoumen is the first EPC consortium collaboration between Vinci Construction and ANDRITZ Hydro. Both partners look forward to the successful completion of the project and are confident it will open the way to further future collaboration.

ANDRITZ Hydro is pleased to support Morocco in the development of its abundant, sustainable and renewable energy resources to achieve the state's ambitious goals for the future.



Abdelmoumen | Morocco

Technical data:

Total output:	350 MW
Scope:	2 × 175 MW
Head:	555 m
Speed:	600 rpm
Runner diameter:	3,200 mm

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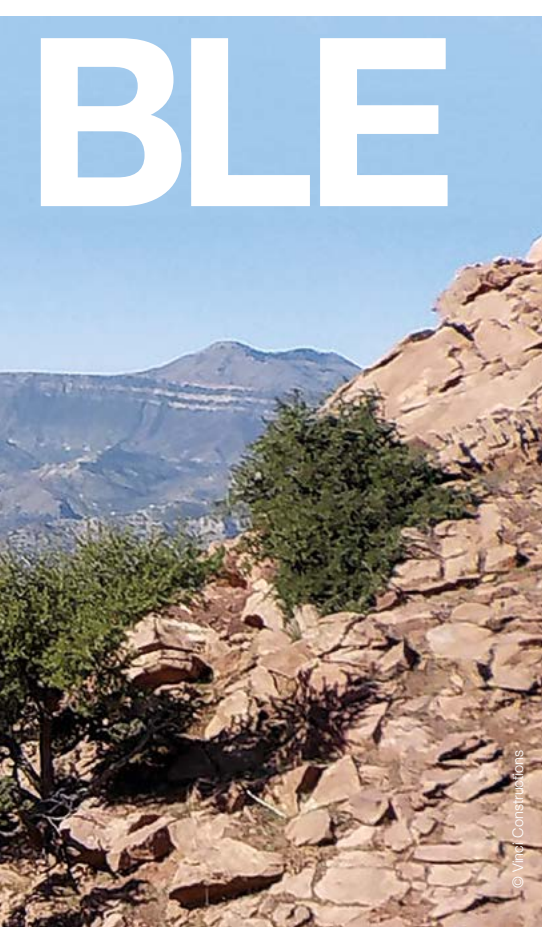
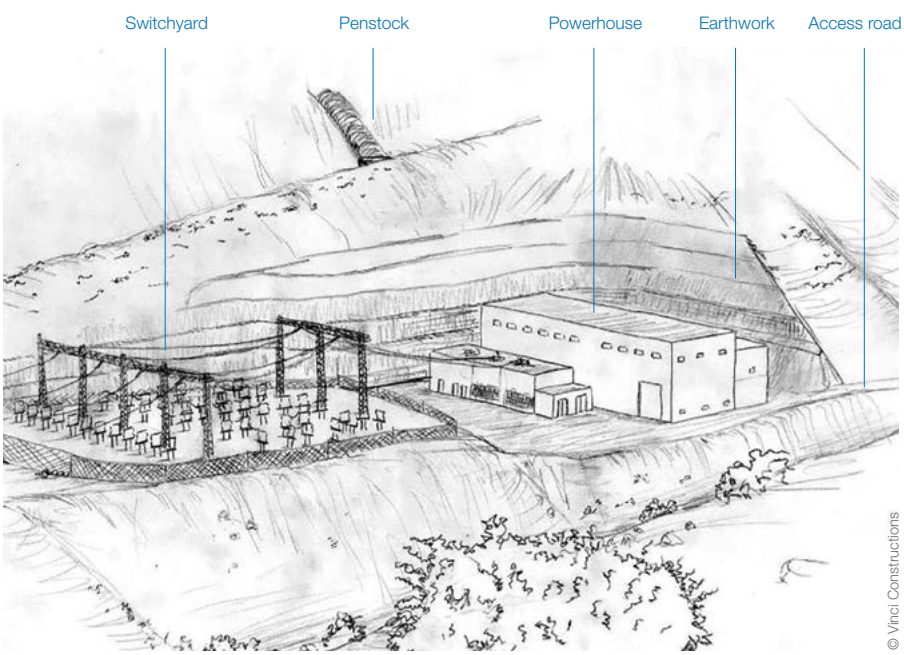


© Vinci Constructions



© Vinci Constructions

Design sketch of the future power station

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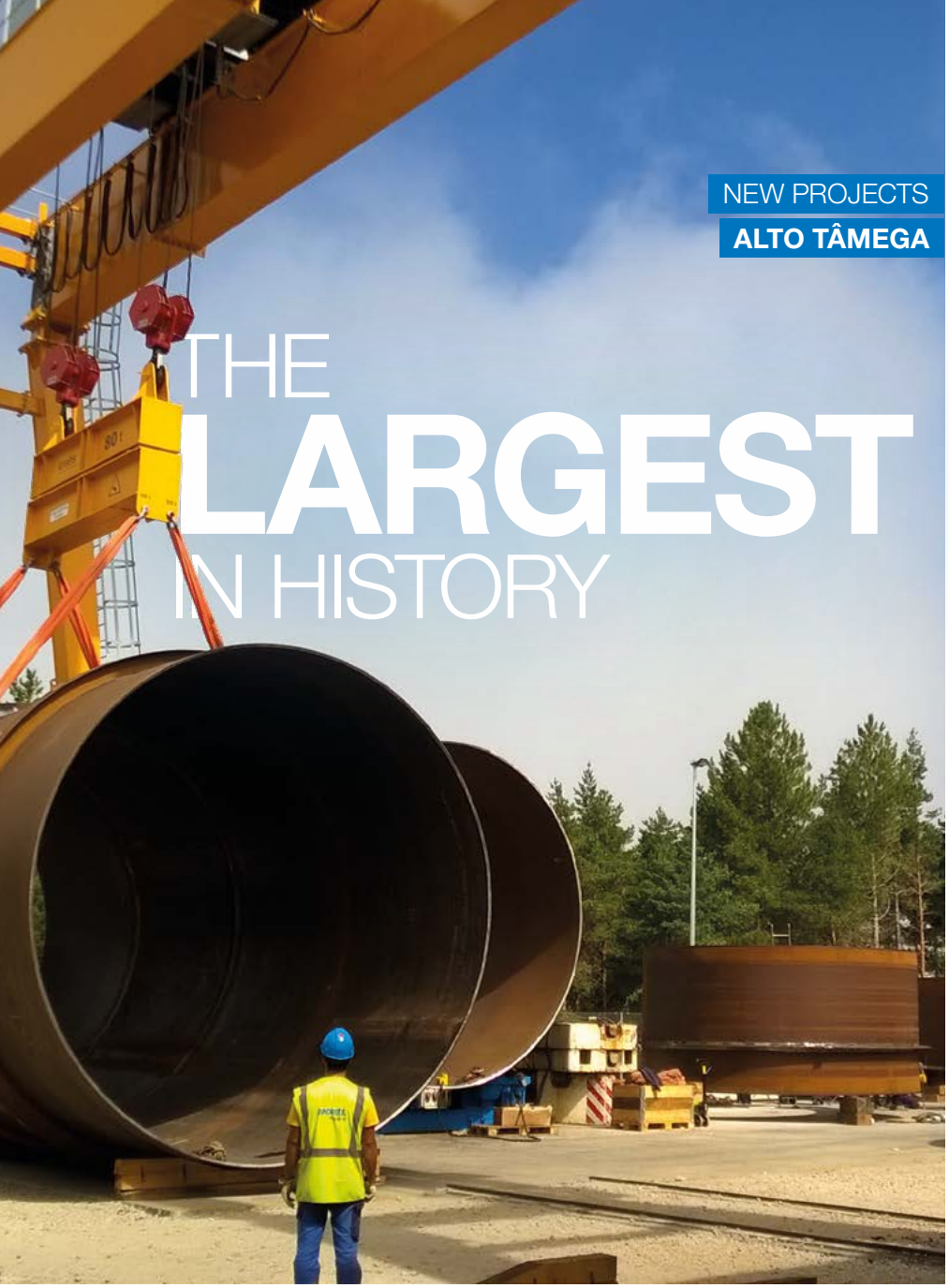

NEW PROJECTS

ALTO TÂMEGA

THE LARGEST IN HISTORY

Alto Tâmega | Portugal

Technical data:

Total output:	1,158 MW
Av. annual production:	1,760 GWh
Steel:	1,000 tons (HPP Alto Tâmega)
	780 tons (HPP Daivões)
	660 tons (PSPP Gouvães)

PORTUGAL – The Tâmega Hydroelectric Complex represents the largest hydropower project in the history of Portugal and, furthermore, is one of the European energy sector's most important initiatives of the last 25 years.

Designed by Iberdrola to generate up to 1,760 GWh annually, Tâmega comprises three dams: Alto Tâmega, Daivões and Gouvães. In particular, the latter will be commissioned in 2021 and will be used for energy storage. It will guarantee the supply of energy for the almost three million inhabitants of the city of Porto. In 2023, the entire complex will be finished and ready to provide a combined generating capacity of about 1,158 MW.

Iberdrola, a leading company in energy storage, expects the Tâmega Hydroelectric Complex to boost northern Portugal's economy with the creation of 3,500 direct and 10,000 indirect jobs, especially in the towns nearby as the project is carried out. However, the true value of the Tâmega complex lies in PSPP Gouvães and its contribution when renewable energy production exceeds demand. The system, about 120 km northeast of the city of Porto, will use surplus energy to pump water back into the upper reservoir. From there it can be used to generate power when needed.

After the receipt of the contracts for the electro-mechanical equipment and the penstock for the pumped storage hydropower plant Gouvães in 2016, ANDRITZ Hydro secured a further contract with Iberdrola Generación España S.A.U. for the hydro-mechanical equipment in June 2017. The scope of the contract awarded comprises the design, manufacturing and installation supervision of trash racks, radial and roller gates and stop logs, including hydraulic equipment, for all three power plants of Tâmega Hydroelectric Complex. The contract represents a total of about 2,440 tons of steel.

For ANDRITZ Hydro this is the third contract received in the Alto Tâmega Hydroelectric project. Once more, ANDRITZ Hydro was able to secure the contract award with an economical and technically sound offer, as well as its long-term experience in the project management of such complex projects. With this latest contract ANDRITZ Hydro has become the main supplier for hydro equipment to this outstanding project.

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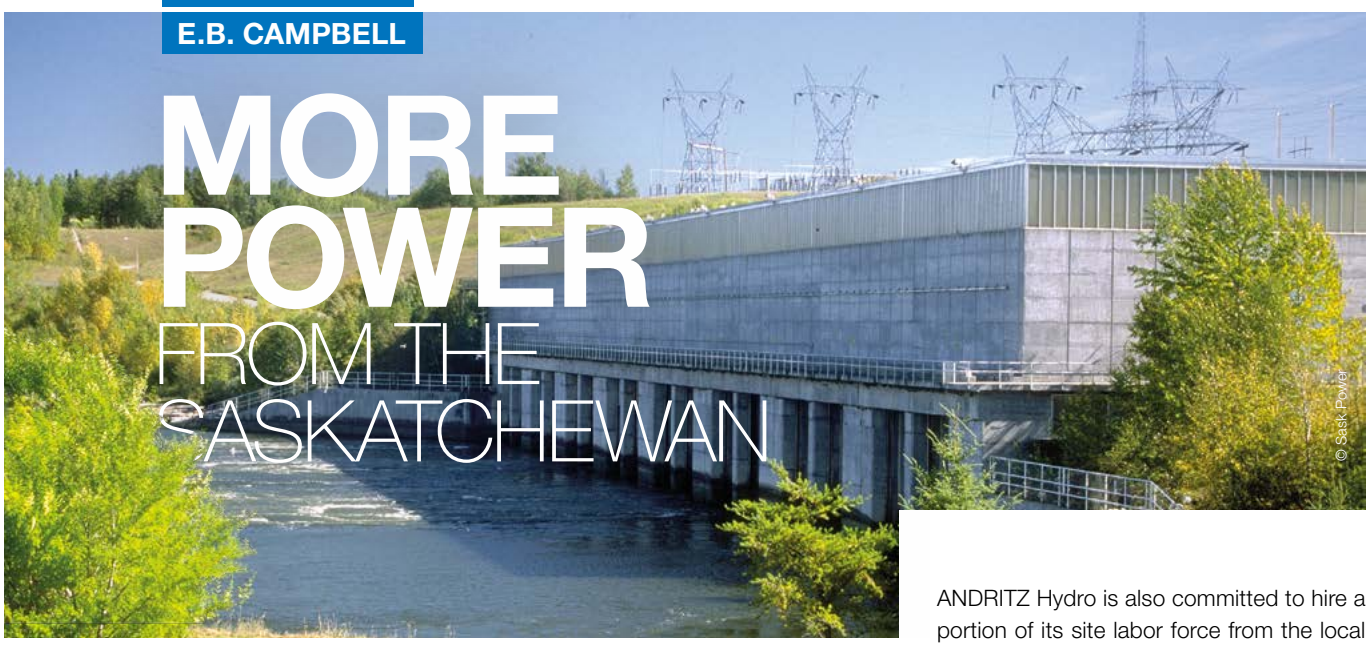
NEW PROJECTS

E.B. CAMPBELL

MORE POWER FROM THE SASKATCHEWAN


© Sask Power

CANADA – In April 2017, ANDRITZ Hydro Canada signed a contract with SaskPower for the refurbishment of six of the eight units at the E.B. Campbell Hydroelectric Station. The goal of this project is to extend by at least 50 years the reliable operation of these units and increase their generation capacity. Originally commissioned between 1963-1964, the plant is located on the Saskatchewan River, about 75 km north-east of Nipawin in Saskatchewan, Canada. The other two units were already refurbished by ANDRITZ Hydro eight years ago.

The scope of work includes 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 (bottom ring, wicket gates, head cover, gate operating ring and mechanism), a new stator frame, core and windings, as well as many refurbished components (turbine shaft, shaft seal, thrust and guide bearings, poles, brakes, etc.) will be installed. New caterpillar head gates, trash racks, hoists, refurbishment of gates and trash rack guides, instrumentation and controls will also form part of the ANDRITZ Hydro scope of supply.


© Sask Power

Model testing was successfully completed and witnessed by the customer in August 2017 at ANDRITZ Hydro's hydraulic laboratory in Canada, during which all performance guarantees were met. Following the achievement of this very crucial milestone, engineering design activities commenced. Procurement activities also started in September 2017. New components are sourced globally, whereas any refurbished components are to be worked on locally. Runners and coil windings are being manufactured in ANDRITZ Hydro workshops.

Under the terms of the contract, the first unit will be dismantled in August 2019 and is due to be put back into operation less than a year later in July 2020. The remaining five units will follow at a rate of one per year until 2025. There will only be a period of three months between completion of the work on one unit at the site and the start of the disassembly work on the following unit.

ANDRITZ Hydro is also committed to hire a portion of its site labor force from the local First Nations population.

The Life Extension Program aims to meet increasing regional electricity demand and the newly refurbished units will generate 35 MW each at a rated net head of 32 m. This is the biggest refurbishment contract for ANDRITZ Hydro in Canada to date.

