

The background of the cover is a photograph of a large concrete dam with a road on top, situated next to a calm lake. In the distance, there are steep, rocky mountains with patches of green forest under a blue sky with light clouds.

VOITH

MAGAZINE FOR HYDROPOWER TECHNOLOGY

HyPower

#25 | Autumn 2014

ADAPTING PUMPED STORAGE TECHNOLOGY FOR THE FUTURE

MULTI-TALENTED

FROM THE ARCHIVES

VOITH HYDRO'S PUMPED STORAGE HISTORY

GLOBAL EXPERTISE

SERVICE CAPABILITY FROM VOITH HYDRO
FOR CUSTOMERS WORLDWIDE



IMPRINT

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MULTI-PURPOSE, MULTI-TALENT



Pumped storage hydropower has proven itself worldwide to be the only technology that can store energy on an industrial scale, with a very high level of efficiency. Indeed, 99% of the world's existing energy storage capacity consists of pumped storage. But pumped storage is not only sizable and efficient: It can also help to better stabilize the energy grid, and prevent wasting surplus energy from volatile renewable energy sources like wind and solar.

Voith is further developing this important storage technology and providing tailor-made solutions to our customers that underlay the central advantages of pumped storage: namely, fast reaction times and high flexibility. Innovations such as reversible machine sets and variable speed technology can rapidly and flexibly respond to changes in supply and demand from the grid, and provide quick-reacting coverage in cases of power shortage.

For more than a century, pumped storage technology has been storing energy for communities and industries worldwide. In fact, Voith's Brunnenmühle pumped storage hydropower plant, completed in 1908, was the first of its kind in Germany. Today, the Brunnenmühle is the heart of Voith's global hydropower R&D network.

These days, the minds of policy-makers around the world are turning more and more towards renewable energy production. Teaming up volatile renewables like wind and solar with stable renewables like hydropower and pumped storage will provide the necessary stability for reliable renewable energy production on an industrial scale.

This issue of HyPower will provide further insights into the multi-purpose, multi-talent that is pumped storage.

Enjoy the read!

Yours sincerely,

A handwritten signature in blue ink that reads "Ute Böhringer-Mai".

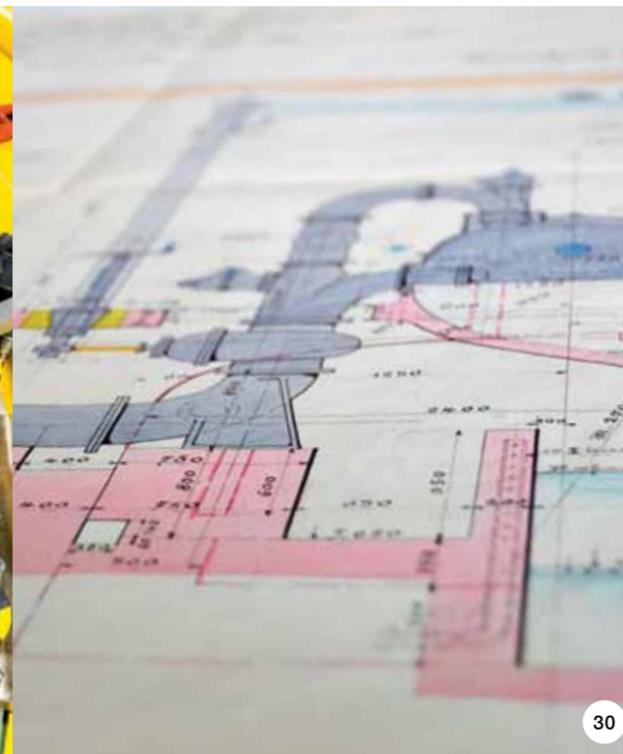
Ute Böhringer-Mai
Head of Communications



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An easy-to-check reference of the Voith Hydro projects mentioned in this edition of HyPower



MODERNIZATION IN BRAZIL

BRAZIL Reliable energy generation continues on the Paranapanema River in Brazil as Voith has completed rehabilitation of the first generating unit at the Chavantes hydropower plant. Voith will modernize another three units at the plant, which has a total installed capacity of 414 MW, and has been in operation since 1970. Managed by Duke Energy, Chavantes is going through a complete modernization process, covering the renewal of three generating units, including turbines, generators and associated electro-mechanical systems. //

SOUTHEAST ASIAN PUMPED STORAGE

THAILAND A promising market has shown another positive step forward, with the recent order for the extension of the Lam Ta Khong pumped storage power plant in Thailand. Lam Ta Khong is the first pumped storage plant in Southeast Asia to be equipped by Voith Hydro: a great development for Voith's presence in this emerging hydropower region. Ordered by the Electricity Generating Authority of Thailand (EGAT), the project includes complete electromechanical equipment for the plant: two vertical pump-turbines of 255 MW each, two motor-generators, automation systems, electrical and mechanical balance-of-plant systems, civil works, and site installation. The completed extension will increase the capacity of the Lam Ta Khong pumped storage hydropower plant to 1,000 MW – almost doubling its current capacity. //



Micro Tubular: a smart solution in small hydro

SMALL, SMART, EFFICIENT

ITALY / JAPAN With the Micro Tubular Turbine and Generator, Voith offers a smart, efficient product in the small hydro segment: a compact system that can be integrated in existing piping systems with minimum effort. Factories, waterworks, sewage treatment plants and irrigation canals are possible application fields for the Micro Tubular Turbine that comes with belt-driven generator and a Kaplan turbine with adjustable runner blades mounted in a tube to control flow. The standardized product delivers cost-efficiency and fast installation, requiring minimal engineering and civil works during the execution phase. It meets demand for an economical mini small hydro solution, without compromising on Voith standards. It comes in three sizes: S, M, or L, arranged serially or in parallel to meet required heads and flows, and has a typical range from 2 to 20 m head, 3 to 250 kW per single turbine. Developed by Voith Fuji Hydro Japan, it has been adapted by Voith Hydro Italy to meet local requirements, and is already attracting attention on the market. //

HIGH QUALITY AGAINST THE CLOCK

INDIA When the stator at India's largest pumped storage power unit needed replacing, operator Tata Power called on Voith Hydro in Noida, India. The order for the Bhira Pumped Storage project, now underway, comprises design, upgrade, manufacturing, supply, erecting and commissioning of the new stator for the 200 MVA motor-generator. The new stator is due at the customer within 11 months. The shutdown period cannot exceed 45 days, as the plant supplies power to the megacity Mumbai. Tata Power, India's largest integrated power company, called on Voith due to over a century of successful collaboration between the two companies: Voith first supplied the Tata Power Khopoli powerhouse with four units of 13 megawatts each back in 1911. //

COMPARING STORAGE TECHNOLOGIES

Sizable, economical, durable, ecological: when looking at the potential of pumped storage as a major player in our energy systems, the numbers speak for themselves.

1 Major share

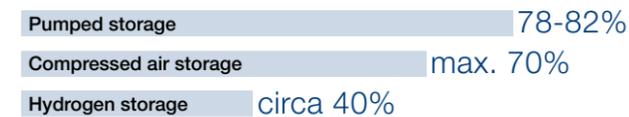
99% of the world's energy storage capacity is provided by pumped storage hydropower – with the remaining 1% supplied by batteries, compressed air energy storage, and other storage technologies.



2 142,000 MW is the combined generating capacity of all the world's pumped storage hydropower stations.

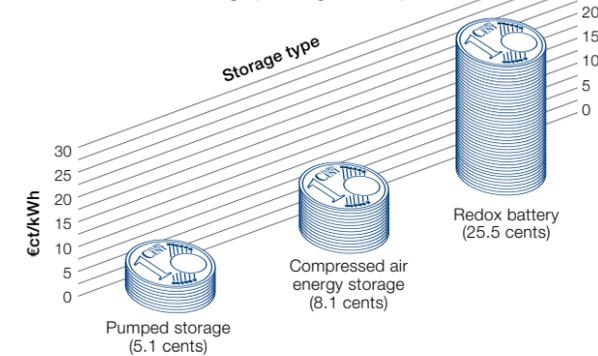
3 Highly efficient

Pumped storage is around twice as efficient as hydrogen storage.



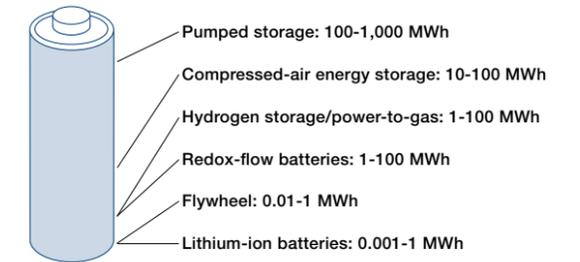
4 Cost effective

Additional costs for energy storage per kWh for different forms of short-term storage (referring to 2010).



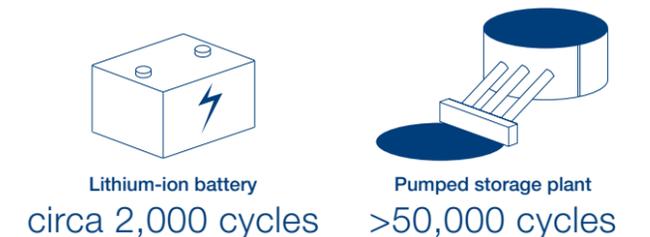
5 Large scale

The potential capacity of pumped storage is remarkably higher than the potential capacity of other forms of energy storage.



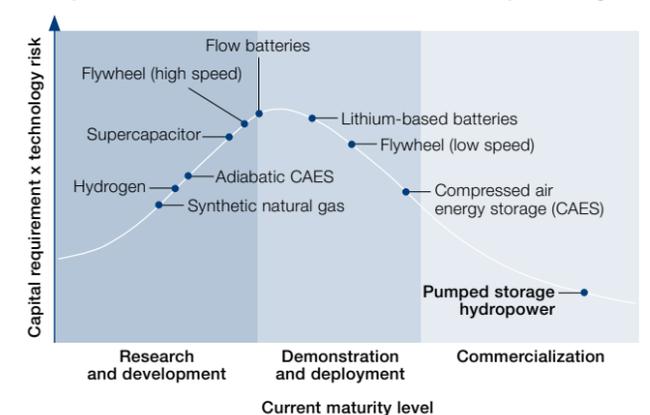
6 Extremely durable

The lifetime duration of a pumped storage hydropower plant by far exceeds the life cycle of many other energy storage options.



7 Technological maturity

Readiness-for-market of various storage technologies. Pumped storage is already commercialized, well established – and continuously innovating.



#HYDROPICTUREOFTHEWEEK

Scan the QR code below or visit twitter.com/Voith_Hydro to keep up with Voith Hydro news on Twitter. Be sure to check out our feed every Friday when we share our hydropower picture of the week!



Sources: 1 2 IEA analysis and EPRI (Electronic Power Research Institute), *Electrical Energy Storage Technology Options*, Report, EPRI 2010; own research 3 5 and 6 SRU 2011, Büniger et al. 2009, Oertel 2008; supplemented by own data 4 DLR/Fraunhofer IWES/IFNE, *Long-term scenarios and strategies for the deployment of renewable energies in Germany in view of European and global developments* (BMU-Leitstudie), 2010. 7 Decourt, B., and R. Debarre, *Electricity storage Factbook*, Schlumberger Business Consulting Energy Institute, Paris, France and Paksoy, H., 2013; "Thermal Energy Storage Today" in *IEA Technology Roadmap Energy Storage*, p. 16., 2014.

PUMP FOR THE FUTURE

More than just a short-term energy repository, **pumped storage plants provide fast, flexible and efficient support** for our electricity grids. As we integrate more renewables, their importance is set to grow.

This isn't the first energy transition that we have witnessed during the last century in Germany, but it is the first one that will have a profound effect on the system architecture of our electricity power supply," says Klaus Krüger, Head of R&D at Voith Hydro. Using Germany as an example, he explains how coal was replaced by oil during the 1960s and 1970s, which was in turn replaced by nuclear power over the following 30 years. "These transitions shared a common factor in that only the primary energy carrier changed – while the system architecture of the German electricity power supply stayed the same."

▷ As Krüger explains, energy storage systems did not have an important functionality in the previous service landscape, as there has always been a sufficiently high and permanently available power reserve through coal and nuclear power plants. So far, energy storage has been undertaken via use of the primary raw materials coal, gas, uranium and oil. Power generation followed afterwards, as needed: “The order has been first storage and after that generation,” he says. The generation of renewable energies from wind and photovoltaic sources, however, mostly occurs in an uncontrolled way, without respect for demand. It is in this way that the latest energy transition has changed the order of storage and generation. In this context, pumped storage power plants can help to significantly reduce renewable energy curtailment, and can substitute fossil energy generation by releasing stored energy from renewables.

In use since the early 20th century, pumped storage has traditionally been thought of purely as a means of storing energy for peak load compensation. However, with solar and wind power playing an increasingly important role in many countries around the world, pumped storage is beginning to show its full potential as a flexible, dynamic contributor to ensure stability of our electrical grids.

Wind and solar energy may be more environmentally friendly than coal and nuclear power, but they are also less reliable, influenced purely by nature alone, and not at all adjustable. There will be periods when these sources generate large amounts of energy, but there will also be periods where they don't.

