

**VOITH**

MAGAZINE FOR HYDROPOWER TECHNOLOGY

# HyPower

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HYDROPOWER IN AFRICA

## HIGH POTENTIAL

SUCCESSFUL PARTNERSHIPS

REPLACE OR REFURBISH?

FULL LINE SUPPLIER

WHY SMALL HYDRO IS BIG NEWS

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## UNLOCKING POWERFUL POTENTIAL

**Diversity. Complexity. Potential.** Three words that sum up Africa pretty well in many different contexts – geographical, political, economic and social. They also apply to Africa's energy-generation infrastructure. While some African countries have plentiful oil and gas reserves, some have none. Some can rely on hydropower for nearly all their power requirements, some need to import almost all their electricity from outside their borders. And even if the resources exist, building an infrastructure that delivers power to homes and businesses reliably is another challenge altogether – especially in countries that have been ravaged by recent or current conflicts.

As a result, there is one reality that applies to some areas of every African country: electricity supply is nowhere near sufficient to meet demand. In fact, even in 2016, around three-quarters of the African population do not have access to reliable, constant power. From a hydropower perspective, Voith is at the forefront of efforts to change this.

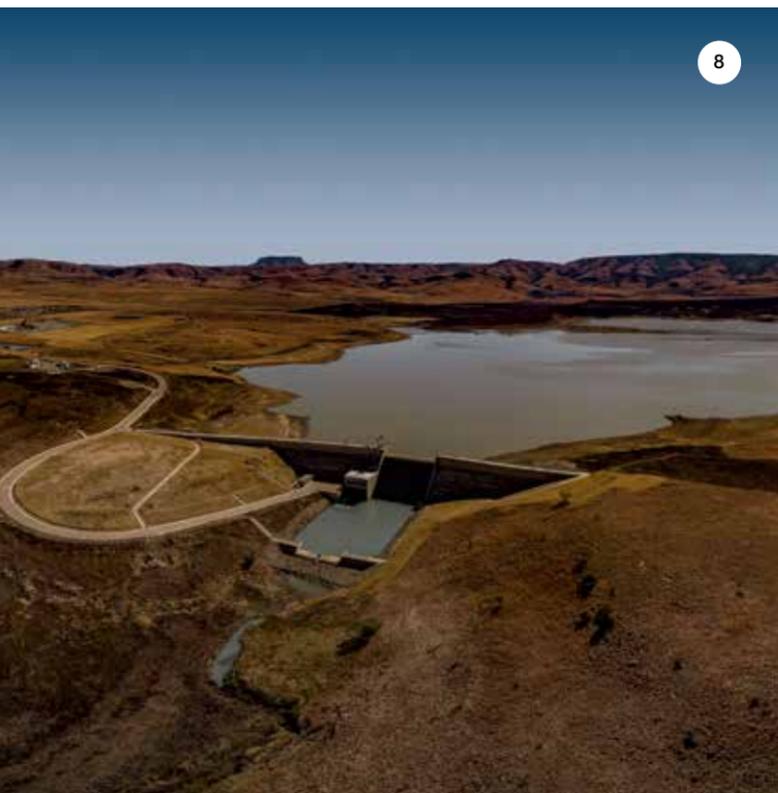
To harness Africa's hydropower potential, financing flexibility, expertise and commitment are all essential. Voith has all three in abun-

dance. We work closely with leading financial institutions and insurers to help our African customers spread the cost of building or rehabilitating hydropower facilities over realistic time frames. Our experts in Heidenheim and across the world are ready and willing, not only to manufacture the equipment required, but to spend weeks and months on site, working closely with customers to transfer knowledge, build skills and ensure that once a plant is completed, it can be run effectively by local people. We are also investing in improving our local servicing capabilities to permanently improve service for our customers.

This new edition of HyPower showcases how customers and communities in Africa and elsewhere are benefiting from maximizing their hydropower potential, and leveraging the newest technologies to do so. Enjoy!