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E.B. Campbell | Canada

Technical data:

Total output:	6 × 35 MW / 2 × 43.55 MW
Scope:	6 × 35 MW / 6 × 43.5 MVA
Voltage:	14.4 kV
Head:	32 m
Speed:	120 rpm
Runner diameter:	4,094 mm

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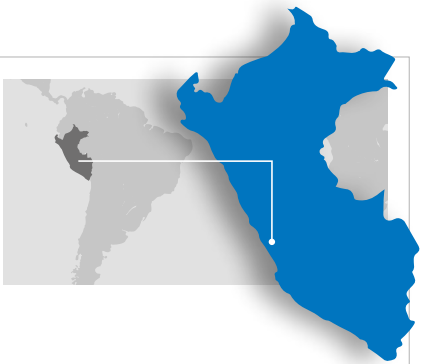
NEW PROJECTS

CALLAHUANCA

BRING BACK TO LIFE



Callahuanca | Peru

Technical data:

Total output:	82 MW
Scope:	3 × 20 MVA / 1 × 44 MVA
Head:	425 m
Speed:	514 rpm / 450 rpm
Runner diameter:	2,000 mm / 1,800 mm

PERU – Callahuanca hydroelectric power plant, 52 km east of Lima, was designed to utilize the water from the Santa Eulalia River, the main tributary of the Rimac River that flows through the city. In 1934, more than 1,200 men started construction works on the site and in 1938 the power plant was finally connected to the grid for the first time.

Detail of the damaged powerhouse

Following torrential rains caused by the "el Niño" phenomenon, at the beginning of 2017 the 82 MW Callahuanca hydroelectric plant was severely damaged by landslides. The damage was so devastating that the entire power station had to be shut down. Initial reports confirmed severe impairment of the powerhouse, with generators and turbines, the substations, all auxiliary services, and the complete control and protection systems damaged.

In August 2017, ANDRITZ Hydro received an order for the complete rehabilitation of HPP Callahuanca. The scope of supply includes the rehabilitation of three 20 MVA generators and the existing turbines. In addition the contract includes the supply, installation and commissioning of a new 44 MVA generator, new mechanical and electrical power systems, as well as a new automation and control system.

The contract was signed with owner ENEL. The ANDRITZ Hydro office in Peru will be responsible for the organization and coordination of all local activities, such as transport of the supplied equipment to site, dismantling of the damaged components and installation of the new ones. ANDRITZ Hydro locations in Austria, Italy and Mexico will take care of all engineering and reverse-engineering activities required to design and refurbish existing components as well as any new elements, providing efficient and profitable future operation of the plant.

Immediately after signing of the contract, dismantling works at the site started in parallel with the associated engineering activities. Commissioning of the first unit is scheduled for August 2018. Considering the strategic importance of this hydropower plant for the energy supply of the entire region, the project will be completed in the shortest time possible, guaranteeing a reconnection to the grid in the third quarter of 2018.

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NEW PROJECTS

CHENAUX GS

AUTOMATION AT ITS BEST

CANADA – In June 2017, Ontario Power Generation (OPG) awarded ANDRITZ Hydro Canada a contract for replacement of all control and protection systems for eight generators. The order for ANDRITZ Hydro in Chambly includes design, manufacturing, testing, installation, and commissioning at the Chenaux Generating Station in Canada.

Located along the Ottawa River north of Renfrew, the eight unit station takes its name from the French plural word for 'channel' - a reference to the powerful rapids the facility has harnessed to generate clean, renewable electricity for nearly 150,000 homes.

Initial construction of the station began in 1948 and included a concrete pour large enough to build a 1,400 km sidewalk. The units were placed into service in the early 1950s.

ANDRITZ Hydro automation is very familiar with the project as its falls into the core product line of controls and protection systems. Following a site visit, it was noted that the controls and protections were original with the exception of two units which were upgraded in the mid-1990s.

The solution proposed to the client was a complete removal of the existing control and protection equipment and its replacement with new unit and plant control panels. This includes protection panels, remote I/O panels, communication racks, and DC terminal racks, all fully integrated into the local and remote control station. As with most projects, the SCADA system is to be designed and programmed locally in Chambly.

A two-step installation approach is being used as half the equipment will be installed in 2018 with the remainder in 2019. ANDRITZ Hydro is providing full turnkey services to OPG including site installation and commissioning services. Commissioning of the last two units is currently scheduled for October 2019.

This order strengthens the relationship with the customer, for which ANDRITZ Hydro has already executed some projects. And it also represents an interesting automation reference for ANDRITZ Hydro Canada in Chambly.

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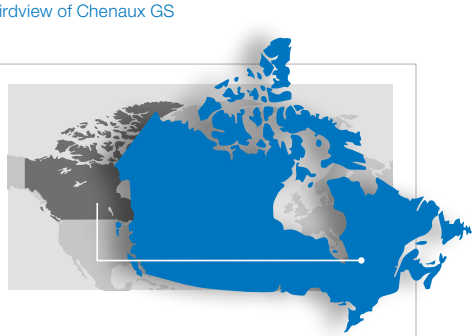
Birdview of Chenaux GS



Chenaux GS | Canada

Technical data:

Total output:	143.7 MW
Scope:	143.7 MW
Head:	11.6 m
Voltage:	13.8 kV

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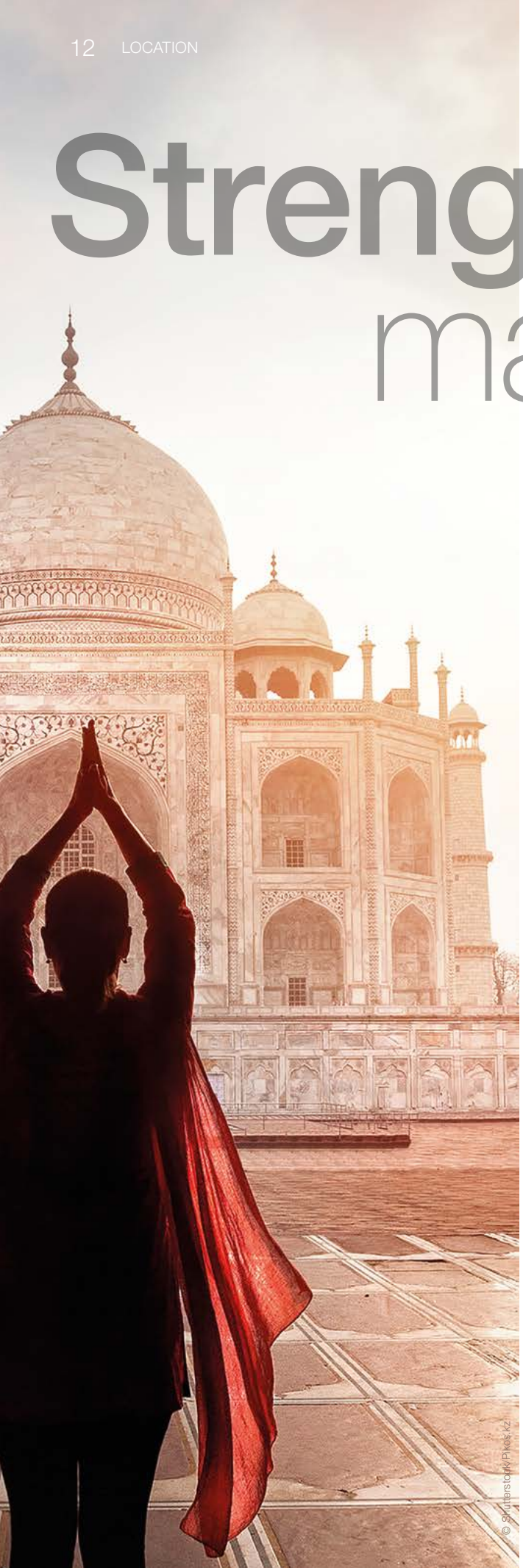
Strengthening market ties



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INDIA – To further strengthen the company's turnkey approach and to be close to its customers and stakeholders, ANDRITZ Hydro Private Limited, India, has recently opened a new office in the Indian capital of New Delhi. The office was inaugurated on November 10th, 2017 by Mr Santosh Kumar Gangwar, Honourable Minister of Labour and Employment for the government of India, in the presence of high-ranking officials from the Ministry of Environment, Forest and Climate Control, the National Hydroelectric Power Corporation, and other important clients.

Over 200 employees are housed in this new office, an entire building covering over 2,600 m^2 of working area and located in south Delhi. The state-of-the-art sustainable building environment is LEED Silver certified – conserving energy as it is equipped with a heat recovery ventilation system and variable refrigerant volume HVAC system, day lighting and occupancy sensors. The energy and water efficient building is in line with global environmental commitments leading to a greener and healthier work environment for all.

"The new building is state-of-the-art and further confirms the environmental commitment of ANDRITZ Hydro not only to its customers, but also to its employees."

For many years now, ANDRITZ Hydro has been a leading player in India's hydropower market and has supplied and installed equipment with a capacity of more than 17,000 MW to date. The company has been proudly associated with prestigious projects like Karcham Wangtoo (1,000 MW) and Teesta III (1,200 MW). Both projects were commissioned on time and have contributed significantly to the national energy system (⟶ see article page 32).

ANDRITZ Hydro also holds a leading market position in neighbouring Nepal – a country with a hydropower potential of about 80,000 MW – executing various projects of national repute in the country. To garner proximity to its esteemed clients in Nepal, a wholly-owned subsidiary of ANDRITZ Hydro India is now in operation here too (⟶ see article page 42).

Visit of Honourable Minister Santosh Kumar Gangwar

Advisory and Managing Board of ANDRITZ Hydro India

In 2017, ANDRITZ Hydro India also entered into a joint venture with the Himalayan kingdom of Bhutan's state-owned power utility Druk Green Power Corporation. This JV is now incorporated as Bhutan Automation and Engineering Limited to manufacture secondary equipment for hydropower plants.

"With two long-established and state-of-the-art manufacturing locations, as well as the new corporate office and more than 1,400 trained and qualified engineers, ANDRITZ Hydro India is now one of the largest set-ups of ANDRITZ Hydro globally."

India's GDP is expected to grow at 6.7% in 2018, which is expected to bolster growth in infrastructure and manufacturing. Along with this, the government of India's target of 175 GW of renewable energy capacity addition by 2022 makes for a robust business environment. Of this 175 GW, small hydro projects are expected to contribute about 5 GW of capacity, for example. Pending hydropower policies that are further anticipated to boost India's hydropower sector are much awaited. With its new office, ANDRITZ Hydro India is now even better prepared to contribute to the country's future hydropower development.

Today, ANDRITZ Hydro India is a consolidated company which has increased its business portfolio to include penstocks and gates, operation and maintenance of hydropower plants and high capacity engineered pumps. The company not only caters for the Indian and South-East Asian market, but has also exported equipment and generators to more than 28 countries, including North America.

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India Facts:

Population	**1,295 Mio**
Access to Electricity	**79.2%**
Installed hydro capacity	**48,913 MW**
Hydro capacity under construction	**10,773 MW**
Share of generation from hydropower	**9%**
Hydro generation	**130,180 GWh**
Technically feasible hydro generation potential	**~ 660,000 GWh**

Source: Hydropower & Dams Word Atlas 2017 and the World Bank

ANDRITZ Hydro Facts:

- Headquarter in New Delhi
- Manufacturing workshops in Prithla and Mandideep
- Marketing offices in Kolkata, Bangalore and Jammu
- Installed units: 414
- Total capacity: 11,790 MW

For further content use the QR-Code on p.5

A SCARCE COMMODI

© Shutterstock / Rahul Ramachandram

At its zenith, the sun is a ball of fire in the sky. Scorching heat hangs over the fields and the horizon shimmers in the distance. A few droplets of water splash onto the parched ground and evaporate immediately. A hand shakes the water hose in desperation, but the trickle of water, which has been getting steadily weaker, has finally dried up. Once again, there is no water. Davinder wipes the sweat from his brow and looks toward the sky in despair. Brilliant sunshine, unbearable heat, and not a single raincloud in sight. His parents named him after the Indian god of rain and storms. A cruel irony, because it won't help him water his crops. Davinder shares his fate with many farmers in India – two thirds of the agricultural land is dependent on the monsoon or regular rainfall, only one third has reliable irrigation to provide water for people, livestock and farming.

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NEW PROJECTS

KALESHWARAM

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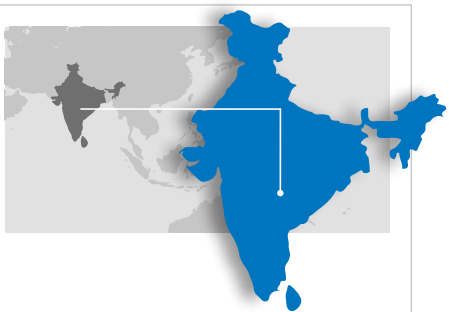

Kaleshwaram | India

Technical data Pump station #1:
11 vertical volute pumps

Head:	40 m
Flow rate:	60 m^3/s
Efficiency:	up to 90%

Technical data Pump station #2:
8 vertical volute pumps

Head:	25.9 m
Flow rate:	83 m^3/s
Efficiency:	up to 90%

Technical data Pump station #12:
8 vertical volute pumps

Head:	107 m
Flow rate:	31.1 m^3/s
Efficiency:	up to 90%

INDIA – Over recent years India, especially Telangana State, has been hit by extremely high temperatures creating problems for irrigation and crops, diminishing economic development and causing human tragedies. In 2016, about 1.4 million farmers left this region.

With a series of irrigation projects in the overarching Jala Yagnam project, the local government has undertaken measures to solve the irrigation problem for about 3.3 million ha of agricultural land. The Kaleshwaram project is one of the largest sub-projects, designed to store about 4.7 trillion liters of water in order to irrigate 740,000 ha. This project comprises a dam and several pumping stations with reservoirs. Water is transported over a height of 500 m and a distance of 200 km. It is the first multi-stage lift irrigation project of this magnitude and complexity in India. It also contains the longest water transport tunnel in Asia, extending over a distance of 81 km connecting the dam to a reservoir. An irrigation project of this kind is unique, not just in India, but worldwide.

"The traditional name Jala Yagnam translates as worship of water or sacred water."

ANDRITZ was awarded the contract with a partner who is supplying the motors. ANDRITZ will manufacture 27 vertical volute pumps for three pumping stations, each with an efficiency of up to 90%. A special feature of these pumps is that they are similar to turbines due to their impressive size, with a Francis impeller of 3.5 m, a total weight of 130 t up to 200 t per pump, and an spiral outlet diameter of 5.5 m, large enough to park a truck comfortably.

Besides the design and delivery of the pumps and spare parts, installation and commissioning will also be supervised by ANDRITZ. Completion of the entire project is scheduled by the gouverment of Telangana for June 2018. Great hopes are being pinned on the success of this important infrastructure project. Harnessing sufficient water reserves for reliable irrigation of agricultural land will improve the lives of the people of India's most populous state.

For further content use the QR-Code on p.5

NEW PROJECTS

YEN NGHIA

BIG IN VIETNAM

VIETNAM – Vietnam has a sub-tropical climate with a three-month rainy season characterized by the monsoon's heavy storms. These cause rivers and streams to burst their banks and widespread flooding. As a result, over the last decade hundreds of people have lost their lives and countless more have lost their homes.

In order to contain the most severe effects of the monsoon, the Vietnamese Ministry of Agriculture and Rural Development has launched numerous flood control projects. The Yen Nghia project marks the beginning of this initiative. By the end of 2018 the biggest flood discharge pumping station in the country will be built to the southwest of the capital Hanoi, home to about 6.4 million inhabitants.

The Yen Nghia pumping station has been specifically designed and built for flood control applications. This means that the pumps are only activated in case of need, but then have to work with 100% reliability, pumping large amounts of water at low head in the shortest time possible.

ANDRITZ is supplying 10 vertical line shaft pumps for the Yen Nghia project, due for delivery in March 2018. The scope of supply includes the construction, manufacturing, transport, and installation supervision of the 10 pumps in Vietnam as well as spare parts. Each pump has an robust axial hydraulic design in order to withstand the passage of diverse materials washed away by floods. Each pump conveys up to 15 m^3 of water per second.

The required performance test of the pumps will be conducted at the bench facilities of Vietnamese company Hai Duong Pump Manufacturing JSC (HPMC), which is responsible for the supply of the entire electro-mechanical equipment for the Yen Nghia station. ANDRITZ has signed an exclusive distribution contract for large pumps with HPMC for Vietnam, Cambodia, and Lao PDR. This forms the basis for receipt of further common projects in the future.