“A grid needs reliable available capacity. The problem with photovoltaic generation is that even if you have gigawatts of installed capacity, the reliable available capacity is almost zero. For on-



“A few years ago, it would take between two and three minutes to get power on the grid. Now we can provide maximum power within 60 seconds.”

Jiri Koutnik, Head of Expert Support for power units, Voith Hydro

shore wind generation, it is around one percent,” Krüger explains. In 2013, for example, there was a sudden 8 GW power gap in the power supply in eastern Germany due to unexpected mist and fog affecting photovoltaic electricity generation. “At times like this, you need a plan B, something fast and flexible that can help make up energy shortfalls, or compensate for excessive production. Without it, the grid can become unstable and power outages can occur.”

In the past, pumped storage power plants operated on a clear “on” and “off” schedule and only needed to switch between pump and turbine mode a couple of times per day to balance the grid. But as infrastructure has changed and de-

mand for more electricity and increased flexibility rises, pumped storage plant technology has evolved. “Now, we pump seven or eight times a day, for shorter time periods. The machinery has to be faster and more durable,” says Jiri Koutnik, Voith Hydro's Head of Expert Support for power units. Referring to ternary sets, Koutnik says this: “A few years ago, it would take between two and three minutes to get power on the grid. Now we can provide maximum power within 60 seconds.”

Speed is at the heart of a further advantage offered by pumped storage power plants, as it is able to provide a “black start” to the grid in the case of a



- 1 Tai'An, China: Voith in China, Japan and Germany supplied equipment for this pumped storage plant.
- 2 Reisseck-II, Austria: Inspecting one of the two runners supplied for the project in the Alps.

power blackout. “A hydroelectric station needs very little initial power to start – just enough to open the gates or valves and to ensure the magnetization of the generator rotor,” says Krueger. “It can then put a large block of power online very quickly to help restart fossil-fueled or nuclear stations.” ▷

GERMANY AND THE ENERGY TRANSITION

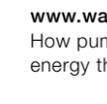
Germany has set itself ambitious targets: by 2022 it plans to phase out nuclear power, and by 2050, 80% of its power is expected to come from renewable sources.

A recent study from RWTH Aachen University, commissioned by Voith Hydro, showed that the use of pumped storage could enable up to 5 TWh of additional renewable electricity to be utilized by 2050. But as Stephan Kohler, Chief Executive of the German Energy Agency (dena), explains, Germany still has work to do if this is to be realized. “The current economic framework means that important investments in pumped storage are not being made. The advantages that pumped storage can bring to the grid are inadequately remunerated – there must be more of an incentive to store energy efficiently.” Together with Voith and other prominent industry partners, dena has launched the platform “Pumped Storage Plants – Partners of the Energy Transition” to address this and other issues. It's important to remember that investment in pumped storage is a long-term one, he adds, with planning and construction periods of 10 to 20 years, and amortization periods of up to 60 years. With this in mind, changes must be made quickly if Germany is to realize its considerable pumped storage potential. If it does, then “it can play a leading role when other countries increase their use of renewable energies,” Kohler says. //

[Further links to pumped storage hydropower online](#)



www.pumpspeicher.info
The dena platform: Pumped storage – partner of the energy transition (German only).



www.wasserkraft.info
How pumped storage can be used to support renewable energy through the energy transition – and into the future.



www.voith.com/psp
An overview of Voith Hydro's pumped storage products and services.

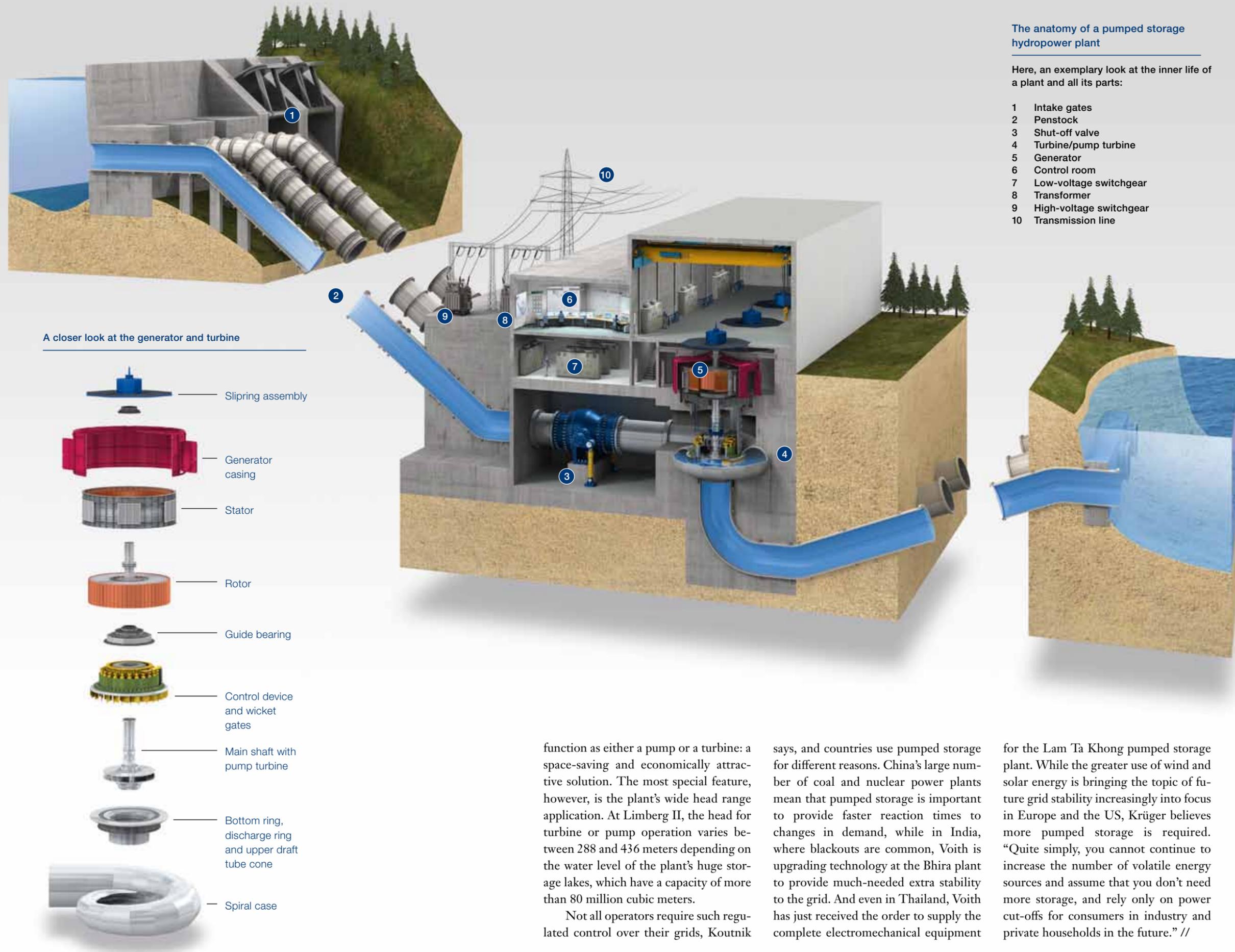


AGENDA SETTING

▷ While pumped storage is a mature technology, it continues to evolve, and one recent key development at Voith has been the enhancement of variable-speed technology. In Portugal, where fluctuating wind energy plays an important role in the country's power supply, Voith is currently installing two variable-speed units at the Frades II plant (see page 18). "Classic pump turbines can only run at one speed, but with doubly fed asynchronous motor-generators, the pump speed can be varied. This allows greater control and regulation of the electricity taken from the grid, and it gives higher operating flexibility and improved plant efficiency," explains Thomas Hildinger, Vice President Generator Technology at Voith Hydro.

At Kops II in Austria, another example of Voith Hydro's innovative expertise can be seen. Operating a ternary system, made up of a motor-generator and separate turbine and pump set, the Kops II pumped storage plant uses a hydraulic torque converter – a unique Voith development – to switch between turbine and pump operation in a matter of seconds. "You can also run both at the same time, creating a hydraulic short circuit," says Koutnik. "This allows you to control the power of the pump, even with a fixed-speed generator, which significantly improves efficiency and flexibility, much like a variable-speed machine." To express it in numbers, Kops II can deliver up to 525 MW of peak energy to the power network within seconds, or take up to 450 MW of surplus energy from the network into storage.

Also in Austria, at Limberg II, you can find an example for reversible fixed-speed pump turbines with an ultra-wide operation range. The two 240 MW reversible pump turbines supplied for the Limberg II plant in the Austrian Alps can work in both directions and, depending on the rotational direction, can

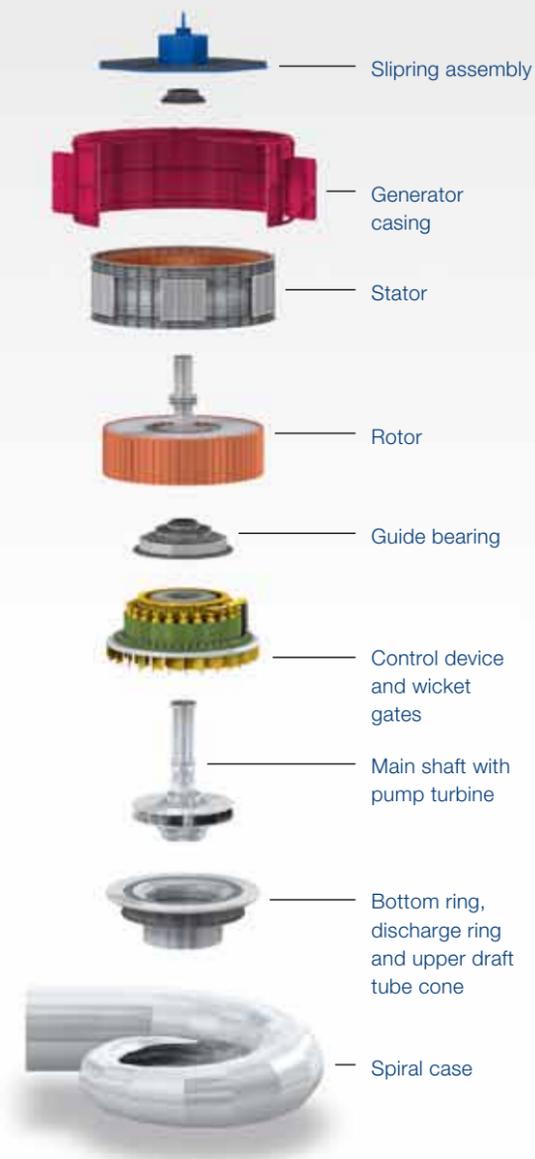


The anatomy of a pumped storage hydropower plant

Here, an exemplary look at the inner life of a plant and all its parts:

- 1 Intake gates
- 2 Penstock
- 3 Shut-off valve
- 4 Turbine/pump turbine
- 5 Generator
- 6 Control room
- 7 Low-voltage switchgear
- 8 Transformer
- 9 High-voltage switchgear
- 10 Transmission line

A closer look at the generator and turbine



function as either a pump or a turbine: a space-saving and economically attractive solution. The most special feature, however, is the plant's wide head range application. At Limberg II, the head for turbine or pump operation varies between 288 and 436 meters depending on the water level of the plant's huge storage lakes, which have a capacity of more than 80 million cubic meters.

Not all operators require such regulated control over their grids, Koutnik

says, and countries use pumped storage for different reasons. China's large number of coal and nuclear power plants mean that pumped storage is important to provide faster reaction times to changes in demand, while in India, where blackouts are common, Voith is upgrading technology at the Bhira plant to provide much-needed extra stability to the grid. And even in Thailand, Voith has just received the order to supply the complete electromechanical equipment

for the Lam Ta Khong pumped storage plant. While the greater use of wind and solar energy is bringing the topic of future grid stability increasingly into focus in Europe and the US, Krüger believes more pumped storage is required. "Quite simply, you cannot continue to increase the number of volatile energy sources and assume that you don't need more storage, and rely only on power cut-offs for consumers in industry and private households in the future." //

ON PUMPED STORAGE

Heike Bergmann on the **powerful potential of pumped storage.**



Heike Bergmann, Member of the Management Board of Voith Hydro Heidenheim, has been working for many years in the energy industry. Based on her experience, she is convinced that pumped storage plants, being multi-functional talents, can deliver an essential contribution to the conversion of energy systems to renewable supply.

What role do you envision for pumped storage plants in the changing energy systems of the future?

As the portion of fluctuating renewable energies like wind and solar is constantly increasing in the energy mix of many regions in the world, energy systems will require more pumped storage plants. They are real multi-talents as they combine storage, reliable performance and flexibility, all rolled into one type of power plant. With these characteristics, they can prevent renewable energy from being wasted: they can store excess energy from wind and solar when energy surpluses occur. Even when all thermal plants are shut down, pumped storage plants can still take the energy surpluses and provide “negative power.” Hours later, they can release this “green” electricity to the grid, within a very short time – and exactly at the time when it is needed. As a result, wind and solar plants do not need to be throttled down – and stability is added to the grid.