Yours sincerely,

Uwe Wehnardt  
President and CEO of Voith Hydro



8



26



39



Discover more about Voith through its other insightful publications.

AGENDA SETTING

- 8 **ENERGIZING AFRICA**  
How significant hydropower projects in South Africa and Angola are transforming economies and lives.
- 16 **MANAGEMENT INTERVIEW**  
Voith Hydro's CMO and African sales leader discuss the potential of hydropower in Africa.
- 19 **MODERNIZING MOUNT COFFEE**  
How Liberia's hydropower infrastructure is being rebuilt to support rapid economic development.
- 24 **GLOBAL TRAINING, LOCAL BENEFITS**  
All over the world, Voith Hydro is delivering training concepts that meet the needs of individual customers.

FULL LINE SUPPLIER

- 26 **SMALL PROJECTS, BIG RESULTS**  
In Asia, a larger number of smaller hydropower projects could be the key to improving rural power availability.
- 28 **MEETING THE LARGE HYDRO CHALLENGE**  
Hydropower projects so large that they can take almost a decade to complete require a special set of skills for success.

FROM THE ARCHIVES

- 30 **TRUE SURVIVOR**  
The rollercoaster history of the Cahora Bassa hydropower plant in Mozambique.

GLOBAL EXPERTISE

- 32 **STOPPING THE FLOW**  
How an electronic control mechanism for ring gates has set new standards in precision.
- 34 **SERVICING AFRICA**  
When it comes to maintenance, it's always better to have local resources on hand. Voith Hydro is investing in developing local African expertise.

SUCCESSFUL PARTNERSHIPS

- 35 **24/7 MOBILE SERVICE**  
In Europe, the Voith HyService Bus is ready to leap into action whenever customers need it.
- 36 **THE POWER TO CHANGE LIVES**  
How a convent in Tanzania and the community it serves are benefitting from Small Hydro.

- 39 **THE BIG QUESTION: REPLACE OR REFURBISH?**  
Why it can pay dividends to overhaul old hydropower equipment, rather than retire it.

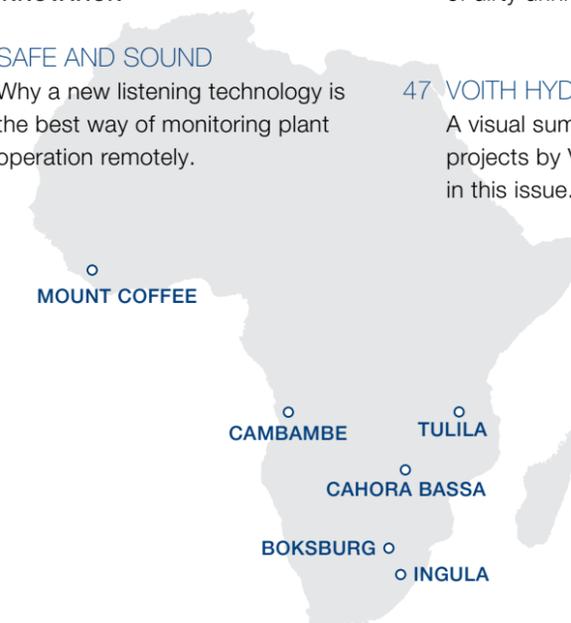
INNOVATION

- 42 **SAFE AND SOUND**  
Why a new listening technology is the best way of monitoring plant operation remotely.

GUEST PERSPECTIVE

- 44 **CREATING THE SAFE WATER BOOK™**  
An exciting water filtering innovation could solve the problem of dirty drinking water for millions.

- 47 **VOITH HYDRO PROJECTS**  
A visual summary of hydropower projects by Voith in Africa explored in this issue.



REGULARS

- 03 EDITORIAL
- 06 WHAT'S NEW
- 07 ON TOPIC
- 43 WORLD OF VOITH
- 46 5 QUESTIONS FOR ...