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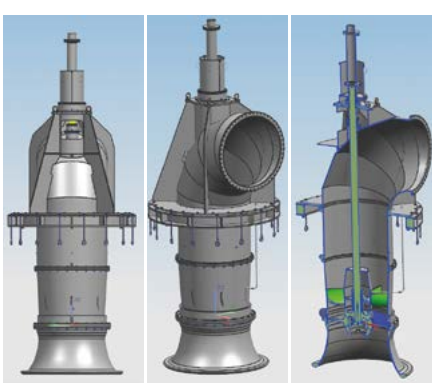
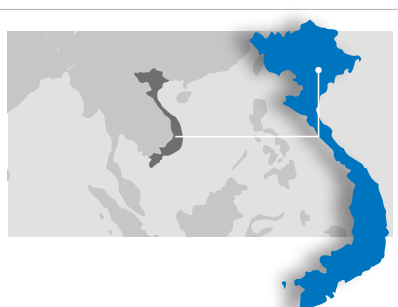


Drawing of the vertical line shaft pump



Yen Nghia | Vietnam

Technical data:

Impeller diameter:	2,040 mm
Head:	4.9 m
Flow:	13.2 m^3/s
Engine performance:	1.25 MW

NEW PROJECTS

FENGNING 2

BALANCING TECHNOLOGY

CHINA – ANDRITZ Hydro is contributing to China's clean energy transition with pumped storage power technology.

The Fengning Pumped Storage Power Station is a key project for the national energy development of China. Located in Fengning Man Autonomous County in Hebei Province, about 180 km from the capital Beijing, construction began in 2013. After completion it will be the world's largest pumped storage facility to date, operated and managed by State Grid Xinyuan Company.

Fengning 2 | China

Technical data:

Total output:	3,600 MW
Scope output:	2 × 330 MVA
Head:	425 m
Voltage:	15.75 kV

With a total installed design capacity of 3,600 MW, PSPP Fengning will be built in two phases, each featuring six reversible pump turbine units with a capacity of 300 MW each. In the second phase two of the six units will be variable-speed motor-generator units. Designed for balancing the intermittent renewable energy resources of large Mongolian wind and solar parks, PSPP Fengning 2 will be connected to the Beijing-Tianjin-North Hebei grid with two 500 kV lines. The designed annual power generation will be 3.424 TWh with 4.565 TWh of corresponding pumped water meeting peak power needs. Securing safe and stable grid operation, and increasing power supply quality, the installation will boost local employment, promote tourism and farming industries. In addition, PSPP Fengning will contribute to emissions reduction and have significant positive social, ecological, and economic perks.

"PSPP Fengning 2 will be a safe, reliable, environmental-friendly, ecologically harmonious quality project which will benefit Chinese society."

State Grid Corporation of China (SGCC)

In 2017, ANDRITZ Hydro received a contract from the state-owned Chinese energy utility company Fengning Pump Storage Co. Ltd. and State Grid Xinyuan Co. Ltd. to supply two variable speed generators for PSPP Fengning 2. The units will have a nominal capacity of 330 MVA in generator mode and 345 MVA in pump mode. Additionally, AC-excitation, governors, as well as protection and computer control systems are part of the contractual scope. The completion of the project is scheduled for 2021.

ANDRITZ Hydro is pleased that the customer has chosen ANDRITZ Hydro technology for these very first pumped storage units with variable speed technology to be introduced into the Chinese system. For ANDRITZ Hydro this remarkable order marks a re-entry into the growing Chinese pumped storage market.

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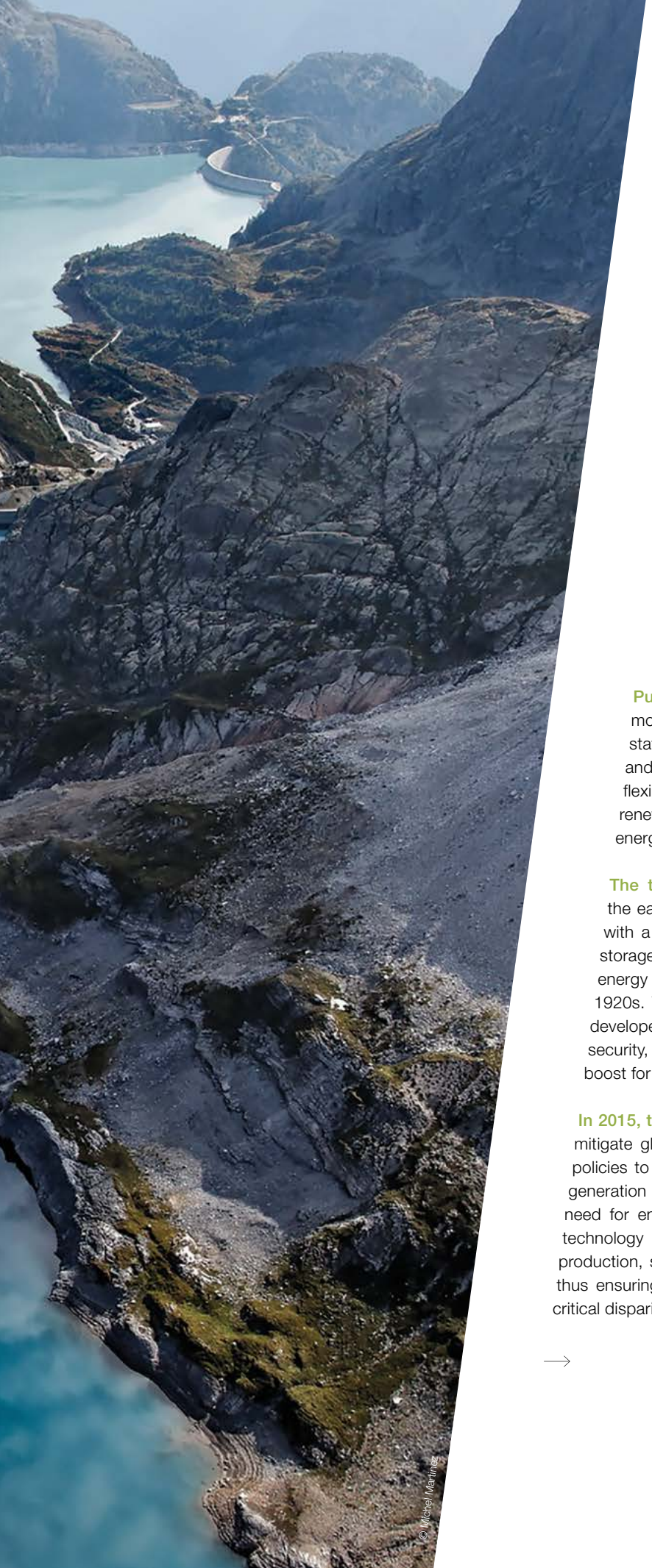
COVER STORY

PUMPED STORAGE FOR THE FUTURE



© Michel Martinez

What is the future role of pumped storage and how can this technology contribute to Sustainable Development Goals? A short glimpse of the current market situation.

Pumped storage hydropower plants are well proven as the most cost-effective form of energy storage to date. They offer state-of-the-art technology with low risks, low operating costs and balance grid fluctuations through their high operational flexibility, allowing the successful integration of intermittent renewable power. Thus, they significantly contribute to a clean energy future.

The technology was first applied in Zurich, Switzerland, in the early 1890s, when a local river was hydraulically connected with a nearby lake via a small pumped storage plant. Pumped storage hydroelectric projects have been commercially providing energy storage capacity and grid stabilizing benefits since the 1920s. Thereafter the technology was significantly improved and developed. In the 1970s and 1980s, concerns about grid and supply security, as well as base load balancing requirements, induced a boost for pumped storage plants.

In 2015, the Paris Climate Agreement (COP21) set global goals to mitigate global warming. Many countries have aligned their energy policies to reduce greenhouse gases emissions and to push power generation from renewable resources. This triggered an increasing need for energy storage. Currently, pumped storage is the primary technology for energy storage services, balancing variable power production, serving as buffer and providing predefined energy supply, thus ensuring grid stability and reducing the risk of black-outs when critical disparities occur between supply and demand.

→

PSPP Castaic Los Angeles County, California, USA

PSPP El Hierro (Gonora del Viento), Spain

Today more than 150 GW of pumped storage capacity is installed throughout the world. In 2016 about 6.4 GW – nearly twice the amount installed in 2015 – was added worldwide. A further 20 GW of pumped storage capacity is currently under construction across the globe.

This confirms that hydropower, and pumped storage especially, represents a substantial part of the renewable power sector. Among others China is trend-setter, having implemented the necessary frameworks to reach a 40 GW of pumped storage capacity by 2020 as part of an energy development plan. (⟶ see article on page 17).

The benefits of pumped storage such as balancing volatile renewable energy sources and supplying security and grid stability are a most welcome contribution to every grid. For small and islanded grids especially, pumped storage hydropower is an ideal partner when independence from fossil fuels can be achieved. For example, on El Hierro, one of the Spanish Canary Islands, a small pumped storage power plant has been combined with a wind power park. Together they are providing sufficient and stable power supply which even allows energy exports to neighboring islands.

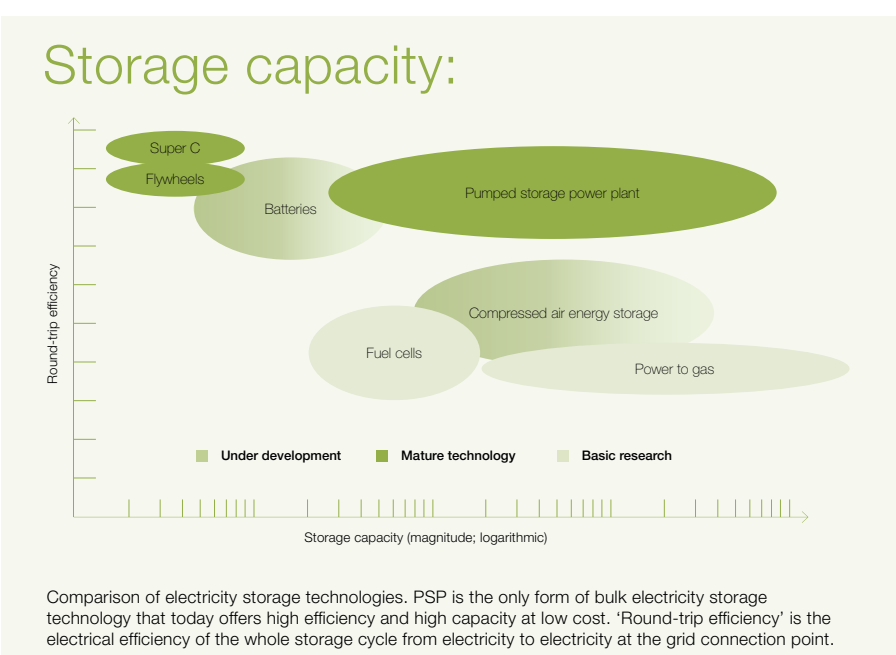
Other energy storage technologies

Along with pumped storage, there are other energy storage technologies in commercial use, mainly batteries based on lead sulfur, lithium ion, sodium sulfur and sodium nickel chloride. They are overall proven technologies with fast response times, applicable almost everywhere and allowing easy interlinking with intermittent renewable technologies. However, batteries have a shorter lifetime, while issues such as sourcing materials for large scale implementation and environmental hazards in mining, production, and recycling represent challenges. Today, only about 2 GW of battery storage capacity is installed globally (in comparison with 150 GW of PSP). Nonetheless, batteries are going to be deployed at scale and in the future electricity landscape, batteries and pumped storage will both remain essential technologies.

Pumped storage technologies

At its heart pumped storage power plant technology sees water pumped to a higher elevation reservoir when there is a surplus of electricity. This water is then released into lower elevation reservoirs to generate electricity when needed.

There are three basic designs of pumped storage technology currently available, depending on the services required.



Comparison of electricity storage technologies. PSP is the only form of bulk electricity storage technology that today offers high efficiency and high capacity at low cost. 'Round-trip efficiency' is the electrical efficiency of the whole storage cycle from electricity to electricity at the grid connection point.

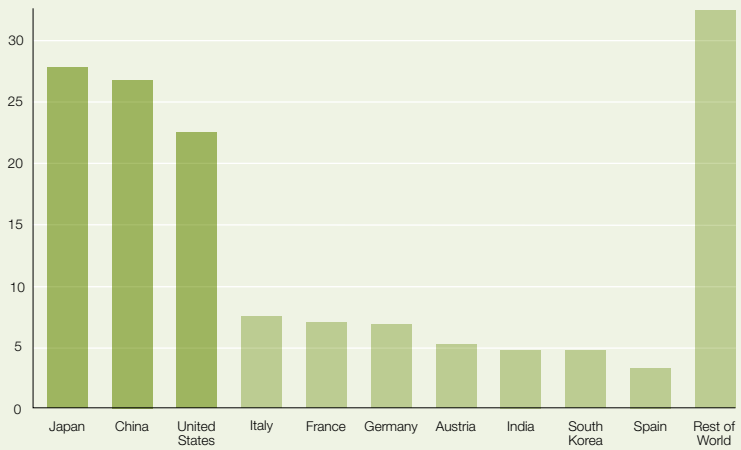
With pumped storage technology, hydropower operators can quickly respond to fluctuations in electricity supply and demand. Utilities are offered a cost-effective way to combine variable energy resources such as wind and solar into the grid. Pumped storage is the most important and economic solution for large-scale energy storage available today.

Reversible pump-turbines with a fixed speed motor-generator supply full flexibility in turbine operation. Pump operation is restricted to on or off. Operating a set of pump-turbines in parallel (usually 4-6 units) allows more flexibility in pump mode by adjusting the discharge and power in discrete steps.

Ternary sets with a separate pump and turbine and with fixed speed motor-generator provide full flexibility in both turbine and pump mode. Ternary sets are suitable for very fast (within a few seconds) change-over between modes. With an optional hydraulic short-circuit, these types of units are able to adjust discharge and power also in pump mode.