What is the cost of a pumped storage plant compared with a thermal power plant?

It is hard to compare plants that are powered by fossil energy directly with pumped storage plants, as they pursue different roles, and pumped storage does not generate expenses for fuel or certificates. However, one can say that the cost for each kW from pumped storage is equal to approximately €1,350 on average. For a coal-fired plant, the investment cost amounts to €1,300 per kW. But it must not be forgotten: pumped storage plants have a life span of 60 to 80 years, or even longer, with a conventional plant lasting only 30 to 40 years. Thus, the investment cost for a fuel-fired plant would have to be doubled to compare.

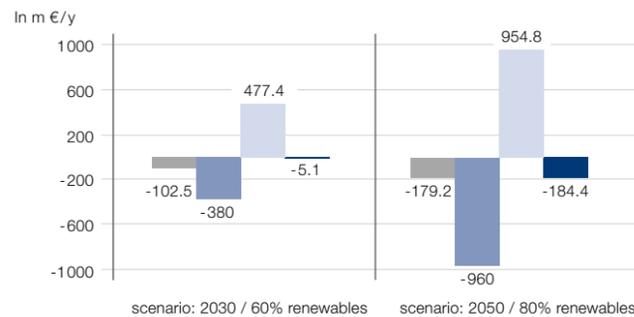
And what about batteries – another form of storing energy? Batteries are much more expensive than pumped storage today and will remain so in the future. The cost of a lithium-ion battery amounts to at least €600 per kWh, while the storage part of a pumped storage plant accounts for €50 per kWh at the maximum – or even less, depending on the location. In addition, batteries allow for significantly fewer charging cycles in comparison with pumped storage.

Voith Hydro in Germany has initiated a study by RWTH University in Aachen examining the contribution of pumped storage plants to the German “Energiewende.” In a nutshell, what are the main results?

The study shows that pumped storage plants make an essential contribution to the success of the German “Energiewende” – or, rather: the conversion of an energy system to renewable sources. The study proves that in Germany from 2030 on, about 70 percent of the surplus energy from wind and solar can be used if combined with pumped storage. Based on this assumed expansion, the entire pumped storage fleet could prevent the throttling down of 6 TWh of renewable energy by 2030, or 17.6 TWh of renewable energy by 2050. The use of pumped storage plants is efficient and economically reasonable: the waste of renewable energy is reduced. We will need fewer gas-fired power plants, as pumped storage power plants can take over their role of bringing flexibility into our energy system. Fuel costs can be lowered, and existing conventional plants can be better utilized. Besides that, the volatility of energy prices will also decrease. //

Reduction of electricity production costs in million euros/year

- Saving of investment in gas-fired power plants
- Saving of variable electricity production costs from storage cycles
- Investment in pumped storage power plants
- Economic benefits

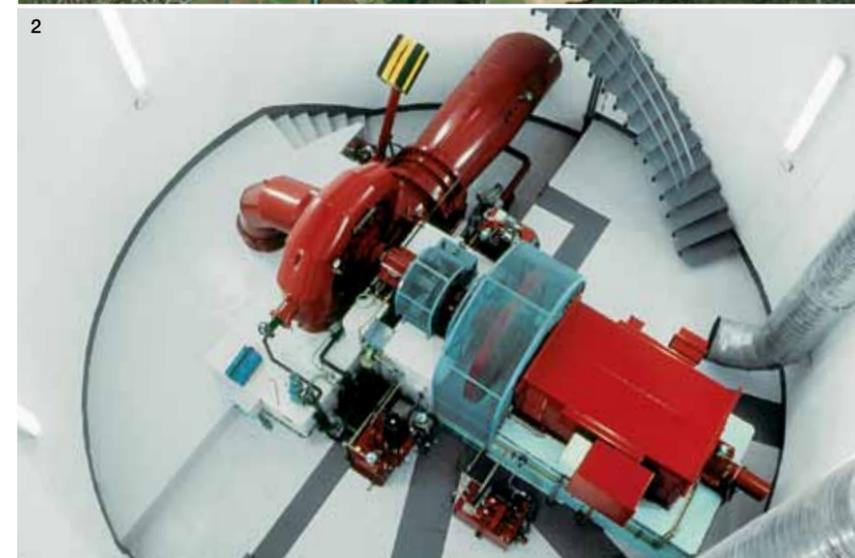


Source: Institute of Power Systems and Power Economics, RWTH Aachen University: “Supporting the Energy Transition in Germany through Pumped Storage: Potential for Improvement of Economic Viability and Supply Reliability”



- 1 Gaildorf integrates pumped storage directly into on-site wind turbines.
- 2 Inside the pumped storage plant.

For more information (in German), visit: www.naturstromspeicher.de



will generate 20% more power than a standard wind turbine, says Alexander Schechner, director of Naturstromspeicher. Due to the volatile nature of renewable energy, the need for flexible and more efficient energy storage has been garnering growing interest in recent years.

The chief restrictions in renewable energy come from nature and physical space, says Schechner. That is why it’s important to make intelligent use of limited land – hence the integration of a water reservoir into in the wind turbine’s structure. Another concern in the energy industry is the ecological footprint. The next technological step, Schechner says, is to construct penstocks out of flexible polyethylene plastic and implement them in existing pathways. “A forest has its own streets and infrastructure,” he explains. “A typical pipe runs straight across and you have to cut trees to make way for them. By curling the pipes along the existing structure, we can optimize environmental impact.”

WIND AND HYDRO: JOINING FORCES

An exciting renewable energy innovation puts pumped storage right where it’s needed.

In a first-of-its-kind project, pumped storage and wind energy have joined forces at a new power plant in Baden-Württemberg, Germany.

Voith will supply equipment for the highly innovative Gaildorf pilot project by Naturstromspeicher, a German company that specializes in natural power storage. The project, currently under

construction, will combine wind energy generation and pumped storage – with a difference. At Gaildorf, a natural lower reservoir feeds four small upper reservoirs, built directly into the base of four wind turbine towers. The complete towers will reach 178 m in hub height and each have a 5 MW capacity. Due to the increased hub height, the dual system

Schechner hopes that Gaildorf’s implementation will encourage a more diverse, flexible approach to renewable energy. Smaller power plants have the benefit of easier installation, better control and more flexibility. Large projects are more cost-effective by maximizing the amount of possible energy production. Geography can best determine what type of project to apply. By widening the variety, the hydropower industry can increase renewable energy production and therefore run more efficiently, Schechner says. //



THE INVISIBLE POWER STATION

New pumped storage plant Reisseck II functions as an **environmentally friendly battery** in the Alps.

Deep inside a mountain overlooking the picturesque valley of Mölltal in the south of Austria, up to 250 highly skilled specialists are hard at work. A network of underground tunnels and caverns has already been dug and blasted out of the rock, and these are now being fitted with state-of-the-art hydropower equipment. In the main cavern, 25 m wide, 58 m long and 43 m high, engineers are working under floodlights to install the machine units. But what at first glance might look like a military bunker or the fantastic underground lair of a James Bond villain is in fact one of the most modern and powerful hydroelectric facilities in Europe, where engineers from Voith are currently installing two reversible pump turbines, each with an output of 215 MW.

Mölltal has a long history of hydropower, with the Reisseck-Kreuzeck system built from 1948 to 1961, and the Malta network completed in 1978, each with its own reservoirs, generators and self-contained hydraulic systems. With



- 1 Installation works on the control device of one of the machine units.
- 2 Voith engineers inside the cavern, discussing next steps.
- 3 The Rottau power station and Rottau Reservoir are connected to the Reisseck-Malta system.



Watch a video about Reisseck here (in German):
www.verbund.com/pp/de/pumpspeicherkraftwerk/reisseck-2

the launch of Reisseck II into service this year, the Austrian energy provider VERBUND has brought these two networks into the 21st century. “The new plant will connect two previously independent power plant groups,” says Martin Nussmüller, Project Manager at Voith Hydro. “This means it is not necessary to build new reservoirs and dams, and a part of the penstock of the existing power plants can be used. By connecting these two groups, the overall capacity can be increased by more than 40% with a relatively small amount of effort.”

In order to maximize the new facility’s output, VERBUND needed to install the most-efficient high-performance turbines on the market. “One of the reasons for the contract award to Voith Hydro was the outstanding high efficiency we could demonstrate during the model acceptance test,” says Nussmüller. “The turbines have a very high power density on the runner – that means a small runner with an extremely high power output.” The units are built with spiral cases that are made entirely

of stainless steel, use an operating ring and have a stay ring made from a single forged part. They were completely assembled at the workshop of Voith Hydro in Sankt Pölten and delivered as a single compact unit. “For this project we were able to draw on the knowledge and lessons learned from a large number of pumped storage projects completed by Voith in Austria over the last few years.”

The move to renewable energy sources is a major topic all across Europe. However, it is not as simple as just building more solar facilities and wind farms, as output from green energy sources can be very irregular, and alone would lead to a highly unstable grid. Pumped storage facilities like Reisseck II are a major part of the solution. “The concept of this power plant is to regulate the grid, and compensate for the energy peaks and troughs from wind and solar plants as well as from changing daily demand,” says Nussmüller. Each of the two turbines is reversible, acting as a pump or a

generator, to store excess power or to generate electricity as needed. Modern systems need to be able to react quickly to changes in the grid. “Because of this, quick response to load changes in the grid was a major parameter for the plant. It can store and release energy equivalent to that from a 200-turbine wind farm, reacting almost instantly.” This increased stability will benefit energy consumers not just in Austria, but also the neighboring countries.

As Reisseck II will be connected to the grid in 2015, the cavern is sealed and the construction works cleared away. With no new reservoir and no new dam, only an access road to the site remains as evidence of the invisible power station that has turned the Reisseck-Malta system into one of the most powerful hydropower facilities in Europe. //

Hydropower in AUSTRIA

Hydropower makes up almost 63% of all renewable energy capacity in Austria.

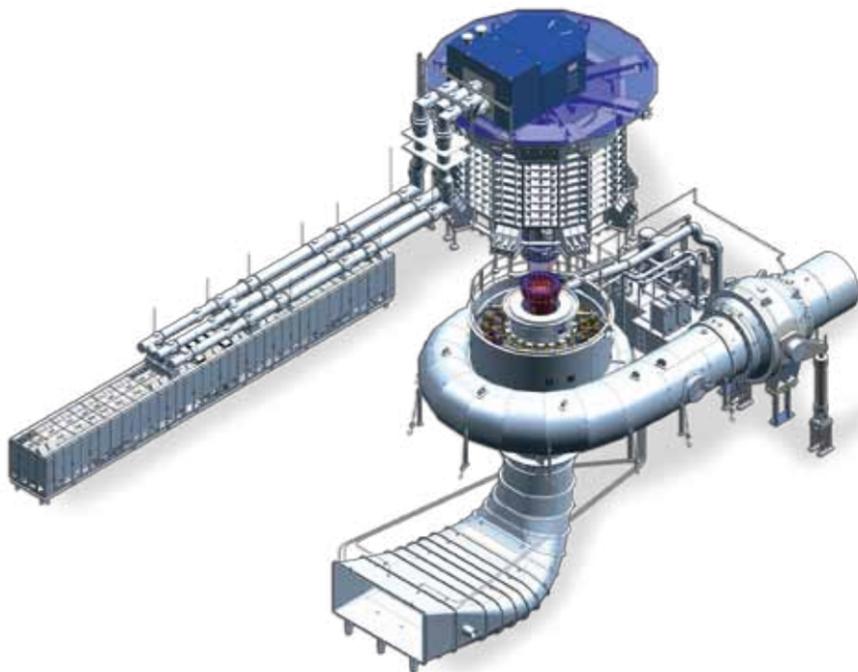
A BOLD LEAP FORWARD

Voith gives a new edge to a trusted technology at **Frades II in Portugal**.

Pumped storage hydropower has been a vital part of our energy networks for more than a century. In recent years, such plants have taken on an even greater importance, with a crucial supporting role in the move to renewable sources of energy. However, the technology that is involved has not changed fundamentally – aside from continuous improvements in efficiency and performance. All of this could be about to change. Voith Hydro engineers are currently installing two 390 MW variable-

speed, reversible pump-turbine units at the Frades II facility in northwestern Portugal. This immense pumped storage hydropower plant will not stand alone: it will be an important addition to an existing eight-plant cascade system, Cávado-Rabagão-Homem.

Frades II is the third facility of this kind to be built in Europe, and when it is connected to the grid in 2015, it will be the largest variable-speed pumped storage station in the continent. The future is variable speed.



Variable speed for increased flexibility: a 3-D model of the Frades II machine.

“The key element of this plant is a special asynchronous motor-generator: the DFIM, or doubly fed induction machine,” says Wieland Mattern, Project Manager for Voith Hydro in Heidenheim. “In contrast to a conventional synchronous machine that always turns at a fixed speed in time with the 50 Hz grid frequency, in the new DFIM machines the mechanical rotation speed is decoupled from the grid frequency, and can vary.” This has two main advantages. First: the new systems allow a fast and flexible response to active and reactive demand from the power grid. Whereas a traditional facility is either on or off in both motor and generator mode, the new units can be run at any speed within a given speed range, to match the current demands on the network. This was a major factor in the bidding process, and will be increasingly important in other markets, too. Second: variable-speed facilities offer additional stability in cases of voltage drop, reducing the likelihood of a blackout and enabling the system to come back into operation much faster following such an event, as compared with traditional, fixed-speed turbines.