## VOITH AT HYDROVISION 2016

**USA** The StreamDiver was the focus of a presentation delivered at the recent 2016 HydroVision International event in Minneapolis, Minnesota. Presenter Philip Daus, a Small Hydro engineering project manager at Voith Hydro, said, "Hydropower is among the best solutions to energy market challenges, and we are using our technology and expertise to achieve the best outcomes in economy and performance, both technically and environmentally."

Other important Voith innovation papers presented at the event covered: a rotor rim slot reshaping process for increasing generator longevity; a new analysis and replacement process for damaged turbine thrust collars, which improves monitoring, maintenance and repair; a new forecasting method to increase accuracy and improve short-time pumped-storage balancing; and an overview of improved online assessment processes for hydro-components.



1 Voith exhibition booth.  
2 Customer event banquet.  
3 Bob Gallo, Bill Malus and Martin Andra at HydroVision 2016.



Klaus Schädler, Voith, at groundbreaking ceremony.

## BREAKING NEW GROUND

**GERMANY** One of the most exciting innovations being introduced at Voith Hydro in 2016 is the construction of a small hydropower plant (called 'Alte Bleiche') at the Heidenheim site, to act as a demonstration facility for customers, employees and the public. The 35 kW plant will also feed electricity directly into the local grid – enough to power 100 homes. Construction work started with a groundbreaking ceremony in April, and the plant should be operational by year end.

Voith apprentices are involved in the design and manufacturing, and are working to an eco-friendly design – created in cooperation with the Technical University of Munich – that eliminates the need for a new powerhouse. The plant will feature Voith's new StreamDiver generator unit, recently showcased at a series of roadshows across Latin America. StreamDiver is designed for low-head river plants and deployed underwater, eliminating noise emissions, minimizing local environmental impact and making small hydro-power plants more cost-effective.

## MORE POWER FOR UGANDA

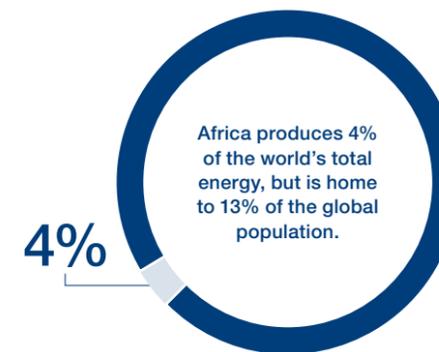
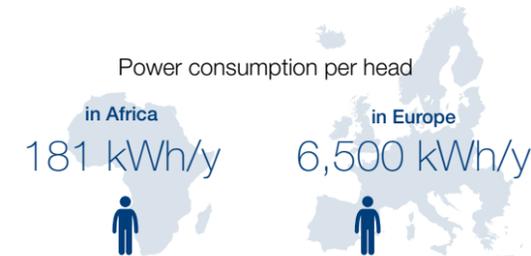
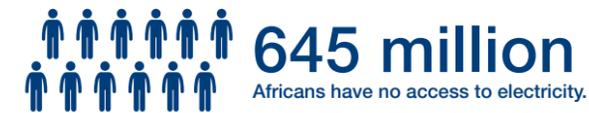
**UGANDA** Voith Hydro has been awarded a contract for the complete design, manufacturing, supply, installation and commissioning of the electromechanical equipment for the new hydropower plant on the Achwa River in northern Uganda. The plant features four vertical Francis turbines and vertical synchronous generators with an installed capacity of 42 MW. The project will involve close collaboration between Voith, M/s

Berkeley Energy and customer ARPE Ltd. Commenting on the project, Head of Voith Hydro's Small Hydro Business Klaus Schädler said, "We are happy to be part of the project that supports reliable power production and sustainable economic development in the region. We look forward to putting our ideas into practice, and to foster our collaboration for renewable energy in Uganda."