Reversible pump-turbines with variable speed motor-generator provide infinitely adjustable discharge and power in both turbine and pump operation, plus enhanced grid services like virtual inertia. →

Worldwide distribution of pumped storage capacity (GW) at the end of 2016:



Pumped storage hydropower capacity (GW) in operation

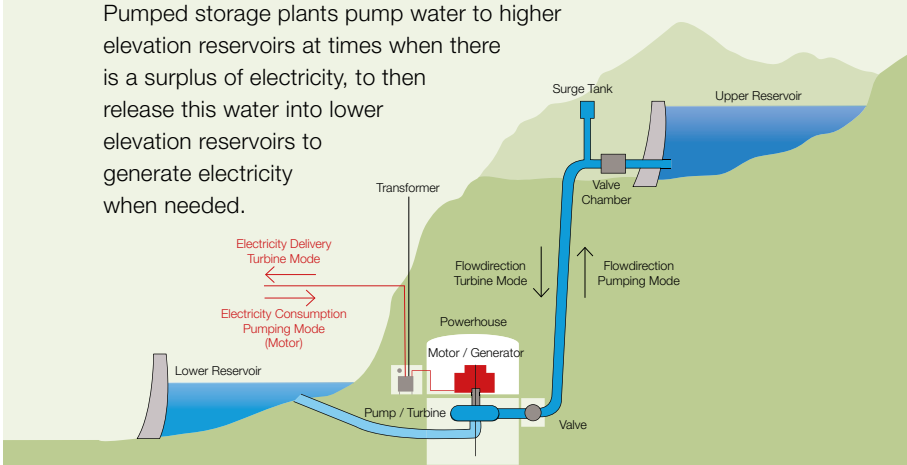
Source: IHA, International Hydropower Association, 2017 Key Trends in Hydropower

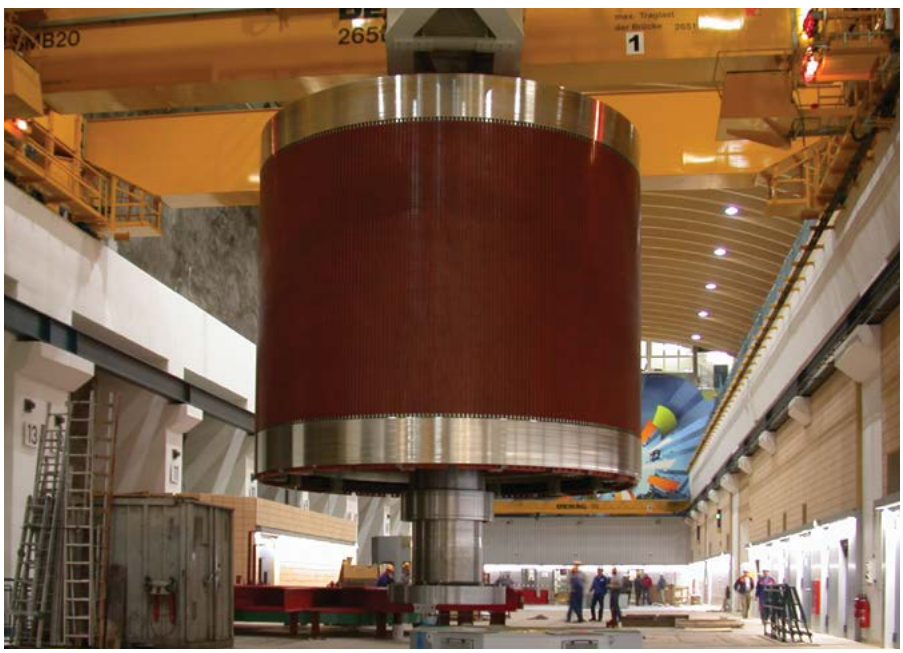
Benefits of pumped storage:

- Best-proven, low-risk technology
- Balancing volatile renewable energy generation with demand
- Managing grid bottlenecks
- Supporting grid stability by virtue of a quick response to changing demand or sudden outages
- Contributing to grid stability by increasing grid inertia and providing black start capability
- Very long facility lifetime

The principle:

Pumped storage plants pump water to higher elevation reservoirs at times when there is a surplus of electricity, to then release this water into lower elevation reservoirs to generate electricity when needed.



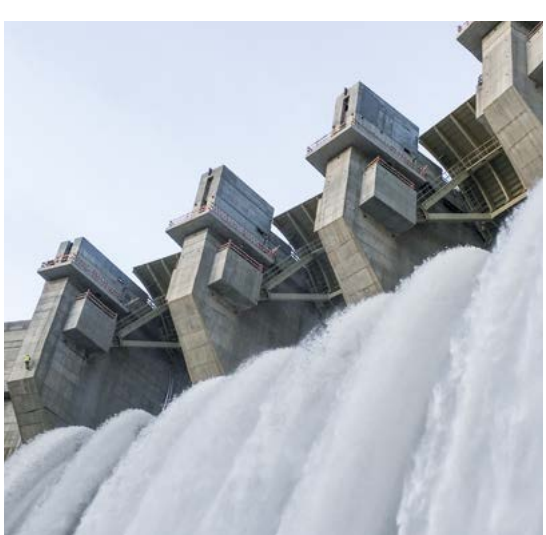


PSPP Goldisthal, Germany

PSPP Shi Shan Ling, China

ANDRITZ Hydro's long history

ANDRITZ Hydro supplied the generating units for the world's first commercial pumped storage plant – Niederwartha in Germany in 1929 – and has continued to provide groundbreaking technology ever since. For example, the storage pumps of Provvidenza (Italy, 1949) as well as Limberg (Austria, 1954) were the world's largest at the time of the contract awards. Germany's largest pumped storage plant, Goldisthal, was the first variable-speed pumped storage plant outside Japan. Since Niederwartha, ANDRITZ Hydro has delivered about 500 pumped storage units with a total capacity of about 40,000 MW. The company has been involved in major projects around the globe, like Tianhuangping and Tongbai in China, Northfield, Muddy Run and Castaic in the USA, Edolo and Presenzano in Italy, Malta-Reisseck in Austria, Drakensberg in South Africa and Aldeávila in Spain, as well as Vianden in Luxembourg – the largest pumped storage plant in Europe and where unit #11 was recently commissioned. For Lower Olt in Romania ANDRITZ Hydro supplied the largest low-head Bulb type pumped generating units in the world.



PSPP Foz Tua, Portugal

Currently, ANDRITZ Hydro is executing Gouvães in Portugal and has recently signed a contract for two speed-variable generating units for Fengning 2 in China, which will become the largest pumped storage plant in the world when completed. (⟶ see articles on pages 08, 17 and 29)

Research and Development

Constant evaluation and development is necessary to meet changing customer requirements. ANDRITZ Hydro engineers are permanently refining technologies such as adjustable speed and closed-loop systems – projects without a continuous connection to a natural water body outside the hydraulic scheme. Customized designs can also be deployed in special locations, such as in the marine environment with ultra-low heads like in Swansea Bay, Wales/UK (⟶ see article on page 31), for example.

Today, the focus is on smooth and stable operation, as well as an extended operational range, dynamic operations and high reliability and flexibility. This is despite the requirement for frequent mode changes, rapid load changes and quick change-overs between pumping and generating. Improved structural integrity of the units ensures a long service life.

Pumped storage is a proven, low-risk technology with high efficiency. It benefits from long asset lifetimes and shows lower operating costs than any other technology that can provide similar services. By successfully integrating intermittent renewable generation resources into the grid pumped storage can thus contribute significantly to a clean energy future.

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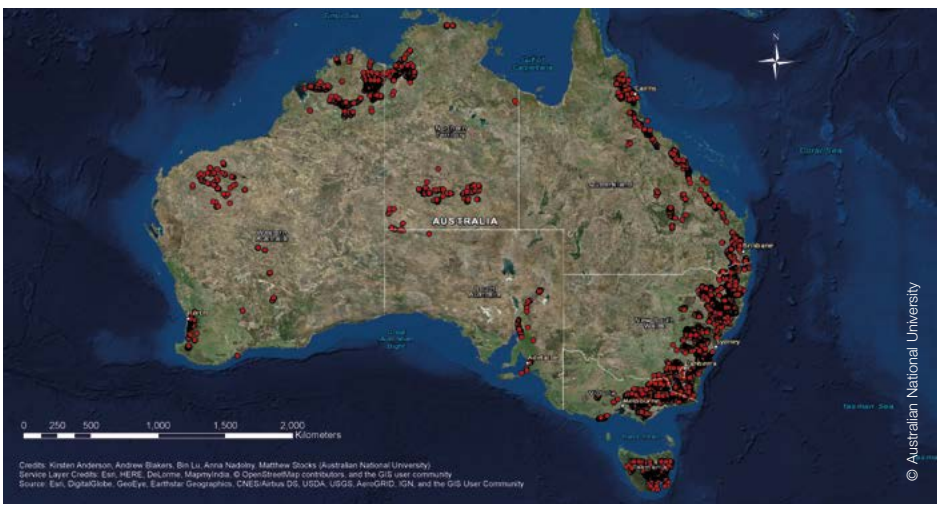
Overview of possible off-river pumped storage sites in Australia



Pumped storage in Australia: On the road to a 100% renewable electricity future

Rapid growth in the deployment of wind parks and commercial solar PV projects has prompted associated growth in pumped storage hydropower in Australia. Triggered by the on-going energy transition and the associated investments in renewables, especially in South Australia, numerous pumped storage developments around the south and east coasts have been prompted.

Now, new research reveals that by using river-based projects Australia's pumped storage potential is far greater than had been previously anticipated.

As the only mature and economically viable technology for large scale energy storage, pumped hydro accounts for almost 97% of the total energy storage capacity installed worldwide to date. Ideally, pumped storage power plants are operated in combination with other renewable resources, such as wind and solar PV, allowing balancing of intermittent energy production and stabilizing of the grid. Power is available at short notice when needed, avoiding power shortages. However, concerns over the volatility of renewable energy resources were exacerbated by a major electricity blackout in South Australia in September 2016, potentially impacting on the continued clean energy roll out. In fact, unpredicted high demand and the unavailability of thermal and wind generation caused this energy crisis.

In response to the power outage, the Australian National University (ANU), supported by the Australian Renewable Energy Agency (ARENA) initiated a study for potential sites for off-river pumped storage throughout Australia. Economically viable and with a lifespan of over 50 years, most pumped storage schemes are located on a river or a lake, but there is also a large potential for off-river pumped storage. Headed up by Professor Andrew Blakers, one of Australia's key energy scientists, the research team found more than 22,000 suitable sites with a total storage capacity of about 67,000 GWh. Identified sites were found close to populated areas and with the possibility of a grid connection.

The generating potential of the sites range from 1 GWh to 300 GWh. Australia is in need of only about 450 GWh of energy storage for a 100% renewable energy electricity system, a transition which is already underway.

Pumped storage along with decentralized smaller battery solutions will certainly play a major role in the future energy storage concept, bringing Australia closer to its goal of a 100% renewable energy future.

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For further content use the QR-Code on p.5

SIGNIFICANT ENERGY DEVELOPMENT

CUSTOMER REPORT

HONGRIN-LÉMAN

Forces Motrices Hongrin-Léman SA (FMHL) is a 240 MW pumped storage power plant located at Veytaux in Switzerland. It was first commissioned in 1971. Now, two additional 120 MW ternary Pelton generating units have been installed by ANDRITZ Hydro. Commissioning of the project to double the plant's capacity took ← place in January 2017.

Nicolas Rouge, Asset Manager of Forces Motrices Hongrin-Léman SA, talked to Hydro News about this project:

The Hongrin-Léman power plant is owned by Romande Energie, Alpiq SA, Groupe E and the City of Lausanne through the Forces Motrices Hongrin-Léman SA (FMHL) company. Key development partners include the consortium Gihlem consisting of Stucky SA (leader), EDF-CIH and Emch+Berger AG. Within the existing powerhouse are four 60 MW, ternary Pelton generating units. The plant, which has an annual power production of 1,000 GWh, is operated by HYDRO Exploitation SA.

First conceived over a decade ago, ALPIQ AG, as the owner representative, was the company in charge of the supervision of the feasibility study and the implementation of the so-called Veytaux II or FMHL+ expansion project.

The cavern excavation started in March 2011, the embedded hydro-mechanical equipment was installed in the cavern between July 2014 and August 2015.Installation of the electro-mechanical system started in September 2015 to August 2016. Commissioning began in March 2016 and the first turbine was synchronized with the grid in May the same year. The turbines were first used in pumping mode in June 2016. The final commissioning was completed in January 2017 including successful performance tests.

Machining of the Pelton runner

What special characteristics are seen at this project?

In this expansion of the existing Hongrin-Léman pumped storage power plant the new underground power plant FMHL+ is integrated into the existing waterways between the upper Hongrin reservoir at an altitude of 1,255 m and Lake Geneva at around 372 m above sea level, primarily through a link to the original penstock and tailrace.

Built in the Swiss Canton of Vaud, major challenges during the development of the new FMHL+ power plant included construction in a dense urban area, in close vicinity to existing structures and buildings, such as motorway bridges, international railway lines, a historic castle and a major national road.

Furthermore, the project had to proceed without impacting the existing Veytaux I hydraulic facilities as continual operation of the Veytaux I power plant during the construction of the new plant was required. The connection between the existing waterways and the new power plant was a particular challenge, because interruption of power generation by the existing plant had to be kept to a minimum.

Another engineering challenge concerned selection of the machinery in order to meet the requirements set out by the transient analysis and to suit the characteristics of the existing penstock, safety being a key issue. In order to master these challenges and gain acceptance for the project in a densely populated and complex area, specialist studies were carried out.

How did you address any environmental issues or considerations?

All the research results as well as all the environmental impact assessments flowed into an environmental report that was part of the acceptance procedure. In 2009 an environmental impact report was drafted and a public inquiry launched regarding a request to modify the inter-canton concession (Vaud and Fribourg).

Thanks to these preliminary studies and exploratory work, as well as intensive discussions with representatives from local authorities, national authorities and environmental associations, FMHL achieved acceptance for the project without any appeals whatsoever in 2010.

In terms of sustainability, FMHL has built a development that will last for the next 80 years at a hydroelectric plant that has already been in operation since 1971 and which will use the existing hydroelectric facilities (headrace and penstock).

What parameters were applied in selecting suppliers and partners?

Criteria-based public contracts were used to select suppliers. Factors for consideration included price, quality and relevance of bid, quality in execution planning, and quality of references, for example. The existing penstock was a significant factor in the selection of the equipment in order to meet the requirements set out by the transient analysis. The new plant (Veytaux II, FMHL+) uses the existing upstream waterway (headrace tunnel and penstock) and downstream hydraulic system (tailrace channel and water intake). Veytaux I features a double arch wall up to 123 m tall and has a 600 m crown length. It impounds a reservoir of some 52 million m^3. The existing 8 km-long headrace tunnel and the 1.4 km-long penstock have both enough capacity to transfer the new generating and pumping discharges of 57 m^3/s and 43 m^3/s, respectively.

Outline your experience of the planning, design and installation/implementation phases of this project.

Generally very satisfied. Good quality, and the turbine and generator/motor efficiencies are better than planned. During the project phase, the engineers and project leader were very flexible and there was good cooperation with the project management of ANDRITZ Hydro.

View on the reservoir, Lac de l'Hongrin

Château de Chillon on Lake Geneva

Engineering challenges included difficulties regarding the turbine injectors and the six spherical gates. Difficulties arose in assembly, for example damage to MIV5 and CIV5 gate joints, also anti-rust protection was removed locally during jet deflection and the temperature was raised during partial-charge operation. Nonetheless, all problems were resolved through close collaboration between ANDRITZ Hydro engineers and project leader, FMHL project management, the Gihlem engineers, and the operator and responsible for the commissioning HYDRO Exploitation SA.

It is important to build a team including the owner's project management, engineers appointed by the owner, the future operator, and the supplier once contracted. To maintain high levels of trust, effective communications are vital. For us it was a good solution to have the coordination between the three lots "Turbine - Generator/Motor - Valve" with ANDRITZ Hydro in Vevey. Well done to the ANDRITZ Hydro assembly team: great commitment and very professional.

Following commissioning, does Veytaux II (FMHL+) meet all expectations?

The success of the construction project was due to building an excellent technical and assembly team of suppliers who all had the same desire – to succeed in this large project.

Prioritizing technical skills within the project and assemblies made the job much easier for commercial and legal activities.

The passion of the Alpiq, Gihlem, HYDRO Exploitation SA and ANDRITZ Hydro engineers in starting with a blank page and overcoming all the challenges to see all these pieces of the puzzle being assembled with very professional support and commitment is obvious. Their success is measured by the two 120 MW turbine/pumping groups buzzing in a 100 m-long, 25 m-wide and 56 m-high cave – all remotely operated by the Alpiq Production and Operation Management Centre in Lausanne.

In November 2017, for example, the pumping and generating availabilities were 100% with a very important generation and pumping program!

A masterpiece by ANDRITZ Hydro, its suppliers and their workers who helped make this project a great success. Well done and thank you!

COORDINATOR
Roland Cuenod
Managing Director
ANDRITZ Hydro Switzerland

Biography: Nicolas Rouge

A mechanical engineer, Nicolas Rouge is Head of the Asset Management Support Department at Alpiq and responsible for the asset management at the Forces Motrices Hongrin-Léman pumped storage hydropower plant in Switzerland.