Building a variable speed motor-generator of this size came with its own challenges. The rotor is a completely new design. “Instead of salient poles mounted to the rotor rim as for synchronous motor-generators, the Frades rotor has three-phase bar windings similar to the kind normally found in

stators,” says Mattern. “But unlike the stationary windings in the stators, the windings on the rotor turn at approximately 375 rpm and are exposed to high centrifugal forces.” In addition to this, compared with conventional synchronous machines, the rotor is charged with much higher voltage and current from a powerful frequency converter. This converter is 25 times more powerful than for a fixed-speed facility of this output, and is of course larger and heavier. “All that impacts highly on the design of the rotor, so it’s a completely new product development for this project.” Voith Hydro also had to develop a new electrical protection sys-

tem. “The new converter is much faster than traditional models,” says Thomas Hildinger, Vice-President of Voith Hydro Engineering Center. “The new protection thus has to be adapted to meet these increased demands.”

The end result of this technical innovation is a facility that brings additional reliability and stability to the grid. And in the search for improved performance, small changes can have a big impact. “In cases of reduced voltage, when the voltage drops to 5% of normal, a classical, fixed-speed turbine can remain stable for around 150 milliseconds,” explains Dr. Jiri Koutnik, Head of Expert

Support, Power Unit. “It then has to be removed from the grid and resynchronized before it can be reconnected. This can take up to a minute. The turbines in Frades II can retain stability for up to 600 milliseconds.” This might not sound like a huge improvement, but it is significant. “It can mean the difference between normal continued operation and, in extreme cases, a widespread, large-area blackout,” says Hildinger. //

Hydropower in PORTUGAL

Close to 42% of Portugal's renewable energy capacity comes from hydropower.



The rotor hub with the newly developed, semi-automatic stacking platform at the pre-assembly spot, shortly before lamination bundling starts.



A GLOBAL PROJECT

International collaboration on **one of Africa's biggest-ever** pumped storage facilities.

When Voith experts from all corners of the world collaborate, their achievements can be impressive. One such achievement can be found in the sweeping rural landscape of the KwaZulu-Natal region, in eastern South Africa, near a town called Ladysmith. Here, partially submerged under the sun-baked earth, is the immense Ingula pumped storage hydro-power plant – set to be one of Africa's largest ever.

Planning for this enormous project started back in the 1980s, explains Markus Müller, Project Manager for Voith Hydro Heidenheim. “Around 20 locations were considered before Ingula was chosen,” he says. Three decades lat-

er, as the project nears completion, it is set to provide 1,368 MW of power per hour. As Akihisa Hirata, Deputy Project Manager of Voith Fuji Hydro notes, the pumped storage plant will considerably aid in the “provision of a constant supply of energy across South Africa.”

Müller's and Hirata's contributions indicate the crucial international dimension and cooperation that has been so central to this project. Indeed, Voith's role in the Ingula pumped storage power plant is extensive. It has involved pulling together resources from four big company locations: Heidenheim in Germany, York in the United States, São Paulo in Brazil and Shanghai in

China – each in its own way ensuring the project will be a success. Voith Hydro in Heidenheim, for example, has been responsible for carrying out the main work on the four pump turbines, main inlet valves, the SCADA system, and electrical and mechanical balance-of-plant equipment. As Müller says, “This has entailed subcontracting work out to many other Voith branches across the world.” Hence, he describes it as “a truly global project.”

Another central partner has been Hirata's branch, Voith Fuji Hydro in Japan. This company in Voith Hydro's global network is responsible for building the four 373 MVA motor generators, which he says are “some of the

- 1 An aerial view of the beautiful landscape around the Ingula pumped storage power plant.
2 Work on the plant has been a collaborative effort among several Voith locations worldwide.

biggest we have ever supplied.” Besides cooperation in the project, Müller and Hirata also know each other from participating in the Voith Hydro Management Trainee Program, procuring skills they can apply to their current project – and future projects. The program is another example of Voith's global setup and mindset.

Another proud Ingula participant has been group affiliate Voith Paper in Bayreuth, Germany, which in 2011 was commissioned to provide heating, ventilation and air-conditioning systems.

On a technical level, the way this kind of pumped storage power plant works is not new, but it delivers: it stores excess energy during the night, or from renewables, in the upper Bed-

ford Reservoir, and releases water to the lower Bramhoek Dam reservoir to supply energy to the grid when needed. Through this tried-and-true technology, the Ingula plant will be strongly contributing to grid stability in eastern South Africa.

Ingula is located in fantastic natural surroundings, and the construction and planning of the plant has kept this in mind. The rural scenery and beautiful mountain vista have been minimally affected due to concealment of much of the works underground.

Aside from the power station, the integration of much of the apparatus and equipment beneath the surface is hugely significant, says Müller. “There

just isn't the same impact environmentally when compared with a plant fully above ground.” He is, however, appreciative of the general environmental impact of such a major project, and is pleased that various wildlife institutions, such as Birdlife South Africa and full-time environmentalists, have come together to form partnerships in order to check that environmental legal requirements are adhered to.

As it nears completion, the Ingula plant has been more than 30 years in the planning and preparation. With the expertise of a multitude of Voith employees from various disciplines drawn from across the globe, this pumped storage power plant is set to make a major contribution to South Africa's rapidly expanding 21st-century energy demands. //

Hydropower in SOUTH AFRICA

In South Africa, hydropower makes up almost 70% of renewable energy capacity.

ADAPTING AND EVOLVING

Giving the gift of an extended life to a long-serving pumped storage hydropower plant in the United States.

What better way to mark a significant birthday than with the gift of longer life? That's the present Voith has helped deliver to American Electric Power's (AEP) Smith Mountain Project, which celebrates its 50th anniversary next year. Operated by AEP subsidiary Appalachian Power, Smith Mountain is a strategically important pumped storage power plant on the Roanoke River in Virginia, US. Completed in 1964, the project's two dams and reservoirs created about 600 miles of new shoreline and about 25,000

surface acres of water when they reached their normal "full" water level in 1966. As well as providing electricity for the region, the lakes and waterways have become a focal point for residents and visiting tourists alike.

LONG-SERVING, MULTI-PURPOSE

The Smith Mountain Project was developed as one of the first supporting pumped storage facilities to complement an emerging nuclear power industry in the US. To afford an additional safety margin, nuclear plants are typically prohibited from load following, explains Greg Snyder, Service Sales Manager at Voith Hydro in York, US. Originally, Smith Mountain's primary purpose was that of a traditional pumped storage plant. Today, the facility complements AEP's nuclear, gas and coal base load plants in this traditional way, and also helps enhance the value of renewables such as solar and wind.

Voith has played an important part in the development of all aspects of pumped storage hydropower in the US since its inception, both directly and through acquisitions over the years, particularly Allis-Chalmers, S. Morgan Smith, Westinghouse, and the joint venture with Siemens. The specific knowledge base of these strong firms all helped Voith build a deep understanding of all facets of the American hydropower market, as well as incorporating their OEM know-how and expertise.

The half-century-old Smith Mountain Project has three pump-turbines and two conventional generators – a mix of conventional and pumped storage units that also exists at other US hydropower stations. One of the life-extending projects that Voith Hydro in York (VHY) has undertaken on the plant's motor-generators has involved the re-winding of the two conventional generator stator coils – a task carried out by Voith Hydro in Mississauga, Canada. Further recent works by VHY involved a rotor rim shrink on unit three – the largest unit at the plant – involving realignment to extend the life of the unit.

TRUST AND THOROUGHNESS

"These successful works have resulted in the development of considerable trust and respect between the plant's owners and operators and Voith," says Snyder. Both the breadth of Voith's expertise and their willingness to go the extra mile to ensure customer satisfaction have been appreciated by AEP.

AEP Energy Maintenance Superintendent Jim Thrasher speaks enthusiastically about the way that Voith resolved challenges that emerged at the initial testing stage. "What Voith offered us was above and beyond anything we had expected, and they ultimately exceeded both the contract specifications and our expectations," he says.

"On the second unit, we found the original poles were significantly damaged on the rotor. Voith was completely open and transparent with us about the

additional costs involved and they ensured that the sense of urgency we felt about getting the job finished was transmitted throughout their own team and to their subcontractors. Their reputation for quality was fully justified by their work for us at Smith Mountain."

And what of the three pump units? Thrasher also says, with a hint of pride, that these units are still original and have not been upgraded – something most unusual for a pumped storage hydropower plant of this age. "People ask us when we intend to do it, and we tell them we'll upgrade when we have serious problems. To date we haven't had any," he says. These units were all made by the Voith-acquired firm Allis-Chalmers. It just goes to show: quality really does stand the test of time. //

Hydropower in the US

The US ranks third in the world for installed hydropower capacity – second only to Brazil in the Americas region.



1 One of two dams at Smith Mountain.
2 The waterways which feed into Smith Mountain form a playground for locals.



Hong Ping project team with the first of the bifurcation pipes destined for the plant.

AMONG THE WORLD'S LARGEST

Voith is delivering hydropower equipment to increase China's mix of renewable energy.

China has launched itself on an ambitious course to significantly increase its mix of renewable energy. Pumped storage will play an integral part in these plans, assisting the nation in reaching its goal of generating 20% of its energy from renewable sources by 2020. According to the International Energy Agency, China's State Grid expects total pumped storage in-

stalled capacity in China to reach 54 GW by the year 2020. Today, the country's total installed energy capacity is approximately 19 GW.

As just one step toward this renewable energy goal, a new pumped storage hydropower plant, with equipment supplied by Voith, is under construction in Hong Ping, Jiangxi province, some 750 kilometers southwest of Shanghai. In its

initial development phase, due for completion in 2015, Hong Ping will supply 1,200 MW of power. Once fully commissioned, it will generate 2,400 MW of power – making it one of the largest pumped storage plants in the world.

Hong Ping's scale is one of the challenges of the project, along with balancing hydraulic performance and operational stability to meet customer

requirements. Using computer-based simulations and carrying out detailed model tests to find the best possible technical solutions for the project, the design and engineering of the equipment began to take shape.

The model acceptance test was completed successfully in July 2013, marking a major milestone in the project: results proved that efficiency rates exceeded the guaranteed values. To reach this point, Voith carried out more than 100 optimizations, based on computational fluid dynamic analysis.

“Our advances in materials and design for Hong Ping, along with developments in other projects, like the asynchronous generator for large-scale pumped storage in the Frades II project in Portugal [see page 18 for more], strengthen Voith Hydro's position as a leading pumped storage plant supplier worldwide,” says Danijel Anciger, Hydraulic Design Engineer for Pump Turbine Development in the Voith Hydro Engineering Center, and involved in the model development for Hong Ping.

Voith is supplying four complete pumped storage units for Hong Ping, including four synchronous generators, reversible Francis pump turbines, governors, inlet valves, excitation, automation and power plant auxiliary systems. Each unit will have a capacity of 300 MW. Voith received the order from the State Grid Corporation of China – the largest energy provider in China.

The advances made for the Hong Ping project include several turbine and gen-

erator optimizations: innovations that will certainly find their way into other pumped storage plants for other Voith customers in the future.

The State Grid Corporation requested very stable start-up behavior for the turbines, which required custom engineering for the runner profiles, Anciger says. At the same time, the customer wanted very high hydraulic efficiency to get the most possible electricity from its storage capacity.

“Achieving stable start-up usually means giving up a bit of hydraulic efficiency, but the customer wanted both. We provided this by redesigning the turbines using precise measurement equipment and a fast design process loop in which we fed back measurement results into the model design,” says Anciger. Another innovative approach for the turbine was achieving an optimal level for balancing pump and turbine operational modes.

Voith made optimizations to the generator by adapting its shaft to increase the accuracy of the guide bearing from 0.03 to 0.015 millimeter. This was achieved by designing a single long welded shaft, instead of using two short shafts connected by bolts, says Helio Moino, the Executive Vice President and Chief Production Officer at Voith Hydro in Shanghai. Moino is responsible for manufacturing and quality activities, including the production of the Hong Ping parts.

Voith also redesigned the pole with new material and an air guide. The new pole helps cool the generator by im-

proving the ventilation of the unit with self-ventilation, instead of forced ventilation with fans. Pan Zhibin, the project manager at Voith Hydro in Shanghai, says he was proud both of the new designs that Voith has created as part of the project and of solving each new complex challenge turning up in the Hong Ping project. “Pumped storage plants are very complex projects. It has been quite a challenge to manage the project with the new designs and materials. I am particularly impressed by the way engineering, purchasing and project management in Germany and China worked together as one team to make this happen.”

Voith took an interdisciplinary approach to solving technical challenges at Hong Ping by holding a project convention and an expert review meeting early on. Voith experts from various divisions around the world met in Shanghai and worked together in groups dedicated to the areas of turbine, generator and automation, as well as balance of plant, purchasing, manufacturing and field services, logistics and coordination.