# DRIVING DEVELOPMENT

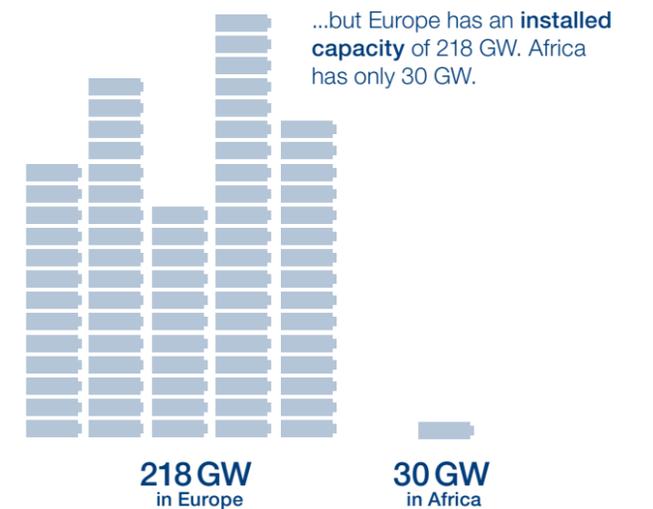
In many parts of Africa, the lack of a reliable electricity infrastructure hinders economic development. **Hydropower can play a big part in changing this picture.**

### 1 Power is patchy



Frequent power outages are the norm in **30 African countries.**

### 2 Hydropower potential is enormous



# ENERGIZING AFRICA

Successful installations at Ingula in South Africa and Cambambe in Angola **illustrate how hydropower is transforming** economies and lives across Africa.

**A** reliable electricity supply brings light and heat (or relief from it) to homes and businesses, powers machinery, and enables hospitals and schools to function effectively. In a continent as large as Africa, with many countries and political regimes, dispersed populations, variable transport infrastructure and a wide range of climates and terrains, generating and distributing power effectively is a challenge.

#### Voith Hydro in Africa

Voith Hydro supports many African nations in making the most of their hydropower generation potential with a wide range of small and large projects in >



Hydropower in Ingula  
Installed capacity: 1,368 MW

Bramhoek Dam (lower dam) in winter.

A view of the reservoir from the pumped storage plant at Ingula in South Africa.

▷ 27 countries. Even so, less than 10% of Africa’s potential hydropower generation capacity of an estimated 400 GW has been exploited to date. Together with its customers, Voith is addressing this opportunity through: new state-of-the-art plants; the repair, maintenance and servicing of existing infrastructure; and the transfer of knowledge to support African countries in running their hydropower facilities self-sufficiently. Two projects in particular, at Ingula in South Africa, and Cambambe in Angola, illustrate the benefits perfectly.

**Ingula pumped storage plant, South Africa**

Situated in the hills of KwaZulu-Natal in eastern South Africa near the town of Ladysmith, the pumped storage plant at Ingula is the largest of its kind in Africa. Its four underground pump turbines have a total installed capacity of 1,368 MW. Following the tender process launched by South African state energy company Eskom in 2007, Voith Hydro was awarded the contract for the provision of the pump turbines, motor generators, the main inlet valve, and key systems in September 2008, some 30 years after the government first started planning the project. And it has a key role to play in South Africa’s energy supply, as project manager Markus Müller explains: “Like most countries on the continent, South Africa suffers from energy shortages which hamper its economic growth. Ingula is particularly important because it will begin making its contribution to the county’s power grid in 2016.”

Site activities began in March 2012 and Voith’s international operations collaborated to deliver the required machinery. While the turbines were designed by Voith Hydro in Germany, the motor generators were supplied by Voith



1



2



3

- 1 Intake structure at Bedford Dam (upper dam).
- 2 An operator adjusts the oil filtration system.
- 3 Machine Hall Unit 1 and 2 side, installation of machine hall ceiling.

“The project has involved employing and training local staff to run the plant once it is completed, which is a key part of the service we provide.”