"Since commissioning the plant is performing very well. It produced more than 400 GWh with 4,343 turbine hours, together with 417.3 GWh of pumping operation during 3,330 hours of operation"

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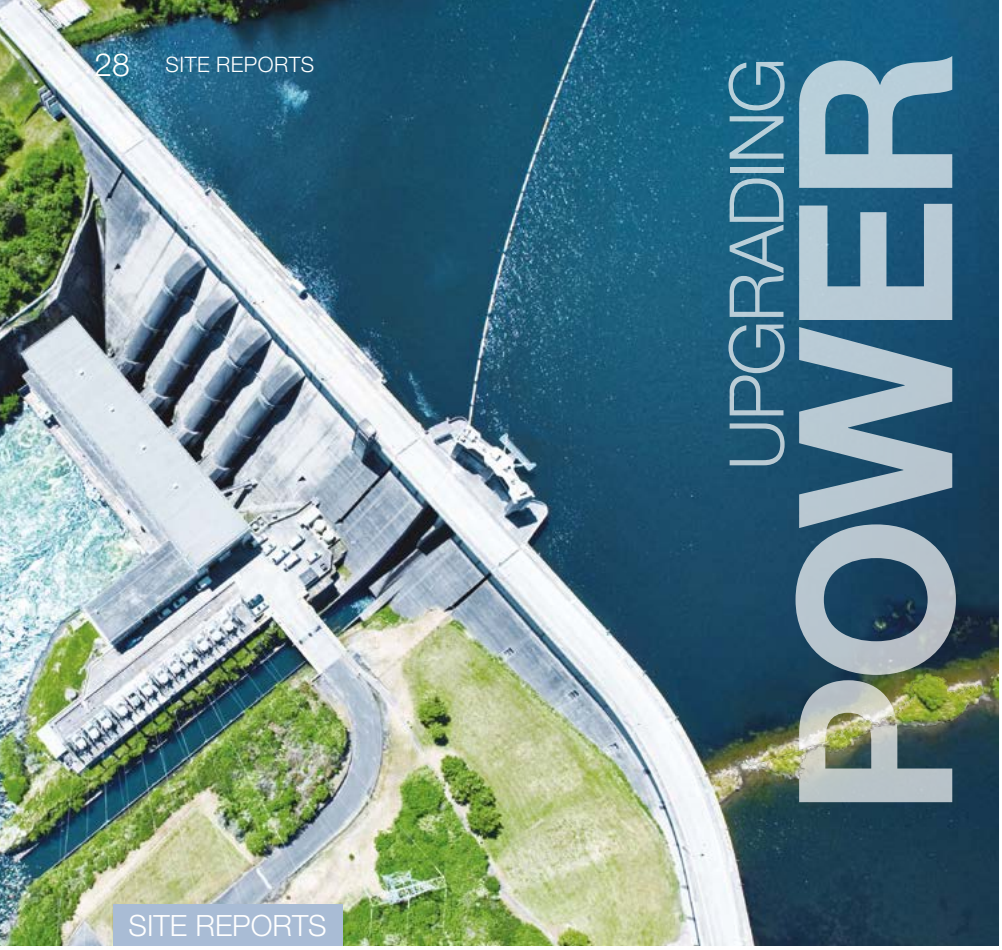

UPGRADING POWER

SITE REPORTS

WHAKAMARU

Whakamaru | New Zealand

Technical data:

Total output:	127.2 MW
Scope:	4 × 31.8 MW
Head:	36.5 m
Speed:	136 rpm
Runner diameter:	3,425 mm

NEW ZEALAND – Whakamaru Hydro-electric Power Station is one of several on the Waikato River owned by Mercury NZ Ltd. New ANDRITZ Hydro turbines have substantially increased the flow capacity of the power station, reducing spill and optimizing operation of the river chain.

Originally commissioned in 1956, HPP Whakamaru comprises a concrete dam with short penstocks connected to four Francis turbines that were rated at 26 MW at 136 rpm and a net head of 36.5 m. The original turbines were delivered by the former Dominion Engineering (Canada), now part of ANDRITZ Hydro.

"The new turbine in the Whakamaru hydro station is performing better than expected, we got about 8% efficiency increase, which means the plant will provide about 40 GWh per year of extra energy."

Phil Gibson
General Manager
Hydro & Wholesale, Mercury NZ Limited

When the tender was released in 2012 the customer's main technical objective, other than modernizing the power station, was to maximize the flow and power at within environmental limits to reduce spill and optimize the operation of downstream power stations.

ANDRITZ Hydro was awarded the contract to upgrade the turbines at HPP Whakamaru in August 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 turbine runners were expected to be challenging to design, particularly given the relatively low head and the importance of stable draft tube flow. Included in the contract with ANDRITZ Hydro was a comprehensive model testing package in ANDRITZ Hydro own test rig in Linz, Austria.

A number of challenges were faced during the model test program and a significant number of iterations were necessary to obtain the best technical solution. The final result was an outstanding design with

a turbine rated just under 32 MW – a rating increase of 22%. There were no significant modifications to the embedded parts. In addition, the turbine at model test stage significantly out-performed the guaranteed model efficiency.

Installation and commissioning of the first unit was completed in May 2017. Site efficiency testing was undertaken during commissioning and showed a significant gain in efficiency over the old turbine and more than had previously been expected.

The next three units are expected to be installed at a rate of one per summer through until 2020.

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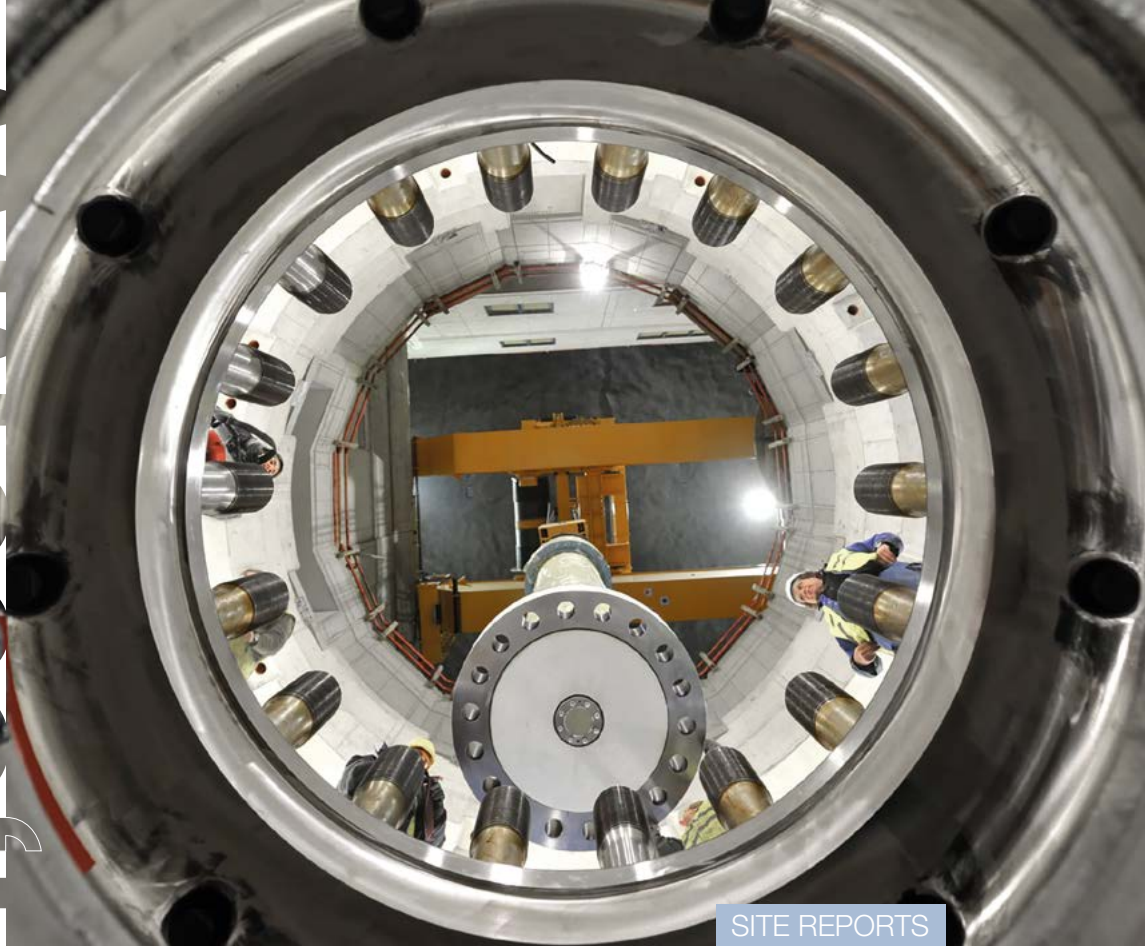
1,300 MW PEAK POWER



SITE REPORTS

VIANDEN

LUXEMBOURG – At the end of August 2017, ANDRITZ Hydro received the Final Acceptance Certificate (FAC) for unit #11 of the Vianden pumped storage power plant in Luxembourg. Located in the Our Valley in the heart of the industrial areas of Northwest Europe between Luxembourg and Germany, the plant benefits from a favorable topographical position, excellent geological conditions along the Our River.

PSPP Vianden has been operating since 1962 with nine generating units – ten units since 1976. Due to the increasing need for balancing power, SEO (Société Eléctrique de l'Our S.A. Luxembourg) decided to expand the hydropower station with an eleventh unit. In 2010, SEO and RWE Power awarded ANDRITZ Hydro with the contract to supply a pump-turbine and the motor-generator for Vianden, the largest pumped storage power plant in Europe. This machine has a capacity of 200 MW and is housed in a separate cavern.

Grand Duke Henri von Luxemburg and the german federal president Joachim Gauck are synchronizing unit #11 together

The extensive warranty inspection of unit #11 was carried out by the customer from May until July 2017 and showed the excellent condition of the pump-turbine and the generator parts, although being in operation relatively frequently since its commissioning in September 2015. This was very pleasing, not only for the customer but also for ANDRITZ Hydro and all the engineers involved.

With 11 units and a total generating capacity of about 1,296 MW, the PSPP Vianden provides renewable, sustainable peak power to the European grid.
(⟶ see Cover Story page 18)

The successful completion of the guarantee period has strengthened the customer's trust in ANDRITZ Hydro and the position of the company in the European hydropower market.

Vianden | Luxembourg

Technical data:

Total output	1,296 MW
Output scope:	1 × 200 MW
Head:	295 m
Voltage:	15.75 kV
Speed:	333 rpm
Runner diameter:	4,262 mm

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OCEAN ENERGY

MEYGEN

THE NEXT GENERATION

SCOTLAND – In late July 2014, Edinburgh-based MeyGen Ltd. signed a contract with ANDRITZ Hydro Hammerfest for the supply of three 1.5 MW tidal stream turbines to the MeyGen Phase 1A project.

Supplied to the largest commercial tidal energy project worldwide in the Inner Sound of the Pentland Firth in Scotland, following Phase 1A, MeyGen is now planning to install a total tidal capacity of 398 MW – feeding predictable renewable energy into the UK's national grid.

All three ANDRITZ Hydro Hammerfest tidal stream turbines were successfully reconnected to the grid between July and August 2017 following the implementation of system enhancements on the turbines earlier in the year.

Energy production since the project's first commisioning exceeds 2 GWh. With over 700 MWh of generation having been dispatched to the national grid in August 2017 alone, the project sets a milestone as well as a benchmark for monthly production from a tidal stream power station.

The anticipated average generation of each turbine is some 4.1 GWh per year. Realization of this project is an important step towards the sustainable production of renewable and predictable energy from ocean resources and a major contribution to future power generation.

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MeyGen | Scotland / UK

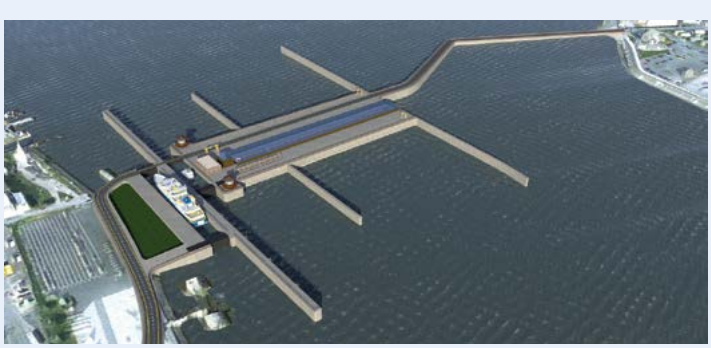
Technical data:

Scope:	3 × 1.5 MW
Blade diameter:	18,400 mm
Installation depth:	50 m
Av. annual production:	12.3 GWh

A 160 MW tidal barrage planned for Northern England

UNITED KINGDOM – Rather than demanding a large hydraulic head to power the turbine from a large dam system, the Wyre Tidal Barrage will harness the natural kinetic energy of the incoming and outgoing tides to produce clean, renewable electricity.

The River Wyre's tidal range exceeds 10 m, which combined with just a 600 m span between the Fleetwood and Knott End banks, makes it one of the most economically viable tidal locations in the world.



"As market leaders in the technology of low-head turbines, we are confident that today's technology is more than sufficient to ensure successful delivery of the power generation aspect of this project."

OCEAN ENERGY

SWANSEA BAY

HARNESSING THE POWER OF TIDES

WALES – Following the international trend to expand the share of renewable energy sources, UK has set tangible efforts on the utilization of tidal energy.

Individual facilities for the direct transformation of marine energy have already been in operation for some time. For example, MeyGen in Scotland (⟶ see article on page 30). Another approach calls for the transformation of tidal energy into electricity using an artificial lagoon. With each high-tide/low-tide cycle the lagoon creates a commercially exploitable differential head, which can be utilized with machines of 20 to 30 MW each.

Tidal Lagoon Power has designed a 320 MW facility at Swansea Bay, in Wales, as a pilot project. It has already been developed to a rather advanced stage. ANDRITZ Hydro, together with a consortium partner, were selected as suppliers and contracted for the initial preparatory work.

Despite being backed by favorable economic figures, the project demands a guaranteed purchase price, which requires the British government's approval. Previously, a group of experts had been tasked with examining the concept behind the planned Swansea Bay project. The resulting report, which was published in early 2017, recommends commencing Project Swansea Bay soon.

"It was considered important to implement a 'scout project' without delay to make full use of the promising tidal energy potential while giving British industry a boost."

Hendry Report

In early October 2017, ANDRITZ Hydro approached the British government, reconfirming its continuing strong interest in implementing this crucial project. By now, the plans for a manufacturing plant in Swansea are ready, and the pre-planned collaboration with multiple manufacturing firms in England and Wales would allow for a rapid implementation with the extensive participation of local industrial providers.

ANDRITZ Hydro is confident that this promising project will soon get the go-ahead and that it will prompt a series of interesting follow-up projects. After all, tidal energy is an energy resource of the future. ANDRITZ Hydro is ready and able to contribute substantially to its utilization.