Moino says, “With our innovative solutions at Hong Ping, Voith is playing an important role in stabilizing the grid and providing clean energy in China, one of the world's biggest engines of economic growth.” //

Hydropower in CHINA

China is the number one hydropower market in the world, with around a quarter of all hydropower capacity.



SAVING IFFEZHEIM

Voith Hydro provides services for a plant in need – preventing further damage and ensuring rapid repairs.

The Iffezheim Barrage is located in the Alsace region in France, on the section of the Rhine that forms the border between Germany and France. It was constructed in the late 1970s to enable better control of flow on the river, and simultaneously to allow the generation of electricity from a run-of-river hydroelectric facility built into the barrage itself. In 1976, Voith supplied parts of the plant's four turbines, each with a power of 28.3 MW. Today, it is one of the largest hydroelectric facilities of its kind in Germany.

In October 2013, engineers on site noticed a large amount of water had leaked into one of the four runners. "It

was really from one day to the next," says Alois Taglieber, Sales Manager at Voith Hydro Heidenheim. "A small amount of damage to one of the seals around the runner can lead to a huge leakage." Following meetings with the customer, Voith engineers got to work last December, with the task of refurbishing the non-moving parts of the affected runner.

Working conditions at the Iffezheim facility are challenging. Access is limited due to the plant's design, and the individual machine parts are huge: the discharge ring alone is 5.9 meters in diameter. There are safety concerns as well, as many machine components are sealed with an anti-corrosive paint that contains asbestos. "We have a very good, close working relationship with the customer to ensure the highest safety standards," says Taglieber. On top of this, the true scale of the job to do only became clear when the engineers began to disassemble the enormous components of the runner. "As part of our work, we disassembled the bearings and performed routine non-destructive testing – not because we thought there was a problem, but to guarantee smooth running for the next 40 years. This testing revealed corrosion

- 1 Outside view of the Iffezheim Barrage on the Rhine River.
- 2 The discharge ring being serviced in the Voith workshop.
- 3 A look inside the machine unit being serviced by Voith.

issues on the thrust bearings and the discharge ring as well as on the shaft itself," Taglieber explains. As a result, the main shaft then needed to be removed for surface refurbishment – no mean feat for a piece of equipment weighing over 30 tons. "We had to build scaffolding and load-bearing structures to remove the shaft – the site looked like a forest of iron beams," adds Taglieber.

Thanks to quick and flexible intervention by Voith Hydro's team of experts, in close communication and collaboration with the customer, repairs are now well underway, with the generator due to go back on line by March 2015. Iffezheim is a perfect example of Voith's after-market business section's successful work in preventing further damage and a possible shutdown, and bringing a facility back to full operational capacity within a short time frame. //

Hydropower in GERMANY

Germany has set a target of generating 35% of its energy from renewable sources by 2020 – including hydropower.



SMALL HYDRO MULTI-TALENTS

With **innovative solutions and a reputation for reliability**, Kössler is a market leader in small hydropower.

For insights into the high quality that Voith subsidiary Kössler guarantees, two recent projects are a good example, showing the company's excellence in after-market business (AMB) and new builds: an upgrade of a turbine and belt drive in Hochstadt, Germany, and a new hydropower plant at Tröpolach, Austria.

Ensuring customer satisfaction via an intelligent AMB culture is central to the way Kössler functions, with the Hochstadt upgrade as a fine example. Back in 1985, Kössler played a leading role in the establishment of a small hydropower plant at Hochstadt. A high level of performance over three decades meant that the firm was called in again to carry out an upgrade in early 2014, notably of a Kaplan A-Bulb turbine and belt drive.

"At the heart of the plant is a four-blade runner made of bronze," explains Kurt Schiep, Head of AMB at Kössler. "Due to abrasion, it was no longer able to achieve the maximum efficiency for the power station." The turn-around for the project was short, and a start in January meant the plant was up and running again by the middle of April. Kössler experts repair-welded the blades at the outer diameter and leveled the runner chamber, while, for example, also overhauling the wicket gate

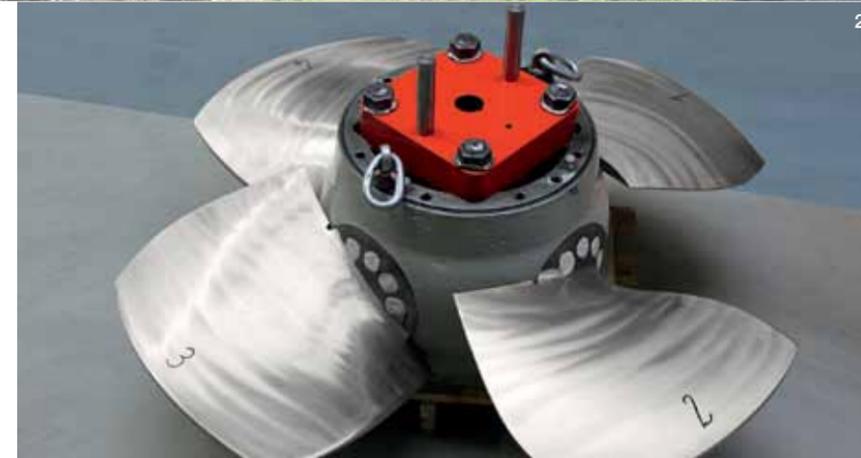


1
2

by inserting maintenance-free guide van-shaft bushes. Added to the effect of rebuilding the main turbine guide bearing, says Schiep, "the output of the plant has been significantly increased."

The age of the technology involved was just one concern for the operator, with sustainability also key to the customer's corporate philosophy, explains Schiep. "Now we're finished, the plant won't need another upgrade for 30 years." This is great news for the region's energy supply – particularly for the town of Hochstadt, he adds.

Across the Alps in Austria's Carinthia region, bordering Italy, is picturesque Tröpolach. This is ski country, with the highly regarded Nassfeld slopes attracting many thousands of visitors every season. As Karl Wieder, Head of Sales and Planning at Kössler, explains,



Tröpolach's climate and surrounding environment made it an ideal location choice for a new small hydro plant: specifically, "its very high rainfall and the Oselitzenbach Torrent."

To complement the optimal natural environment, Kössler designers came up with the perfect technological com-

ination: two models of the company's turbines (the PV6i/1080/330) and generators (the PV4c/650/160), which, though not new, "are used here for the first time in tandem," Wieder says. The result is the provision of 16.5 GWh of eco-electricity – enough to power around 4,700 households. In such

- 1 The new small hydro plant at Tröpolach is fed by the Oselitzenbach Torrent.
- 2 New shine: the Kössler-restored four-blade runner from Hochstadt.

beautiful nature, where the look and feel of the mountain vista is so important, there is always concern for the environment. Ensnared in a winter sports area, "with its energy-intensive ski facilities, the plant is good for the region," says Wieder. Indeed, the operator Kraftwerksgesellschaft Tröpolach GmbH calculates that the Tröpolach hydropower plant "saves the environment 6,811 tons of CO₂ emissions and 11.9 kilograms of radioactive waste, reducing Austria's carbon footprint".

Kössler's reputation has been built on eight decades of carrying out successful small hydropower projects, as the upgrade at Hochstadt and the new plant at Tröpolach evidently show. And with small hydropower solutions very much in demand, the Voith Hydro company looks set to continue going from strength to strength. //

PIONEERING TECHNOLOGY

Together with Voith Hydro's Brunnenmühle R&D center in Heidenheim, **Germany's first pumped storage plant was established over a century ago.**

It is said that only when inventions and ideas see the light of day can one refer to them as being trendsetting and innovative. Often, they are the combined result of a pioneering spirit and foresight, as well as an actual, practical need. This is true of Germany's first ever pumped storage power plant, located at Voith Hydro's Heidenheim corporate headquarters. When Friedrich Voith launched construction of the plant in 1908, he played a crucial part in establishing a technology that has now become essential for efficient electricity storage. He could never have anticipated then how pumped storage would become so important in the switch to renewable power generation a century later: allowing large amounts of sustainably generated power to be stored efficiently, and distributed flexibly, helping

to ensure a reliable power supply and a stable grid.

When the facility was being built, the focus was on the practical, more immediate benefits it would bring. Here, innovation went hand in hand with the pressing need for a technical solution – a principle that still applies to Voith today. The objective of the plant was to supply the Brunnenmühle water mill, acquired the previous year, with electricity and the water pressure necessary for it to function as a development and test laboratory for high-pressure turbines. Construction was also motivated by a newly signed contract to deliver 12 Francis turbines to the Niagara Falls hydroelectric plant – turbines which had to be designed with the utmost precision for maximum performance and rotational speed.

In the summer of 1908, a reservoir was built on top of the Schlossberg in Heidenheim, about 100 meters above the Brunnenmühle. The reservoir was filled using multistage centrifugal



Brunnenmühle reservoir	
Diameter:	36 m
Depth:	8 m
Capacity:	8,000 m ³

pumps, with water from a nearby well. The electrical energy required for these pumps came from a high-voltage line installed by Voith, originating from another Voith hydroelectric and testing facility in Hermaringen, about 15 kilometers away. The principle was simple and ingenious – and it still is to this day. With inexpensive, excess energy (available mostly at night and on Sundays), water was pumped up the mountain into the reservoir. During the day, it was allowed to rush down to the Brunnenmühle station to drive the power-generating turbines installed there, thus supplying the test facilities with the water and pressure they needed. The day the hydraulic machines began operating as a pumped storage plant, Brunnenmühle became Voith Hydro's first testing facility – a significant milestone in the company's history. To date, it remains the technological core of the company, and, with the support of centers of competence in Shanghai, York, Noida, São Paulo and Västerås, it is the heart of Voith Hydro's worldwide R&D work.

The reservoir of Germany's first pumped storage power plant still exists today. Together with its turbines, generators, pumps and other equipment, the site is registered as an historic landmark. The description in the registry of historic places states that "all pumped storage facilities in Württemberg [where Heidenheim is located] played a pio-

neering role in the development of this technology, in particular this very first facility" – securing Voith's significant part in the history of pumped storage.

Voith may not have known in 1908 that the plant's operating principle would still be relevant over a century later. But pumped storage technology has now proven itself around the world to be the most cost-effective, highly efficient, large-scale energy storage solution available. And, as it increasingly supplies power grids worldwide with energy from the fluctuating output of renewable power generation sources, the role of pumped storage takes on a new – and greater – relevance. //



1 Construction of the eight-meter-deep reservoir gets underway.
2 The completed, filled reservoir on top of the hills around Heidenheim.

At work on a turbine in the Shanghai workshop.

A BRIGHT FUTURE

Voith Hydro Shanghai marks the company's 20th anniversary, with an eye on a promising hydropower future.

As Voith Hydro Shanghai (VHS) prepares to celebrate its 20th anniversary this November, the time comes to reflect on Voith's pioneering role in the development of hydropower and renewable energy in China. The wheels first started turning in 1910 when the company provided turbines for the Middle Kingdom's first hydropower station, Shilongba, in Yunnan Province.

After more than a century of partnership with China, Voith can count among its achievements the supply of top quality equipment and services to landmark projects such as Gangnan in Hebei in 1967, the country's first pumped storage project, and Lubuge in Yunnan, the first Chinese hydropower project open to foreign contractors, financed by the World Bank, in 1983.

Business proceeds apace since VHS was established in 1994 with Shanghai Electric Corporation as a partner. VHS has supplied the Chinese hydropower industry with localized design, engineering and manufacturing, thus contributing to the strength of the company's overall activities. It has since become a major supplier to projects such as the Three Gorges Dam – among many other large-scale works. With a workforce of 600 employees, 99% of whom are native Chinese, VHS is Voith Hydro's second-largest manufacturing base worldwide. Localization is key to the company's success, says Martin Andrä, President of the VHS Board of Management. "Our localization efforts



福源伊始 二十载风华卓行
Together, Moving Forward for a Reliable Future

1910

Construction of Shilongba, China's first hydropower plant, with turbines and generators from Voith.



in all business areas – like design, engineering, manufacturing, project management and field service – has enabled VHS to become even more competitive on the Chinese and South-East Asian markets. Geographical and cultural proximity helps a lot."

1994

Foundation of the Shanghai Hydropower Equipment Company (SHEC) – a joint venture of Voith, Siemens and Shanghai Electric Corporation.

Voith provides four 300 MW capacity turbines and motor-generators to Guangzhou II, one of the world's largest pumped storage plants.



VHS gains from and fosters technological expertise through its local branch of the Voith Hydro Engineering Center International – a network comprising centers of excellence around the globe. The Shanghai branch provides systematic training and development courses for employees and worldwide job rotation opportunities.

As part of an internationalization drive, VHS develops products for challenging new markets. VHS excels in main inlet valves and performs system engineering locally. That's in addition to meeting the demands of Asian and also African markets, and supplying equipment for further global projects. This strategy owes its success to good performance in the Chinese hydropower market and strong support from headquarters, says Tang Xu, Chief Marketing Officer and Executive Vice President: "We have a diligent, loyal local team with good hydropower engineering backgrounds, which developed quickly from previous projects."

VHS' strong position as a full-line supplier gives it an edge over competitors. Skilled, quality engineering and manufacturing lend it a reputation as a reliable, international supplier. The compa-

2004

Voith delivers the first of six 700 MW machine sets – then the largest of their kind – to Three Gorges Dam, the world's largest hydropower plant.