**Markus Müller**  
Voith Hydro Project Manager for Ingula

Fuji in Japan. The first of the four turbines was handed over to the customer in mid-June 2016. The next two turbines were due for handover in August, and the last by the end of 2016.

**Keeping the plant cool**

In parallel, Voith has fulfilled the terms of a second contract, awarded in 2011, for various supplementary systems including cooling water pipes, fire protection, fire prevention and an air ventilation system for the plant. The latter is particularly important, as Markus Müller explains: “Once they are fully operational, the four turbines will generate a lot of heat, and because they are underground, that heat has nowhere to go if there is no system in place to remove it. We are installing the system, but it will take longer to complete because the four turbines have to be running before it can be fully tested.”

**Customer and community benefits**

Now that the project is nearing completion, Müller can reflect on its success, and the fact that it has delivered many benefits beyond pure power production,

as he explains: “The project has involved employing and training local staff to run the plant once it is completed, which is a key part of the service we provide. Another important element was our participation in the Accelerated and Shared Growth Initiative for South Africa (AsgiSA). This program is designed to ensure foreign firms invest to help grow the local economy by sourcing products and services from local providers. In addition, we oversaw the construction of new infrastructure, such as good quality roads that enabled us to transport materials and people from Durban harbor to the plant site.” Not only that, the area surrounding the site, which includes sensitive wetlands and which has been used to house the people working on the project, will be returned to its original state as part of the project.

Nevertheless, power generation is of course the ultimate goal and here, Müller has one final unique detail to add. “What is very special about the Ingula site is that all the machines have already been producing energy before handover in parallel with the commissioning. As the demand for power in South Africa ▷

▷ is so great, that this was a key requirement from our customer Eskom. It's highly unusual, but I'm delighted that we have been able to meet the customer's needs."

**Cambambe I and II, Angola**

The contrast between the Ingola project and the Cambambe I and II sites in Angola couldn't be bigger. In the mid-2000s, following three decades of civil war, the existing Cambambe I hydro-power plant, located 180 kilometers east of Luanda and originally commissioned in 1963, was in urgent need of rehabilitation. Although two of the original four turbine units were still operating, one was being overhauled, and one wasn't working at all. The decision was taken to replace all four, in order to increase power generation capacity to 268 MW,

and extend the life of the plant for decades. The state-owned electricity supplier ENE selected Voith as a key player in an international consortium to take on the project. Voith's remit: to supply the electromechanical equipment and systems, including four 67 MW Francis turbines and all the required dismantling of old equipment and new installations.

**Modern technology for maximum performance**

To ensure the best possible results, the decision was taken to design a state-of-the-art hydraulic system for the Francis turbines, combined with digital and hydraulics governors from Voith. To ensure the local area could be supplied with electricity throughout construction, the turbines were installed sequentially. Combined with the control package featuring the digital governor, oil supply and pumping groups, pressure tanks, main oil supply valves, regulating valves and hydraulic elements, Voith was able to prove the value of its status as full line supplier beyond any doubt. And when the new plant equipment became operational – with an even higher performance than was contracted – the customer was delighted. So delighted in fact, that in 2012, they commissioned Voith to supply equipment for the Cambambe II project.

**Expansion that will transform a country**

Despite the advances that have been made since the end of the civil war in 2002, Angola still faces huge political, economic and social challenges, as Project Manager Patric Kiehlmann has learnt: "Angola is rich in natural sources, including oil, but the recent lull in oil prices has had a big impact on the economy – the government's income has fallen by 50%. Private enterprise is very limited, and healthcare is very poor. Economic development, and the jobs and increase in living standards it brings, are needed urgently. That's why Cam-

bambe II is so important for the future of the country." The new run-of-river plant with an additional four turbines adds 700 MW of installed capacity, bringing the sum total of capacity of Cambambe I and II to 960 MW. As such, it is a key part of the Angolan's strategy to increase power production capacity to 6,000 MW by 2017.