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Arrival area and rock pools

Western landfall building

Swansea Bay | Wales

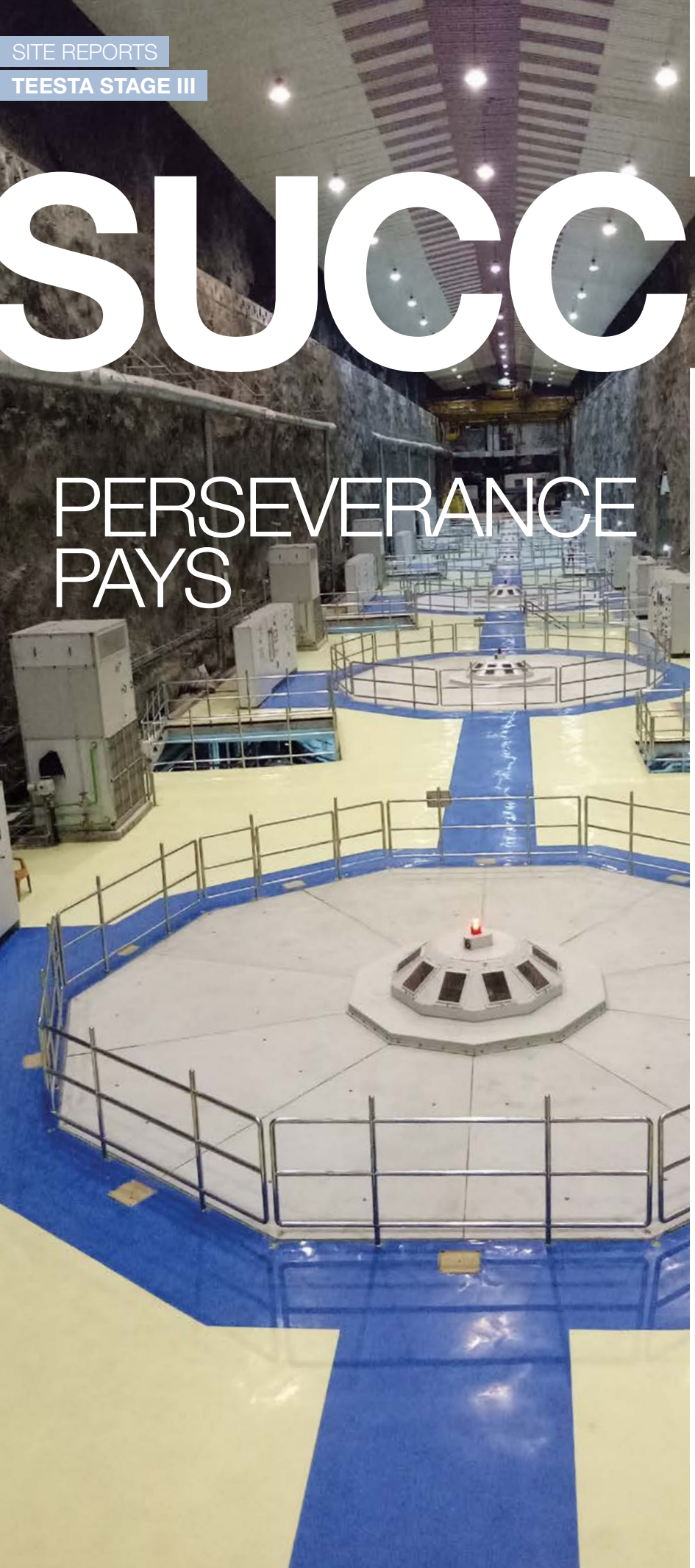
Technical data:

Total output:	320 MW
Head:	8.5 m
Units:	16

For further content use the QR-Code on p.5

SUCCESS

PERSEVERANCE PAYS



INDIA – ANDRITZ Hydro has successfully executed and commissioned one of the largest hydropower plants in India. This is despite challenging circumstances, with a natural disaster prolonging not only the execution of the project but also threatening the whole construction site and its manpower.

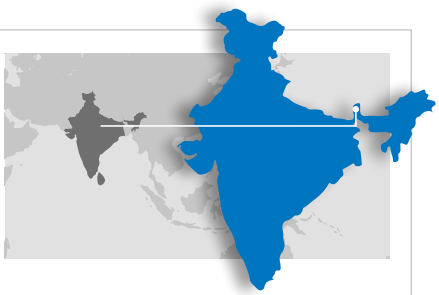
In October 2007, ANDRITZ Hydro signed a contract for implementation of the 1,200 MW Teesta Urja III hydropower plant with an independent power producer (IPP), Teesta Urja Limited. A consortium comprising of ANDRITZ Hydro India and ANDRITZ Hydro Germany was awarded this contract for the turnkey execution of the electro-mechanical scope of the project, including the complete installation and commissioning.

While the turbine's basic design and coated runners were from ANDRITZ Hydro Germany, ANDRITZ Hydro India had responsibility for the entire project management including manufacturing, supply, installation, and commissioning of the plant. Aside from the runners, all major equipment, such as the spherical valves, generators, automation and control systems, and the numerical protection system, as well as the digital excitation system were manufactured at ANDRITZ Hydro workshops in India. The contractual scope also included packages for mechanical balance of plant and electrical power systems, including a 400 kV GIS and 400 kV XLPE cable system featuring one of the longest cable lengths for a hydro project. This project showcases the excellent co-operation and harmonious working practices that can be achieved between multiple ANDRITZ Hydro locations.

Located in the north-eastern state of Sikkim, this run-of-river power plant is one of the largest hydropower plants in India, with a rated head of 780 m and annual generation estimated of about

Challenging transportation

Generator rotor lowering



Teesta Stage III | India

Technical data:

Total output:	1,200 MW
Scope:	6 × 200 MW
Head:	780 m
Voltage:	400 kV
Speed:	375 rpm
Runner diameter:	3,020 mm
Av. annual production:	5,300 GWh

5,300 GWh, 90% dependable over the course of a year. The landmark project was successfully commissioned by ANDRITZ Hydro in 2017, achieving all guarantees and certificates.

An initial contractual duration of 46 months up to commissioning of the last unit was subsequently revised to 112 months, mainly due adverse conditions caused by a massive earthquake. With its epicenter right at the project site, the quake occurred in September 2011 and was followed by the collapse of one the arterial road bridges to the project site in December 2011.

Owing to the extended execution period, one of the main challenges faced during the project execution was related to the preservation and storage of the components for an extremely long duration at various locations near the project site, which was successfully handled by the project team. The long duration of storage caused replacement of a few components on one hand and also demanded refurbishment of a few of these parts too. Furthermore, the transportation of the heavy consignments in an extremely hostile terrain was another mammoth task which was completed successfully.

ANDRITZ Hydro demonstrated its commitment to the project during the extended project duration and proved itself as a reliable partner to the customer, whose profile changed from an IPP to a government-owned entity during the later phases of execution. Due to extensive pre-commissioning activities completed beforehand, the commissioning of all six units was achieved within just one month.

Proving the performance through successful commissioning and by achieving good efficiency figures in the performance tests, ANDRITZ Hydro has demonstrated its high level of competence and dedication.

As a result, it has contributed significantly to the development of Sikkim and ultimately to India's ambitions for national growth. (⟶ see article on page 12)

AUTHOR

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River Teesta is main source of water for many people

For further content use the QR-Code on p.5

SITE REPORTS

PARAISO, GUACA, BETANIA

100% REDUNDANCY

COLOMBIA – EMGESA S.A.E.S.P from the ENEL Group has granted a contract to supply seven out of nine governors for the Paraiso, Guaca and Betania hydropower plants to ANDRITZ Hydro Colombia

The three hydropower plants are located in the center and south-east of Colombia and are strategically important for the generation capacity of the customer. HPP Paraiso and HPP Guaca have three vertical Pelton turbines each with a total capacity of 276.6 MW and 324.6 MW, respectively. HPP Betania has three vertical Francis units with a total capacity of 540.9 MW.

For ANDRITZ Hydro the contractual scope is to rehabilitate the governor system, including new governors for the seven units, replacement of hydraulic power unit instrumentation, and speed measuring devices. The contract also includes integration with the existing SCADA system, as well as installation, commissioning, and training. A major objective of this project is to accomplish primary regulation according to the CREG 25 code of Colombia.

Due to the high concentrations of hydrogen sulfide at HPP Paraiso and HPP Guaca, a high efficiency air filtration system has been considered for each electrical cabinet to keep the electronics safe.

Unit #1 of both HPP Betania and HPP Paraíso have been successfully installed. During commissioning, complete redundancy tests were carried out, verifying that the system has 100% redundancy. Integration of the new hydraulic system surpassed the expectations of the client after new hydraulic blocks for the distributor valve and the deflectors for the Pelton units were installed. The original lever-driven feedback governors were replaced by state-of-the-art electronic governors. During the fingerprint vibration measurement, the maximum over speed for load-rejection in the Pelton unit was 106% after the new implementation. This compares with 112% prior to the upgrade.

Currently, the assembly of unit #2 at HPP Paraiso and unit #3 at HPP Guaca is ongoing. Commissioning of unit #2 of HPP Guaca and units #2 and #3 at HPP Betania are scheduled for 2018.

With the successful execution this project ANDRITZ Hydro Colombia strengthens its market position for governor modernization in Colombia.

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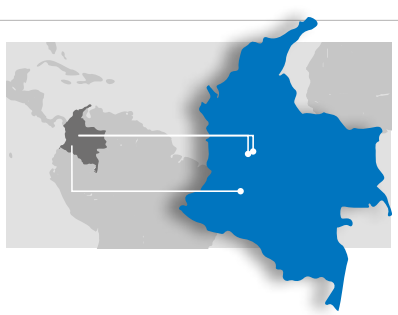


Paraiso, Guaca, Betania | Colombia

Technical data HPP Paraiso:

Output:	3 × 92.2 MW
Head:	865 m
Voltage:	13.8 kV
Speed:	514 rpm

Technical data HPP Guaca:

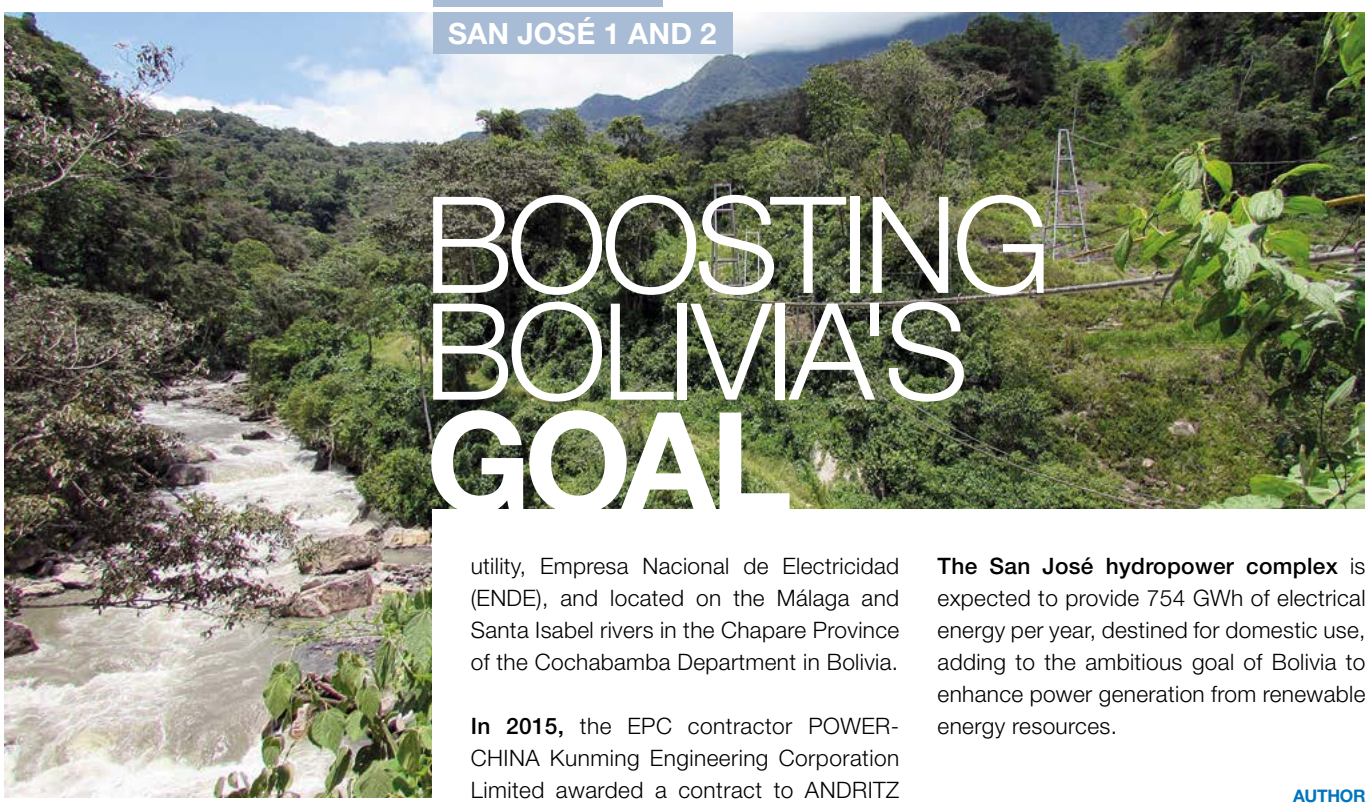
Output:	3 × 108.2 MW
Head:	1,015 m
Voltage:	13.8 kV
Speed:	514 rpm

Technical data HPP Betania:

Output:	3 × 180.3 MW
Head:	72 m
Voltage:	13.8 kV
Speed:	128 rpm

SITE REPORTS

SAN JOSÉ 1 AND 2



BOOSTING BOLIVIA'S GOAL

BOLIVIA – An important part of Bolivian plans to increase renewable energy production is the San José hydropower complex. The Bolivian government has set a target that 70% of its domestic electricity should be generated by renewable energy sources, mainly hydropower, by 2025. As of 2017, only about 20% comes from hydropower. To boost installed hydro capacity from 475 MW up to more than 11,000 MW, various plans are in execution.

This includes the San José complex, consisting of two powerhouses – San José 1 (56 MW) and San José 2 (70 MW) – which is owned by Bolivia's state power utility, Empresa Nacional de Electricidad (ENDE), and located on the Málaga and Santa Isabel rivers in the Chapare Province of the Cochabamba Department in Bolivia.

In 2015, the EPC contractor POWERCHINA Kunming Engineering Corporation Limited awarded a contract to ANDRITZ Hydro China. This deal covered the supply, installation supervision, and commissioning supervision of all four Pelton turbines at the San José hydroelectric complex. By November 2017, the installation of HPP San José 1 was finished and the commissioning was successfully completed.

Especially challenging for the project execution team was a complicated interface among the involved parties, EPC contractor Kunming, ENDE, and ANDRITZ Hydro. For example, the documents submitted had to be trilingual – Chinese-English-Spanish – and there is a 12 hour difference in time zones. To meet the contractual terms with short delivery dates and repeated changes to key data, the design and manufacturing periods had to be shortened. Fortunately, the highly efficient project team cooperated very well with all involved parties and all components were delivered to the site on time.

© Powerchina

The San José hydropower complex is expected to provide 754 GWh of electrical energy per year, destined for domestic use, adding to the ambitious goal of Bolivia to enhance power generation from renewable energy resources.