2007

Voith was awarded the supply of eight 610 MW Francis turbines to Jinping II – the highest head mega turbine in China.

2008

Voith was awarded the supply of three generator-turbine-sets – the most powerful ever built at Voith – for Xiluodu, the third-largest hydropower plant in the world.



2012

Voith was awarded the contract for four 300 MW capacity pumped storage units and auxiliary facilities to Hong Ping (see p. 24).

2014

Voith to supply three 470 MW Francis turbines and generators, automation systems, and BOP E&M for the expansion of Tarbela, Pakistan – following other international contracts in South-East Asia.

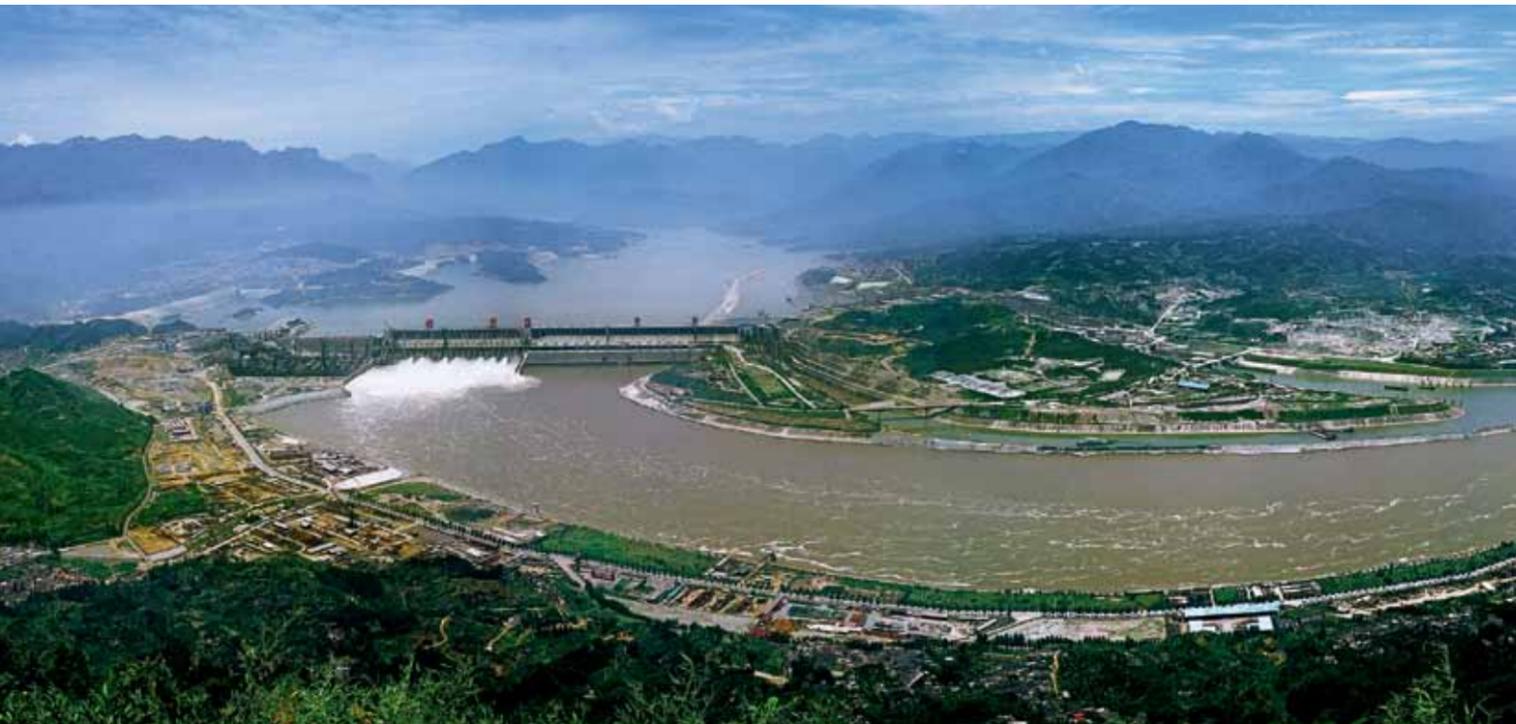
▷ ny strictly applies standards and cooperation common to Voith Hydro entities worldwide, in terms of design, production, quality and performance. Regular project conventions conducted with experts from throughout the Voith Hydro network help to assure the optimum performance of projects, Andrä says.

The benefits of hydropower for China and its people aren't limited to power supply. When the Voith-assisted Three Gorges Dam project was completed, adjusted river flows meant improved flood control on the Yangtze River, especially the flat, flood-prone Jingjiang section. The resulting reduction in the

likelihood of potentially devastating floods – from approximately once every 10 years to once a century – will protect lives and livelihoods.

China already has an installed hydropower capacity of 280 GW (by 2013) – that's almost 25% of all global installed hydropower, giving it by far the biggest share of all nations. And it has vast further hydropower potential: around 400 to 500 GW. The Chinese government's five-year plan emphasizes renewable energies, with the goal of achieving a 45% CO₂ emissions reduction by 2020. Developing hydropower as the most powerful of these is key to achieving that goal, Andrä concludes. //

Three Gorges Dam on the Yangtze River: the world's largest hydropower plant.



Improved original: Voith-restored 1920s components at Pointe du Bois.

KEEPING THE WHEELS TURNING

Through **services and modernizations**, Voith helps get the best out of long-established Canadian plants.

The world's fourth largest producer of hydroelectricity, Canada is also one of few countries that generates the majority of its electricity this way. With approximately 500 hydropower installations and 1,500 individual units, with an average age of about 60 years, it is also a highly mature market – and this leads to a high demand for services and modernization as equipment ages.

Present in every Canadian province and territory for over a decade, Voith Hydro enjoys a strong reputation in the field of after market business (AMB) services. Headquartered in Brossard, Québec, Voith Hydro Canada focuses on engineering, customer service, business development, project management and project administration for large hydropower, small hydropower, automation and the service businesses. Voith's

Canadian Hydropower Service Center for AMB, which is also the company's center of excellence for multi-turn coils, is located at a modern plant in Mississauga, Ontario, while the subsidiary Vortex Hydro in Granby, Québec, has added to Voith's strength in such areas as auxiliary mechanical systems, specialized hydropower products and consulting.

In the case of the Pointe du Bois run-of-river hydropower plant in Manitoba, Voith's AMB services were in demand. Completed in 1926, Pointe du Bois is the oldest power plant still in operation on the Winnipeg River. The operator, Manitoba Hydro, engaged Voith in 2010 under a time and materials contract to undertake service work on five units – some close to 100 years old. However, as the work progressed, a wide range of 'out-of-scope' conditions emerged. Each as-found ▷



- 1 The reservoir at GM Shrum Generating Station.
- 2 Installing a new head cover at GM Shrum.
- 3 The dam at Pointe du Bois, Manitoba.

equipment manufacturers, such as Westinghouse generators and Allis Chalmers turbines and generators. In tackling the challenges of AMB or refurbishment, therefore, Voith brings a unique and very broad level of insight and knowledge to almost every project.

Expecting the unexpected is also important. During refurbishment of the GM Shrum Generating Station in British Columbia (see images 1 and 2), it emerged that repair welding over the years had impaired the efficiency of the original turbine runners. New runners and hydraulic profiles, however, have improved efficiency substantially, improving reliability and cutting maintenance costs in the process.

Helping customers review options to achieve a good balance between higher future revenues, lower maintenance costs and the immediate capital cost is a major but highly rewarding challenge, says Laurent Bulota, Head of Proposals at Voith Hydro Canada. "The future design life of modernizations we are handing over now could be 50 to 80 years, but the return on investment has to be under 10 years – and ideally achievable within five," says Bulota. He notes that in Canada, the world's fourth-largest hydropower producer, knowledgeable buyers of hydropower services demand high quality, reliable, long lasting, state-of-the-art solutions and equipment: qualities reflected in Voith Hydro's own core values. //



Visit voith.com/hyservice for more on Voith Hydro's service business.

Hydropower in CANADA

Close to 90% of all renewable energy capacity in Canada comes from hydropower.



▷ condition different from expected was carefully documented within a Field Problem Report specifically developed for the project, and a costed solution proposed by Voith. Innovation was also needed in technical areas. Sophisticated scanning techniques were used by Voith engineers to create a 3D cloud of data points to accurately model an upstream runner crown, band and blades, making it possible to accurately replicate the Pointe du Bois' original 1920s components.

"Some of the units had not been in operation for many years", says Neal Cumming of Voith Hydro's AMB center based in Mississauga, "and it gave us tremendous satisfaction to know that by providing economically viable solutions we have been able to bring some of the machines at the plant back to life."

The Pointe du Bois project has highlighted another aspect of project planning: appropriate staffing. Having determined Manitoba Hydro's needs, Voith suggested using a hybrid crew comprised of both Voith employees and local unionized labor. Directed by a Voith Site Manager, this team includes two Manitoba Hydro technicians, who will gain valuable experience in execution of in-situ turbine rehabilitation. "It is this kind of thinking outside the box, putting ourselves in

our clients shoes, that has established and helped to reinforce a strong working relationship between Voith Hydro and Manitoba Hydro," says Cumming. "Facing situations that haven't been dealt with previously in an open manner has helped to create solutions that are best for both parties." Manitoba Hydro continues working together with Voith at Pointe du Bois and has recently extended the previously awarded AMB work scope still to be performed for the modernization of units 12, 13 and 14 at the plant.

"It's an exciting side of the business," says Michael Secord of Voith's AMB work. Secord has recently been appointed Head of AMB for Voith Hydro in Canada. "We're building a highly responsive service. We want to respond to our clients' maintenance and improvement needs quickly, and we also want to make it as easy as possible for them to avail of our services." Secord is also exploring ways that 'big data' might be used to enhance maintenance support. His intention is to develop a new 'reliability centered maintenance unit' in Canada, which will use the constantly growing banks of operational data to accurately predict wear rates, for example, and their effect on output performance.

MODERNIZATION: INTO A NEW AGE

Apart from the growing importance of the services business, the increasing number of hydropower plants in Canada that have been running for several decades now also leads to a growing trend towards modernizations and refurbishments. Those typically also involve new designs to improve efficiency, increase output, improve reliability or reduce maintenance costs, and Voith Hydro comes with broad experience in this field providing optimum solutions for existing hydropower plants, and with a number of successful reference projects, particularly in Canada. Technical advances mean that significant, sometimes exceptional improvements in performance, output and reliability are possible. Voith typically achieves increases in turbine efficiency of more than three percent, and output gains of between 15 and 25 percent are not uncommon. At Hydro-Quebec's La Tuque power plant on the Saint-Maurice River in Quebec, for example, Voith increased the output of three units by more than 50%, notes Pierre Séguin, Head of Business Development at Voith Hydro Canada. "Our successful partnerships with our customers are proof of excellence in rehabilitation," observes Séguin. Voith now owns the technologies developed by many of well-known original

POWERING LATIN AMERICA

A conversation with Voith Hydro in Latin America's **President and CEO Marcos Blumer** and **Chief Marketing Officer Alfredo de Matos**.

Having assumed the new positions as CEO and CMO of Voith Hydro in Latin America, what are your main targets for the company?

Blumer: My understanding of being CEO is to serve the company, to become better every day and to do everything to develop the best solutions for our customers. There may be various objectives and initiatives, but all have one superior goal: to serve our customers and to make Voith Hydro their preferred choice. This is based on three pillars: our entire organization needs to be customer-oriented – the customer always comes first. Secondly, we aim to be a lean, fast and efficient company. And we want to establish a great-place-to-work environment, in order to have the best people.

De Matos: In this spirit, we also aim at further expanding our local presence in the markets. We want to strengthen our network in the regions, establish more regional offices with local people to deepen our understanding of market needs, rules and processes. This does not mean, however, that we will move away from global Voith standards – technical leadership, high quality and the optimum solution are principles that continue to apply everywhere around the globe.

What is the current status of these localization efforts in Latin America?

De Matos: First of all: we are already used to the local markets. We are here, experienced, and we have a strong heritage. Celebrating the 50th anniversary of Voith this year means 50 years in Latin America – not just Brazil. In the past few years, we have already successfully established offices in Colombia, Peru, Ecuador and Chile. Mexico and Argentina are our next steps.

What role does the Manaus facility play in this context?

Blumer: Our newly established manufacturing facility in Manaus is located very close to what I call “the next hydropower frontier” in Brazil. The potential for hydropower plants in this area is close to 90 GW, with only 14% already explored. Manaus is also capable of covering production needs for other countries in northern Latin America.

Beyond localization, are there any business segments you particularly want to promote?

De Matos: One of our targets is to promote and expand our service business, especially with regard to integrated services and asset management. We want our customers to know that we have

vast experience and can offer comprehensive service solutions for their hydropower plants. To further improve our service offering, we are streamlining processes so that we can respond to customers even faster.

Blumer: Closely connected to integrated services is the field of automation. We are offering stand-alone solutions in automation and have increased our market share significantly. Besides new installations, we're also digitizing old hydropower plants with our modern HyCon automations systems, and supplying governors and excitation systems when existing hydropower plants are being modernized.