AUTHOR

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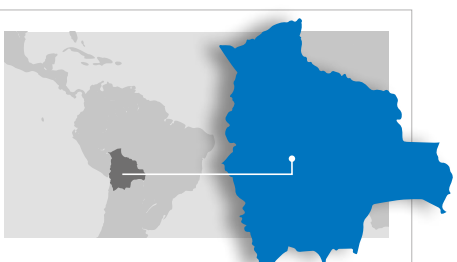


San José 1 and 2 | Bolivia

Technical data San José 1:

Total output:	56 MW
Scope:	2 × 28 MW
Head:	294 m
Speed:	375 rpm
Runner Diameter:	1,860 mm

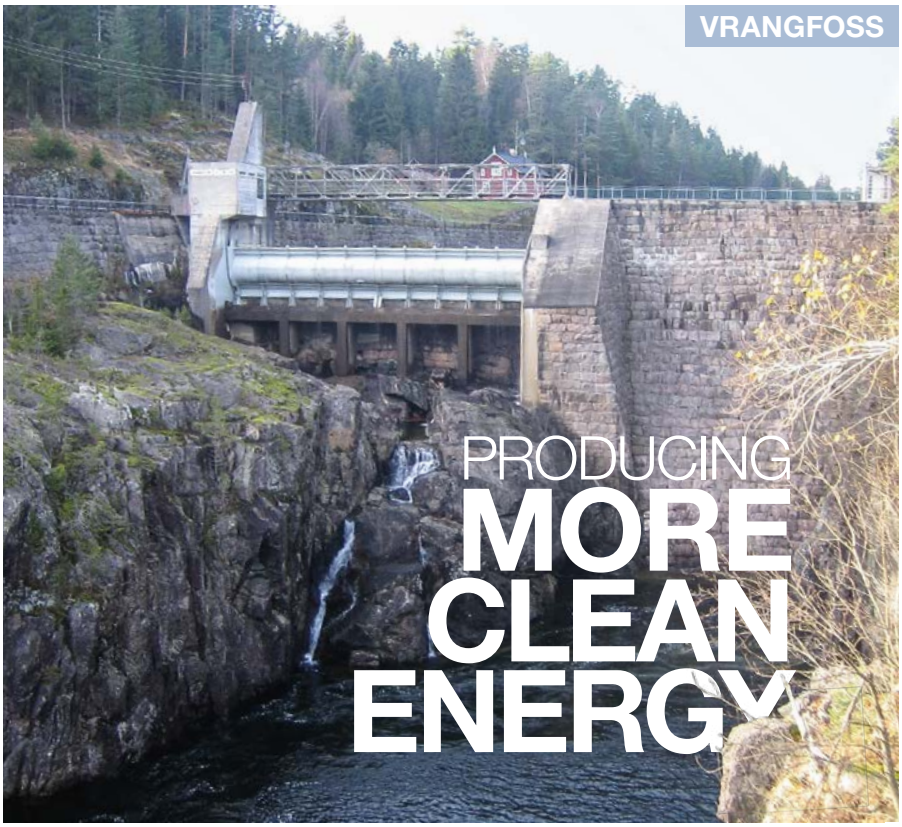
Technical data San José 2:

Total output:	70 MW
Scope:	2 × 35 MW
Head:	342 m
Speed:	428 rpm
Runner Diameter:	1,740 mm
Av. annual production:	754 GWh

For further content use the QR-Code on p.5

SITE REPORTS

VRANGFOSS



NORWAY – Since 2017 the Vrangfoss hydropower plant has been producing clean energy for the Norwegian grid with a new control system supplied by ANDRITZ Hydro.

HPP Vrangfoss is a run-of-river hydropower plant, owned by Norsjøkraft AS and operated by Statkraft Energi AS, using the waters from the Skien water system. Located in Eidselva, Telemark County, it was originally put into service in 1962.

Two Kaplan turbines with a total capacity of 35 MW utilize the 23 m head from the Nomevann Lake, producing an average annual output of 190 GWh. The intake dam is built above the power station, which is an underground installation, while the 132/66 kV switchyard is located outside close to the station. Parallel to the intake gates there is a 25 m wide and 3.5 m high spillway gate. This is mainly in use during spring and autumn season to control the waterways in flood situations. Next to the hydropower plant is the biggest ship lock in the entire Telemark canal with its five locking chambers and a lift height of astounding 23 m.

For ANDRITZ Hydro the scope of supply consisted of the replacement of the complete control system according to Statkraft's "Design Principles for Control System for Hydro Power Plants". Additional equipment like electrical protection, station supply, diesel generator, cables, transformers, and busbar systems, as well as mechanical works on the generator and turbine also formed part of the contract.

The ANDRITZ Hydro team consisted of employees from Norway, Austria, responsible for the excitation system, and Czech Republic, providing the PLC and SCADA system. Manufacturing of 120 new electrical cabinets of different sizes was completed by Norwegian partners.

Commissioning was carried out in cooperation between all the involved ANDRITZ Hydro locations to the full satisfaction of the customer. This order confirms again the high competence and know-how of ANDRITZ Hydro and represents an important reference in the Scandinavian region.

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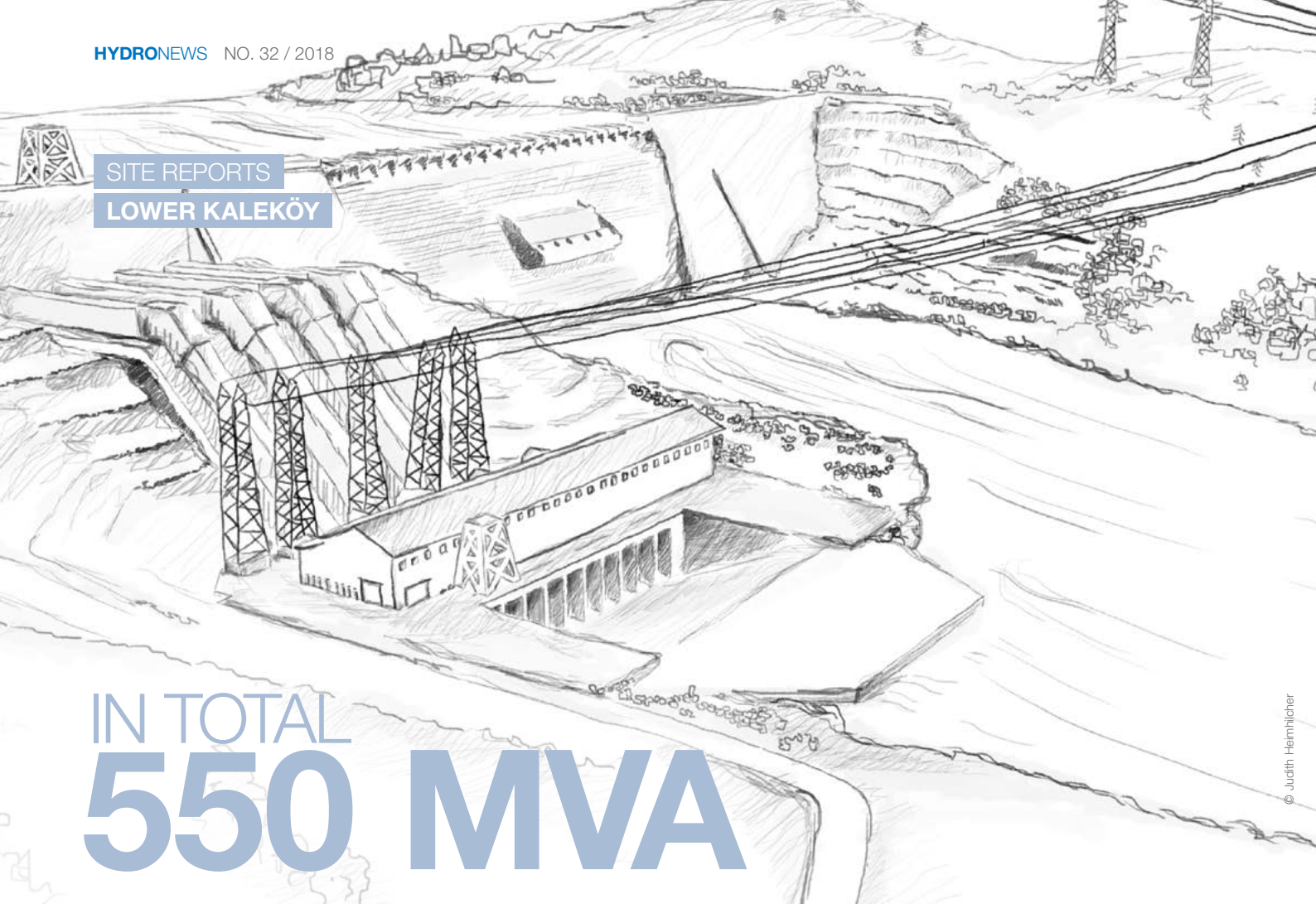
Vrangfoss | Norway

Technical data:

Total output:	35.2 MW
Scope:	2 × 17.6 MW
Head:	23 m
Voltage:	10.2 kV
Speed:	200 rpm
Runner diameter:	3,400 mm
Av. annual production:	190 GWh

SITE REPORTS

LOWER KALEKÖY



© Judith Heimhilcher

IN TOTAL 550 MVA

TURKEY – As a member of an international consortium, ANDRITZ Hydro has secured a contract for electro-mechanical equipment destined for the Lower Kaleköy hydropower plant in Turkey.

The privately owned company Kalehan Genç Enerji Üretim A.S., part of the Kalehan Energy Group, selected ANDRITZ Hydro to design, manufacture, install and commission three 186 MVA generators for HPP Lower Kaleköy.

Each of the three main generators for the plant, located on the Murat River in Bingöl Province, weighs more than 700 t. Moreover, the contractual scope of work covers excitation and monitoring systems for the three main units, as well as for an environmental unit which will generate power from ecological water flows. Two ANDRITZ Hydro locations are involved in the project execution. Core components are to be manufactured in Weiz, Austria, whereas additional generator parts and installation services are to be performed by the local ANDRITZ Hydro company in Izmir, Turkey.

This project is Kalehan's third in a hydro-cascade along the Murat River, a tributary of the Euphrates River. Previously, ANDRITZ Hydro has supplied mechanical and electrical equipment to the Beyhan-1 hydropower station which is already operating and the HPP Upper Kaleköy, which is currently under implementation and is scheduled to start energy generation in the second quarter of 2018.

The overall output of HPP Lower Kaleköy amounts to 500 MW and the hydropower plant will produce about 1,200 GWh of electrical energy per year, thus providing important support to the Turkish grid. Commissioning of the plant is scheduled for March 2020.

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Lower Kaleköy | Turkey

Technical data:

Total output:	500 MW
Scope:	3 × 186 MVA
Head:	88 m
Voltage:	14.4 kV
Speed:	166.7 rpm
Stator Diameter:	10,400 mm
Av. annual production:	1,200 GWh

For further content use the QR-Code on p.5

SMALL & MINI HYDRO HIGHLIGHTS

NEW

TRAUNLEITEN

City of Wels | Austria
Output: 2 × 8.75 MW
Scope: Compact Bulb turbines
Highlight: replacement of existing power plant

→ MORE ON PAGE 40

NEW

SAN ANDRÉS

San Andrés River | Colombia
Output: 2 × 11 MW
Scope: W2W package including 2-jet Pelton turbines

HUNTER CREEK

British Columbia | Canada
Starting commercial operation in 2018
Output: 1 × 11.2 MW
Scope: Vertical 6-jet Pelton turbine
Highlight: hot re-synchronization operating mode

LLYS Y FRAN

Llys Y Fran Reservoir | Wales/UK
Successfully put into commercial operation
Output: 1 × 266 kW
Scope: Mini Compact Francis turbine
Highlight: Drinking Water application; order execution in record time

→ MORE ON PAGE 41

CARHUAC

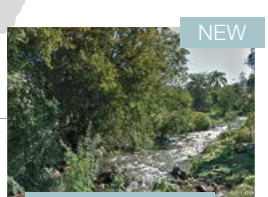
In the last Hydro News No. 31 there was a mistake in the total capacaty of HPP Carhuac in Peru. The hydropower plant has a total output of 20 MW.

Updated status: erection ongoing; expected commissioning during first 1st half of 2018

ANGEL I TO III

Carabaya Province | Peru
Erection finished by end 2017; commissioning expected early 2018
Output: Each 2 × 10 MW
Highlight: cascade system consisting of three identical small hydropower plants

NEW



BARRINHA

Santa Caterina | Brazil
Output: 1 × 1.8 MW
Scope: Compact Axial turbine
Highlight: First Mini Compact in Brazil

→ MORE ON PAGE 41

Global underlying market trends for small and mini hydropower in Asia and Africa remain positive. Megatrends such as population growth, increasing urbanization and the on-going need for access to electricity continues to see many small hydropower projects developed. Furthermore, complementary development with wind and solar projects is a growing and evolving theme as small and mini hydropower solutions become more economically competitive, even in the short and mid-term.

STORÅSELVA

Central Norway
Work on schedule
Output: 3 × 8.85 MW
Scope: horizontal Francis turbines
Highlight: first plant to be built according to the international environmental standard CEEQUAL

→ MORE ON PAGE 40

ISSYK 1

South-eastern Kazakhstan
Installation completed
Output: 1 × 5.3 MW
Scope: "from water-to-wire" package

RHONE OBERWALD

Canton Wallis | Switzerland
Successfully put into commercial operation
Output: 2 × 7.5 MW
Scope: vertical 6-jet Pelton turbines
Highlight: powerhouse in cavern with a return gallery into the Rhone River

NEW

KALANGA PROJECT CLUSTER

Bajhang District | Nepal
Output: more than 64 MW in total
Scope: electro-mechanical equipment for three projects Upper Kalanga Gad, Kalanga Gad und Upper Sanigad

→ MORE ON PAGE 42

KASHIMBILA

Katsina River | Nigeria
Commissioning finalized
Output: 4 × 10 MW
Scope: vertical Compact Axial turbines
Highlight: small hydropower solution for a multipurpose dam

XAYABURI FISH-LOCK

Mekong | Lao PDR
Ongoing installation
Output: 2 × 3.73 MW
Scope: Compact Axial turbines
Highlight: integrated into the fish-lock system of one of the largest hydropower plants in Lao PDR

NORWAY

STORÅSELVA

AUTHOR

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On track

As the first plant in the country to be built according to the international environmental standard CEEQUAL, the small hydropower plant Storåselva in mid-Norway is very important. The customer Nord-Trøndelag Elektrisitetsverk AS (NTE) is an energy utility company that is owned by North Trøndelag County Council. Its core business is the production and distribution of electric energy and they are one of the leaders in the development of wind technology along Norway's coast.

ANDRITZ Hydro received an order for a "from water-to-wire" package for the Storåselva hydropower plant in December 2015. The scope of supply comprises three 8.85 MW horizontal Francis generating units, which were manufactured by ANDRITZ Hydro Germany. ANDRITZ Hydro Norway is responsible for automation and control, as well as the electrical power systems.

To date the work for HPP Storåselva is on track – ANDRITZ Hydro is ahead of schedule. NTE Energy is satisfied with ANDRITZ Hydro and is looking forward to the successful completion and commissioning of the plant.

HPP Storåselva will provide 75 GWh of clean and renewable energy per year to the Norwegian grid. This corresponds to about 2% of NTE's annual output of green energy and the electricity consumption of about 4,000 households.

Technical data:

Total output:	26.55 MW
Scope:	3 × 8.85 MW
Head:	122 m
Voltage:	6.6 kV
Speed:	600 rpm
Runner diameter:	1,037 mm
Av. annual production:	75 GWh

AUSTRIA

TRAUNLEITEN

AUTHOR

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Bulb turbines for more power

Traunleiten, an existing hydropower station in Austria will be replaced by a complete new construction during the next two years. The owner, Wels Strom GmbH, is starting the largest project in its history with this project, located in a suburb of the city of Wels. The project is targeting an 80% increase in power output with a hydroelectric power production of 91 GWh annually.

ANDRITZ Hydro Germany was awarded a contract for the delivery of the two Compact Bulb Turbines and a substantial package of auxiliaries including the hydraulic power units, and cooling system. The two synchronous Bulb generators will be manufactured at ANDRITZ Hydro's own workshop. Installation at site and the supervision of commissioning complete the contractual scope of supply.