De Matos: As Mr. Blumer correctly pointed out, automation is also a good example of our continuous innovation drive: to adapt to the markets, and introduce new – and constantly update existing – products and services. Our automation lab is one of the best-equipped across Voith Hydro globally, where we are customizing solutions to our customers, which can later be used on a global scale.

Is Voith Hydro well known for its products and services in the Latin American markets?

Blumer: We have become a real full-



Marcos Blumer
The President and CEO of Voith Hydro in Latin America sees the company as an “upside-down parliament”: with the customer on top of the parliament and the CEO at the base. Having been with Voith for 25 years, much of that time in the Paper division, he joined Voith Hydro in 2010 as Chief Production Officer, taking care of the production facilities in São Paulo and Manaus. Impressed by hydropower already as a child, he was convinced to join Voith thanks to a presentation given by German engineers to his university class in Brazil.

it comes in multiple dimensions: projects in Latin America are financed from China, for example, while Brazilian companies are at the same time investing in projects in Africa. Global financing will be a trend we need to take part in. With our global presence and cooperation, Voith Hydro is well prepared for that, as we can offer local expertise to customers from around the world.

De Matos: Here, key account management comes into play: Voith Hydro is a true global company, and we will increase working together with our operating units in other markets to serve our globally active customers, in both directions: for Latin American customers and their global business, as well as, for example, big utilities from Europe that are active on the American continent.

Back to the Latin American market: What are your estimations on the future development of this region?

Blumer: In general, Latin America is and continues to be a good region for hydropower development due to its vast natural water resources. We will see an increasing market share of countries outside Brazil. This is not because the market will decrease in Brazil, but because other countries will increase their hydropower share. Colombia, Peru, Venezuela and Argentina have good hydropower potential and are very promising markets, too.

De Matos: Besides new units, large and small, we place a lot of emphasis on the services business: both integrat-

line supplier in recent years. Many customers are aware that we are supplying the whole package: automation, balance-of-plant, integrated services, construction. This approach correlates closely with the market trend, especially for large and mega projects. We support our customers in a “water to wire” solution: a technically integrated solution from water inlet to grid connection. And we offer our customers a one-stop-shop experience, with fewer interfaces and less risk for them.

How would you characterize the hydropower markets and customer structure in Latin America?

De Matos: First and foremost, one has to realize that each Latin American market is different. This is one of the reasons for our local approach. The large hydro segment in Brazil is characterized by very large projects from 200 up to 8,000 MW, which are usually tendered by the government, with large private electrical companies, or special-purpose companies together with investment funds as our customers. State-owned companies also play an important role as part of consortia.

And how about other Latin American markets?

De Matos: Typical projects have a range of 80 to 150 MW, and projects are contracted differently by market: in Chile, for example, private companies predominate, while we see a semi-private market in Peru and Colombia, with some government auctions besides the participation of both state-owned as well as private companies.

Blumer: We have a complex mix of customers, so we need to be flexible and adapt to meet their different demands. As an example, projects in Brazil offered in auctions will be won by the lowest price per MWh. A different approach is design-to-cost solutions: expertise from the customer, the civil contractor, and from Voith Hydro is blended to find the best solution for the customer, gain optimum efficiency for the project and bring it on line faster. This is feasible through our strong technical expertise. I see it as a growing trend.

Is international funding increasingly a factor?

Blumer: Yes, funding will increasingly become a key topic in the future – and

Alfredo de Matos
The Chief Marketing Officer of Voith Hydro in Latin America has 22 years of experience in the B2B industry, many of those in executive positions in the energy sector. Having done business on five continents, he joined Voith Hydro in 2013. He aims at moving the company forward based on his motto “winning and leading” – that is, winning long-term customer relations and leading the hydropower market for another 150 years.



▷ ed services and modernizations. Our expectations are high since the hydro-power fleet across the entire region is aging – many plants are 25 years old or more. Customers are keen on retrieving any possible extra megawatt from their assets, and want to keep them up to date by upgrading them with the most modern HyCon solutions in automation and asset management. Voith Hydro is very experienced in such services and modernization projects, which are always very customized jobs. You can see our successes in this area across the region: projects like Passo Fundo or AES Água Vermelha.

Blumer: At the same time, the market environment has become more competitive, particularly in small hydro, as foreign players enter the business, and government regulations have forced small hydro to compete with wind and biomass – which is hard when you only look at the costs per MWh and do not take into account the other benefits of hydro, like contributing to grid stability or long life cycles. We need a supporting legal framework here, which in some countries also means a change toward more simple and reliable regulations.

De Matos: As you can see from all that we have just stated, I am quite confident Voith Hydro has a lot to offer. We need to focus on our broad experience and heritage, our technical leadership and our deep know-how. We want to assertively show that as a real full-line supplier we are capable of serving the ever-changing needs of the market: from single components to turnkey solutions, from new automation solutions to future trends like the use and end benefits of big data within plants.

You mentioned the regulatory framework: is it in favor of hydropower, or do you hope for improvements?

De Matos: Across the various Latin American governments, clear energy

matrices and long-term policies are of high importance, but as of today there are too many uncertainties. Also, with regard to permission processes and environmental licensing, we need clearer rules and more efficient paths. Incentives for investment in modernizations are another, more specific, but important issue, which governments could easily use to stimulate the supply of additional gigawatts to the grid.

Blumer: Clearer regulations and improved processes will also lead to a greater acceptance of megaprojects like Belo Monte. Hydropower has so much to offer. It strongly contributes to the development of our economy and society, and enables people to evolve from deep poverty to middle class: local development based on hydropower provides access to education and medical care and, ultimately, greater future opportunities.

What is your personal connection to hydropower – and to Voith Hydro?

De Matos: What I like most about hydropower is the complexity of the technology, the variety and flexibility of solutions, the fact that everything is customized, coupled with its tremendous renewable aspect. Voith, to me, is strongly characterized by its clear set of values, its significant heritage and history, and the committed people with their real focus on never letting a customer down.

Blumer: To me, hydropower is an exciting and passionate world. It is amazing how a technology launched a long time ago has developed in such a way that it is still an unbeatable source of clean, reliable energy. Voith is one of the few companies where employees give themselves a nickname that stems from the company name: Voithians. I think that the principles, values and culture that have made Voith strong during the last almost 150 years will also guide us into a strong future. //



6:00



9:00



11:00



14:00

- 6:00 Eric Junior; his wife, Andreia; and their son, Gabriel, enjoying breakfast together before Eric heads to Água Vermelha to begin his workday.
- 9:00 Eric values communication with his team highly. “There are always people who want to say something ... and I am here to listen to them,” he says.
- 11:00 Consulting a team member at work on the modernization of equipment at Água Vermelha.
- 14:00 Hard hats on: discussing safety at the plant with a team member.

LIVING THE PROJECT

On the job with a Voith Hydro Site Manager at Água Vermelha – illustrating personal engagement and technical experience of Voith’s people “on site.”

The time is 6 a.m., and Eric Junior is eating breakfast with his wife, Andreia, and their son, Gabriel. Here begins a routine that repeats itself every day, in myriad forms, in markets served by Voith Hydro across the world.

Eric is a long-serving Voithian who coordinates a successful team in providing field services on Voith Hydro projects. Currently, he is Site Manager for the Água Vermelha hydropower plant near Fernandópolis in Brazil – the latest in a series of service roles he’s held at Voith. “Living in Fernandópolis is great. Peo-

ple here are very helpful and polite,” remarks Andreia. Along with Gabriel and the family dog, Max, Andreia has been Eric’s companion at each project he has carried out for Voith. But things haven’t always been so easy. In a country as large and multicultural as Brazil (with more than 200 million inhabitants spread over 8.5 million square kilometers), Eric and his family have encountered an enormous variety of people, climates and environments at the sites of the many different hydropower projects he has worked on. Among these are “Cana Brava, Quebra Queixo, Jumirim, Corumbá

IV, Furnas, Baguari and Santo Antônio,” Eric recalls.

The family has now been based in Fernandópolis, in the southeast of Brazil, for nine months. Água Vermelha, where Eric works as Field Services Coordinator, is located on the Grande River, which traces the border between the states of São Paulo and Minas Gerais. The plant has been in service since 1978, and its six generating units have a total output of 1,396 MW. Eric, once a Voith customer, has worked for the company since 2002, when he came across an opportunity to join the “Field ▷



16:00

17:00

16:00 Checking up on a Voith automation panel inside the power plant.
17:00 Eric Junior inside the powerhouse of the Água Vermelha hydropower plant.

► Services family,” as the Field Services team is affectionately known.

Eric began working for Voith as a Commissioning Engineer. By his own account, this afforded him great technical and life experience. “In the Cana Brava project, I was incredibly excited when I got the chance to participate in the commissioning of a Voith machine for the first time.” The team, according to Eric, was small and got along very well. “The most challenging places elicit the best memories,” he remarks.

Eric arrives at Água Vermelha to begin his working day. A large Voith logo looms to the left. That’s the place where some 170 employees and suppliers work in various shifts in the areas of planning, quality, occupational safety, site management and technical services. They are responsible for the modernization of generators, turbines, hydromechanical components and their respective mechanical and electrical balance of plant systems.

As the saying goes in Portuguese, some people are like “a log of wood in a flood.” This expression is used to describe those people who constantly stop by to chat with everyone they pass. And that is a precise definition of Eric’s workday. As Voith’s Site Manager, he is both a role model and a person his em-

ployees trust. “The Field Services team needs to know that someone is listening to them, and they should be comfortable giving us their feedback. That is why I make a point to spend a great part of my day roaming around the site. There are always people who want to say something or who have questions, and I’m here to listen to them.” However, when he first started in his role, Eric noticed some colleagues were a bit uneasy. “They thought: ‘How can such a young person, with so few gray hairs, be taking up a coordination role?’” he jokes. But things have changed: Eric now has a few more gray hairs, as well as his team’s trust and admiration. “Both relationships with customers and with colleagues are based on trust. And for us, at Voith, trust is an attribute we never sacrifice. I usually say that the customer’s trust is a consequence of the outcome they get. Voith really delivers on its part, because we strive to meet that goal every single day.”

Eric aligns his work with the wider Voith customer strategy. “We want to be the number one option for the customer. In our field activities, we are absolutely focused on the project’s goals, as well as on our commitment to delivering a final product with the reliability for which the Voith name stands. We are always attentive in correctly identi-

fying our customer’s needs – as well as other opportunities to develop our products, regardless of whether we are focusing on speedier construction processes or solutions to render operation and maintenance easier.”

“Working in the field is to truly live the project, combining technical expertise and relationship skills to find solutions for challenges that arise,” says Eric. “What we experience in the field makes us understand that you never start a project knowing all that is going to happen. In the same way, we never finish a project knowing everything about it. There’s just too much to absorb. It’s an incomparable experience in life!”

At 6 p.m., the sun is setting as Eric says good-bye to his “family” at the site. “Here we are a team, playing for both the customer and Voith to come out as winners. We are responsible for understanding and addressing the customer’s expectations, as well as for ensuring that our projects yield the best possible return. In order to do that, we have to work together as a group, and that is why our success is a shared reward,” concludes Eric.

With that, Eric excuses himself for just a few more minutes to discuss service business with another colleague who has stopped him to chat. //



FROM SCREEN TO FABRIC

VOITH PAPER engineers have used computer simulation to develop new, highly effective dryer fabrics for the papermaking industry. In papermaking, the drying process depends on these fabrics, which transport the wet paper through the dryer section.

In studying the drying process via computer simulation, Voith Paper engineers have developed Evaporite and Evaporite^{High}, two better-performing dryer fabrics. These are more durable, with higher air permeability, resulting in more effective drying. Minimum thread crossing points make the fabric less likely to develop tiny holes and subsequently trap microscopic dirt particles – which can lead to decreased air permeability.

The first dryer fabrics from Voith Paper’s new CleanWeave product range have been developed for the production of paper packaging. CleanWeave technology has already proven in practice to significantly improve drying and machine efficiency compared with conventional dryer fabrics. Expansion of the range is planned, with fabrics for the production of all paper types in development. //



WORLD OF VOITH

A COOL SOLUTION

VOITH INDUSTRIAL SERVICES has helped the Shanghai-based branch of a German automotive manufacturer make significant cost and emissions savings with a transformation plan involving pumps, compressor stations and air conditioning systems in the customer’s Shanghai plant. In a logical yet innovative approach, water required to cool the plant’s machinery during operation is now chilled overnight and stored for production during the day: with energy prices at their lowest during the night time, this has led to significant savings. Furthermore, transforming frequency conversion control to the plant’s facilities at times of peak and off-peak demand has optimized energy and electricity allocation. Energy consumption data at the plant is monitored, and using this input, Voith can further help achieve optimal energy efficiency. Subsequently, the customer will save 2,843.6 tons of coal and about €200,000 in electricity costs annually. //

QUICK, RELIABLE, EFFICIENT

VOITH TURBO is delivering equipment for a hydropower plant in a cross-division cooperation. At Scottish pumped storage power plant Foyers, the two pump turbines have to run up to full power in less than 30 seconds: the only way to react flexibly and promptly to grid fluctuations and secure grid stability in Scotland. The water supply of each pump turbine is controlled by a spherical valve that must open at extremely short notice to ensure a quick change of operational mode. Two hydraulic cylinders drive the spherical valve as fluctuating power demands. Hydraulic power packs from Voith Turbo H + L Hydraulic supply the two hydraulic cylinders quickly, and – most of all – reliably, with the required oil power. The hydraulic power packs have redundant design and thus ensure extremely high

availability: should one of the function-relevant components fail, another component can take over the function without having to shut the system down. The hydraulic power packs are also highly energy efficient, need little installation space and require very low cooling outputs. The operator thus benefits from low operating costs. //



PUSHING THE LIMITS

Freediver Herbert Nitsch dives to great depths – without an oxygen tank.

Breathe in deeply. Hold it. See if you can continue to hold it for nine minutes. For most, not breathing for this amount of time would simply be impossible. But for Herbert Nitsch, it's entirely achievable. Nine minutes (and four seconds, to be precise) is his personal record for static apnea – that is, holding a single breath underwater.

But this breathtaking personal best is a modest achievement compared with the other feats of which Nitsch has proven himself capable. More than a decade of involvement in the sport of freediving has seen the former pilot hold over 30 world records in all eight recognized freediving disciplines.

Freediving is the sport – perhaps art – of diving underwater for extended periods of time without a breathing apparatus, sustained only by the last breath you took before descending into the deep blue.

However, it's not as simple as taking a huge, gasping breath and plunging below the surface. Nitsch explains how he prepares to go underwater: "It helps to try to relax every muscle, and be in a very calm, almost sleep-like state," he says. "I try to take more air in my lungs by 'packing.' This is a technique whereby the epiglottis acts as a piston to push more air in the lungs." With this technique, Nitsch can expand his own lung capacity from an already amazing 10 liters to an impressive 15



- 1 Herbert Nitsch descends into the blue, aided by a guiding wire – and his supporters on the surface.
- 2 When freediving, preparation is everything.

“The mind is amazing in stimulating the body to go beyond limits you first believed were impossible.”

Herbert Nitsch, freediver

liters. Compare this with the lung capacity of the average adult male, which is six liters. This technique, paired with special training to stretch the diaphragm and lungs, helps to make the lungs more flexible so they can expand to hold more air, and compress more from pressure at depth, thus enabling his incredible breath-holding times.

For someone who has earned such accolades in an ocean-based sport, it's surprising to learn that Nitsch is self-trained, and hails from a landlocked country: Austria. To suit his circumstances, says Nitsch, "I figured I needed a different and more efficient approach to training. Where some other elite freedivers had the advantage of training regularly in the ocean, I came up with a combination of breath-hold training on the couch at home, combined with cardio and muscular training." When competing, Nitsch arrives early and goes "spearfishing and fun freediving" in the sea to prepare.

Since 2010, Nitsch has focused solely on the extreme "No Limit" freediving discipline. In No Limit dives, freedivers use a weighted sled to descend as far as they possibly can on a single breath. An air-filled balloon aids their return to the surface. Nitsch holds the current No Limit world record: an astonishing 214 meters, for which he was dubbed "The Deepest Man on Earth." His focus on No Limit diving illuminates a single-minded determination: his ultimate goal of diving to 1,000 feet (304.8 meters).

On 14 June 2012, when attempting to reach this goal, Nitsch almost didn't emerge from the blue. A blackout in the depths led to his suffering a severe form of decompression sickness, known as Type II DCS. That day, Nitsch reached 253.2 meters (830.8 feet). However, because the accident forced him to abort the dive, his record attempt was not officially recognized. His existing record still stands, yet to be equaled or broken. Following a hard-won recovery,

Nitsch is now back to freediving, which he says "feels like finally being back in the real world" again. To another attempt at his 1,000-foot goal, Nitsch takes a "never say never" approach – which implies that he will try again.

In the moment when he is plunging down, his lungs demanding oxygen and all his human instincts inclined to agree, Nitsch needs to take control and harness all his energy for the dive. "I focus on the important things of the moment, and I try not to think about anything else. I tune out any bodily sensations and use my energy solely to concentrate on the essentials."

Fittingly, preserving resources is second nature to Nitsch. Without his extraordinary ability to do so, he couldn't perform in his sport the way he does. This belief extends beyond his own physical resources: Nitsch is a proud ocean conservationist, holding an advisory role with the Sea Shepherd Conservation Society. This environmental consciousness carries over into his everyday life in landlocked Austria: "I decided to get rid of the car, and I bike everywhere in my home town of Vienna. And, I am currently in the process of designing a fast ocean-going eco-sailing boat that uses wind and solar power only, without a combustion engine."

It's another remarkable pursuit from a man who refuses to treat apparent limits as insurmountable. "Freediving taught me that as long as you keep believing things are possible, they are. The body is amazing in what it can do, and the mind is amazing in stimulating the body to go beyond limits you first believed were impossible." //



For videos and more on freediver Herbert Nitsch, visit www.herbertnitsch.com

BALANCED ENERGY

Responsive, flexible, capable: **Voith Hydro CEO Dr. Roland Münch** on the power and potential of pumped storage.

Dr. Münch, have you ever gotten stuck in an elevator during a blackout?

Traveling frequently to visit our Operating Units worldwide, I've experienced a few power outages, but fortunately never in an elevator. However, that's an interesting point: blackouts are occurring increasingly – and most commonly – in those countries where energy generation and consumption are not consistent, and especially where peak demand is not being covered permanently. Hydropower – and pumped storage in particular – is very capable of contributing to a solution to these problems, as it can stabilize the grid and cushion peak demands.

How can hydropower stabilize power grids or even prevent blackouts?

Hydropower is the only renewable energy that meets base load requirements, so it plays a key role in providing a stable and reliable power supply. Pumped storage plants make a particularly important contribution: they can cover peak demand by providing large amounts of energy, reacting very flexibly and within a short time. And they offer a variety of ancillary services to the grid to support reliable supply. This is especially important for power grids that are increasingly fed with electricity from fluctuating renewable sources like wind and solar.

Can you describe these services in more detail?

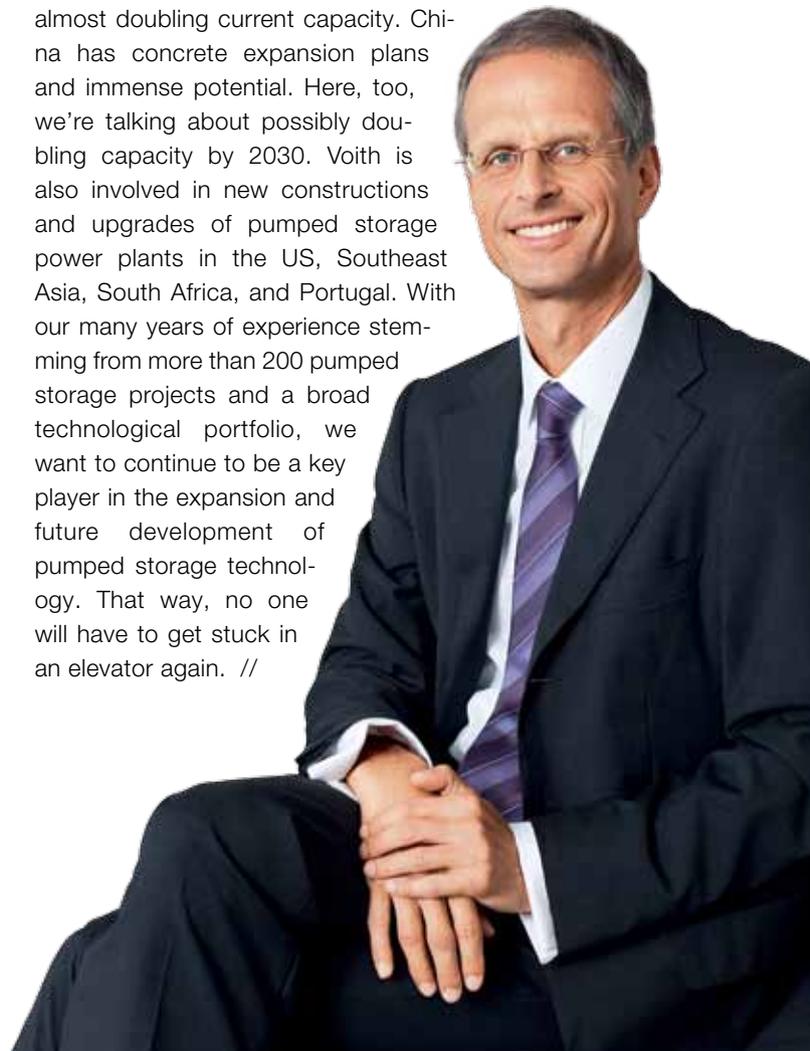
Ancillary services support the transmission of capacity and energy from generation resources to consumers and maintain the reliable operation of the transmission system. This includes regulation services like balancing grid frequency, as well as voltage support. Pumped storage plants can provide all types of balanced energy for frequency-maintaining purposes. They are exceptionally well suited to providing reactive power in a flexible way, to keep voltage at a proper level, and they are black-start capable. That means that after a blackout, they can be restarted without having to rely on the power grid – thus restoring the power supply. If I ever do get stuck in an elevator, I will count on pumped storage power to get that elevator moving again.

Based on that: does pumped storage play a major role in the expansion of renewable energies?

Pumped storage plants can essentially contribute to converting the power supply network. They achieve this both with the services they offer to the energy system, and via their basic function: high-efficiency energy storage facilities storing excess electricity from renewable energies and feeding it back into the grid when needed. Pumped storage technology is the only cost-effective method that has proven itself over the long term to store energy on a large scale and make it available on short notice. And to top it off, it has a very high efficiency level of 80% or more.

Is there sufficient potential for new pumped storage power plants?

Yes. Potential implementation exists worldwide. A study initiated by Voith focusing on Germany's "Energiewende" (the transition to renewable energy sources) shows that in this country alone, all planned pumped storage projects can expand capacity by about 8,000 MW – thereby almost doubling current capacity. China has concrete expansion plans and immense potential. Here, too, we're talking about possibly doubling capacity by 2030. Voith is also involved in new constructions and upgrades of pumped storage power plants in the US, Southeast Asia, South Africa, and Portugal. With our many years of experience stemming from more than 200 pumped storage projects and a broad technological portfolio, we want to continue to be a key player in the expansion and future development of pumped storage technology. That way, no one will have to get stuck in an elevator again. //



PROJECT DIRECTORY

All projects mentioned in this issue of HyPower and Voith's scope of supply



EUROPE AND AFRICA

Hydropower potential in Europe: 873 GW
 Installed capacity: 247 GW (30%)
 Hydropower potential in Africa: 435 GW
 Installed capacity: 26 GW (6%)

- 1 Ifezheim, Germany:** Service contract for maintenance and repair, including the refurbishment of all non-moving parts of one of the four 28.3 MW bulb turbines.
- 2 Hochstadt, Germany:** AMB contract for Kaplan-A bulb turbine overhaul, including repair-welding of blades, leveling of runner chamber, wicket gate overhaul and rebuilding of main turbine guide bearing.
- 3 Reisseck II, Austria:** Supply of two reversible pump-turbines, each with an output of 215 MW, and governors.
- 4 Tröpolach, Austria:** Supply of two small hydro turbines working in tandem with a combined capacity of 7.9 MW.
- 5 Frades II, Portugal:** Complete electro-mechanical equipment, including two 390 MW variable-speed reversible pump turbines and two asynchronous motor-generators.
- 6 Ingula, South Africa:** Four motor-generators and 342 MW pump-turbines,



ASIA PACIFIC

Hydropower potential in Asia Pacific: 1,754 GW
 Installed capacity: 420 GW (24%)

- automation systems, electrical and mechanical balance-of-plant equipment.
- 7 Hong Ping, China:** Four complete 300 MW pumped storage units, including generators and reversible Francis pump-turbines, governors, inlet valves, and excitation, automation and auxiliary systems.
- 8 Bhira, India:** Service project covering design, upgrade, manufacturing, supply, erecting and commissioning of a new stator for the 200 MVA motor-generator.



THE AMERICAS

Hydropower potential in North America: 388 GW
 Installed capacity: 155 GW (40%)
 Hydropower potential in South America: 904 GW
 Installed capacity: 162 GW (18%)

- 9 Lam Ta Khong, Thailand:** Supply of two 255 MW vertical pump-turbines, motor-generators, automation systems, electrical and mechanical balance-of-plant equipment.
- 10 Pointe du Bois, Canada:** Service contract for maintenance and repair works on several turbines in the 75 MW plant.
- 11 Smith Mountain, USA:** Rehabilitation project for generators at the plant, including rewinding works, stator coil supply and rotor rim shrink.
- 12 Água Vermelha, Brazil:** Modernization of six units with a total capacity of 1,396 MW, including a complete overhaul of generators and turbines, associated electro-mechanical systems and the renewal of many components.
- 13 Chavantes, Brazil:** Modernization of three generating units, including turbines, generators and associated electromechanical systems in the 414 MW plant.

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