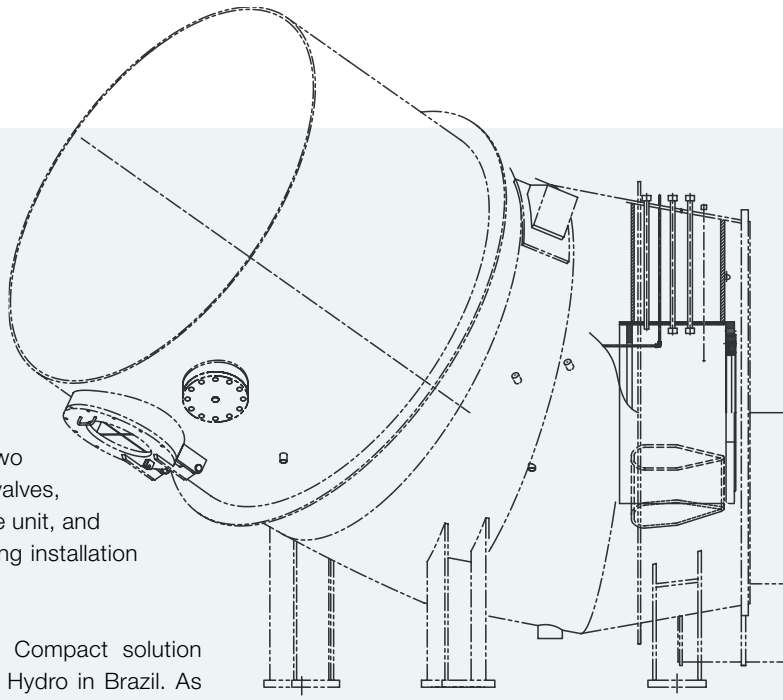
After completion in November 2019, the order for HPP Traunleiten will be another important reference for ANDRITZ Hydro in Austria.

Technical data:

Total output:	17.5 MW
Scope:	2 × 8.75 MW
Head:	15 m
Voltage:	10.5 kV
Speed:	200 rpm
Runner diameter:	3,100 mm
Av. annual production:	91 GWh

BRAZIL

BARRINHA



First Mini Compact for Brazil

The small hydropower project, Barrinha is located in Jardinópolis, Santa Catarina, Brazil. Maue S/A - Geradora e Fornecedora de Insumos, part of CERAÇÁ, a cooperative energy distribution company, is developing the project. The engineering company in charge of the basic project and technical specification is Tamarindo Engenharia.

Initially the client was considering a vertical Kaplan unit at HPP Barrinha, but after some discussions and analysis decided to use a horizontal Compact Axial turbine. This was a bold decision because in Brazil the market is very conventional as vertical machines are not common.

HPP Barrinha has a very special layout as there are 360 m of penstock crossing rock before reaching the powerhouse.

ANDRITZ Hydro received an order for the supply of two turbines, butterfly valves, flywheel, high pressure unit, and thrust bearing, including installation and commissioning.

This is the first Mini Compact solution supplied by ANDRITZ Hydro in Brazil. As of contract, the comissioning is scheduled to be completed by end of 2018.

Traditionally, local manufacturers have a strong market position in Brazil, but ANDRITZ Hydro succeeded with its state-of-the-art technology and economic offer. Hence, the winning of this contract is even more important and represents a significant step into the Brazilian small hydropower market.

AUTHOR

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Technical data:

Total output:	3.5 MW
Scope:	2 × 1.76 MW
Head:	10.95 m
Speed:	450 rpm
Runner diameter:	1,450 mm

WALES / UNITED KINGDOM

LLYS Y FRAN

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Order execution in a record speed

By end of September 2017, the order for the HPP Llys Y Fran in Wales, had been finalized very successfully and in record time. Within only eight months, the entire order execution, starting from the complete new design of the Mini Compact Francis turbine, purchasing of the entire scope of supply, transportation to site, as well as the workshop assembly and installation at site, was concluded. The scope of supply consisted of one horizontal Mini Compact Francis turbine, the hydraulic power unit, one synchronous generator and the inlet butterfly valve.

The ANDRITZ Hydro turbine is integrated into the local drinking water supply and is operated with the raw water from the reservoir with the same name, Llys Y Fran.

At the end of September 2017, the customer Dulas Ltd. had successfully commissioned ANDRITZ Hydro's equipment. The drinking water turbine is running to the utmost satisfaction of the customerand the operating company Welsh Water Ltd. Complete hand over of the scheme is scheduled for beginning of 2018.

Technical data:

Total output:	266 kW
Scope:	1 × 266 kW
Voltage:	0.4 kV
Head:	29.6 m
Speed:	750 rpm
Runner diameter:	478 mm

For further content use the QR-Code on p.5

NEPAL

KALANGA PROJECT CLUSTER

Energizing the Himalayas

ANDRITZ Hydro further strengthened its position in Nepal by bagging a contract for three hydropower projects in the Kalanga river basin after nine long months of deliberations. ANDRITZ Hydro was chosen as the supplier for electro-mechanical equipment by the Kalanga Group of Companies of Nepal, a well-known independent power producer (IPP).


© Daniel Prudek - Fotolia

The projects are located in the Bajhang District in the far west of Nepal. ANDRITZ Hydro is to supply three vertical, four-jet Pelton turbines for HPP Upper Kalanga Gad, two horizontal Francis turbines for HPP Kalanga Gad and two horizontal Pelton turbines for HPP Upper Sanigad, including the entire electro-mechanical equipment. Erection and commissioning conclude the scope of the contract.

The projects are all scheduled to be put into commercial operation by mid- respectively the end of 2020 and are set to boost Nepalese energy production by a total of more than 64 MW.

AUTHOR

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Technical data Upper Kalanga Gad:

Total output:	38.46 MW
Scope:	3 × 12.82 MW
Voltage:	11 kV
Head:	589.29 m
Speed:	750 rpm
Runner diameter:	1,250 mm

Technical data Kalanga Gad:

Total output:	15.34 MW
Scope:	2 × 7.67 MW
Voltage:	11 kV
Head:	115.83 m
Speed:	600 rpm
Runner diameter:	1,073 mm

Technical data Upper Sanigad:

Total output:	10.7 MW
Scope:	2 × 5.35 MW
Voltage:	11 kV
Head:	416.05 m
Speed:	750 rpm
Runner diameter:	1,070 mm

NEPAL

CUSTOMER DAY KATHMANDU

After a very successful event in 2016 and the founding of the local office, the local Nepalese Managing Director and CEO, Mr. Dibesh Shrestha, was pleased to welcome customers, investors, partners, governmental institutions and other interested companies to the ANDRITZ Hydro Customer Day in Kathmandu, Nepal. This second customer day in the Himalayan nation took place on November 1st and 2nd, 2017.

Energizing Nepal has been a priority for ANDRITZ Hydro for the last 20 years. Offering state-of-the-art products, services and technologies, ANDRITZ Hydro is striving to become the ideal partner in Nepal's energy sector.

ANDRITZ Hydro has currently more than 25 projects ongoing in this promising market, among which are Upper Tamakoshi (456 MW), Nepal's national prestigious and biggest project, and Middle Bhotekoshi (102 MW), the third biggest hydro project in Nepal to date.

The Customer Day Nepal once again demonstrated the strong position of ANDRITZ Hydro as a reliable partner in developing the Nepalese hydropower potential and strengthened the company's position in this very dynamic region.

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A new system for a known phenomenon

Auto-oscillation protection by ANDRITZ Hydro

When pumped-storage power plant Waldeck 2 was recommissioned after a shut-down the engineers detected auto-oscillation in the penstock system. This type of oscillation phenomenon tends to occur primarily when the generating units are in standstill. In most cases it is caused by a leakage, for example at the sliding ring of the spherical valve. Based on intense research, ANDRITZ Hydro has developed a new system that allows this phenomenon to be detected early on.

The self-excited oscillation is the result of a pressure wave that moves along the piping and is reflected at the end points. It is typically caused by leakage with specific characteristics - the leakage volume can be described as a function of the pressure being applied. Uncharacteristically, however, increasing water pressure within the pipe reduces the leakage. Diminished discharge then creates a water hammer effect. As soon as the pressure decreases, the leakage increases again. The force of the pressure wave increases with each reflection, up to twice the static pressure.

These rare but dangerous auto-oscillation phenomena may be a consequence of different causes. For example, at Waldeck 2 in Germany the phenomenon was not caused by a leakage but by a mistake in the cabling of the control system. In most other cases auto-oscillation is a consequence of insufficient maintenance.

The increasingly fluctuating pressure in Waldeck 2 alerted the experienced ANDRITZ Hydro experts to the situation in good time. They closed the maintenance seal of the spherical valve which isolated the section that caused the oscillation in the penstock. This stopped the auto-oscillation, preventing damage to the pressure parts.

Uniper Kraftwerke GmbH / Germany has installed the systems in PSPP Waldeck 1 (one 70 MW pump turbine) and Waldeck 2 (two ternary units each 240 MW) in 2017

Based on this experience, ANDRITZ Hydro developed a new system that allows auto-oscillation to be detected at an early stage, so that appropriate counter-measures can be taken to protect people, machines and the immediate environment. One key advantage of the system is that it has been designed specifically for retro-fitting in existing facilities.

With the new system, ANDRITZ Hydro is providing crucial support in increasing operational safety of its customers' facilities.

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A new **experience**

For the very first time, ANDRITZ Hydro invited the audience on a virtual tour through a hydropower plant. The virtual reality (VR) equipment presented a “real” hydropower plant, but in a “virtual” environment. Able not only to support the proper arrangement of all electro-mechanical components, the system is also able to give an impression of the sounds and the dimensions of a plant. Furthermore, the virtual tour can provide astounding views of a hydropower project, for example diving into the draft tube of a turbine or flying above the gates. Many visitors took the chance to experience this new feature.

REWA 2017

BANGKOK – 19th -21th, September

Now in its 25th year, Asia Power Week is the premier power industry event for the Asian continent and the leading platform for industry experts to gather, exchange knowledge, and generate modern solutions to regional challenges.

Over 250 international exhibitors and more than 8,300 visitors participated this year in the Renewable Energy World Asia conference and exhibition – part of Asia Power Week.

ANDRITZ Hydro participated in the conference and exhibition with an international team and presented a paper about Operations and Maintenance. Representatives from ANDRITZ Power Boilers also introduced interested visitors to the portfolio of this business segment.

HYDRO 2017

SEVILLA – 9th -10th, October

In Spain for this event, more than 1,200 delegates from all over the world discussed a wide range of issues relating to hydropower. Particular emphasis was placed on international collaboration: working together in project planning and implementation to shape the future of global hydropower development.

ANDRITZ Hydro presented several papers on a range of topics such as fish surveillance, independent model testing, pump turbine rehabilitation, outstanding motor-generator design, the HIPASE success, and O&M market requirements.

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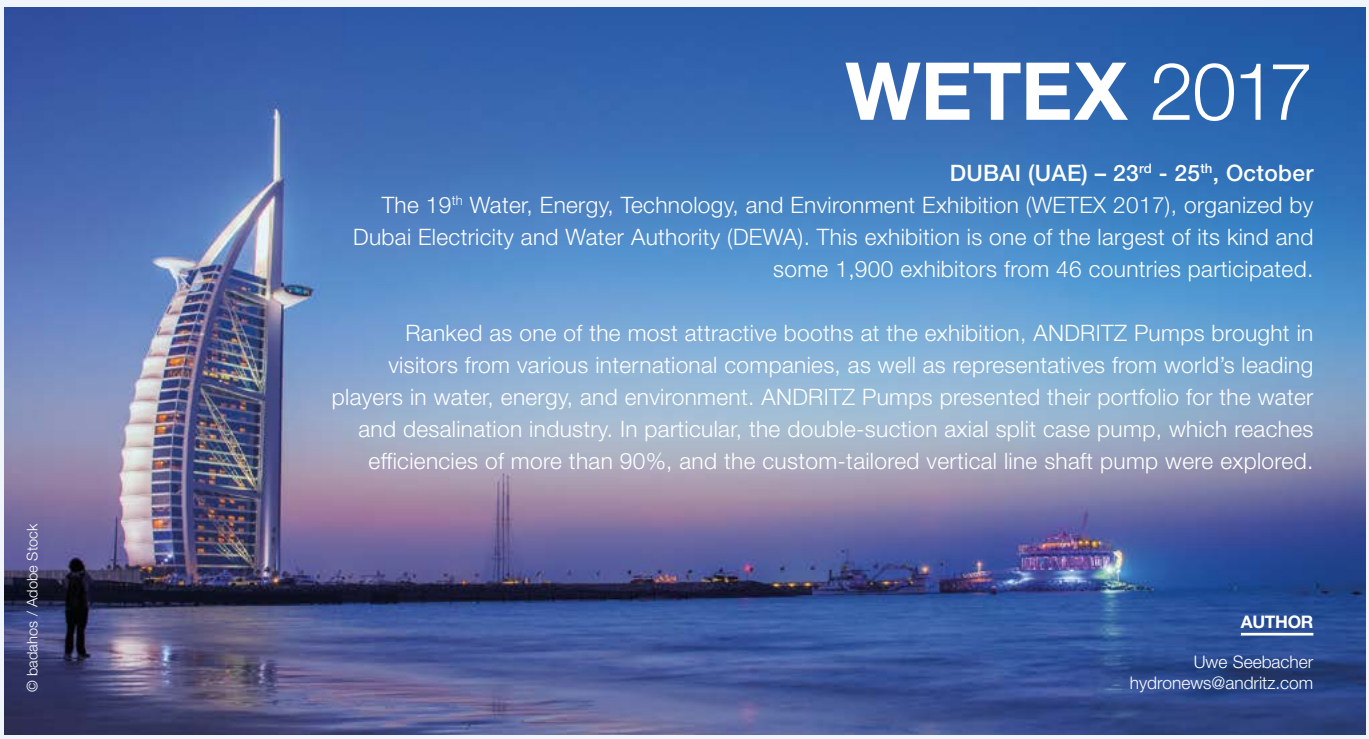

WETEX 2017

DUBAI (UAE) – 23rd - 25th, October

The 19th Water, Energy, Technology, and Environment Exhibition (WETEX 2017), organized by Dubai Electricity and Water Authority (DEWA). This exhibition is one of the largest of its kind and some 1,900 exhibitors from 46 countries participated.

Ranked as one of the most attractive booths at the exhibition, ANDRITZ Pumps brought in visitors from various international companies, as well as representatives from world's leading players in water, energy, and environment. ANDRITZ Pumps presented their portfolio for the water and desalination industry. In particular, the double-suction axial split case pump, which reaches efficiencies of more than 90%, and the custom-tailored vertical line shaft pump were explored.

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Customer Days 2017

ANDRITZ Hydro is pleased to invite customers, local partners, and suppliers, as well as representatives from governmental institutions, hydropower plant operators, the developers, and private investors to special Customer Days in various countries. These events are always a great success and present superb opportunities for an exchange of experience. They also offer an informative platform to explore ANDRITZ Hydro's latest developments and technology solutions, bringing the company closer to the market and its customers.

FOSHAN, CHINA – 13th - 17th, November

For the second time, ANDRITZ Pumps China invited interested parties to its ANDRITZ Pump Coupling Alignment Competition seminar. More than 90 participants attended this event. Under the focal points of pumps service and energy savings, various presentations explored new ANDRITZ pump solutions and technologies. Additional emphasis was placed on the success story of the S-pump series over the last 20 years, as well as the brand new S-hydraulic kit.

HANOI, VIETNAM - 5th October

For the sixth time now, ANDRITZ Hydro has invited participants to the Customer Day Vietnam, the comprehensive range of products and services offered by ANDRITZ Hydro was emphasized through a set of presentations. A special highlight of the presentations was the local capabilities and services available from the new local set-up.

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HYDRO

A NEW ERA FOR PUMPED STORAGE

GOUVÃES, PORTUGAL

AN OUTSTANDING PROJECT

ANDRITZ Hydro has been contracted to supply the electro-mechanical equipment and the penstock for the new pumped storage power plant Gouvães, Portugal. With four 220 MW pump turbines it will be the heart of the Alto Tâmega hydropower scheme, the largest hydropower project in the history of Portugal. It consists of three hydropower plants and will produce 1,468 GWh of electrical energy in total. PSPP Gouvães will cover the need for peak-load energy and will provide fast-responding regulating power, when needed.

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