**Tailored financing package and training**

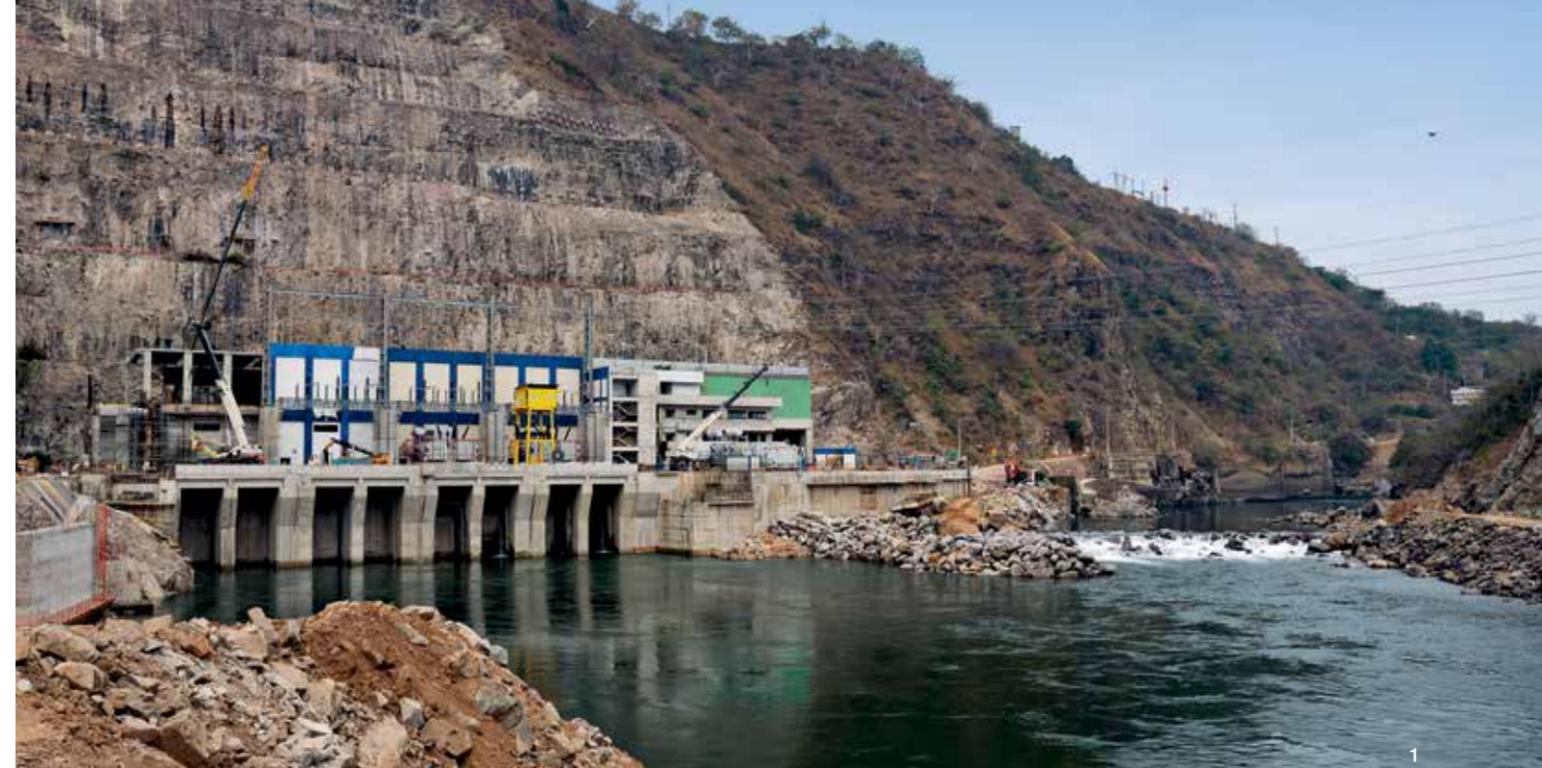
Speaking about the reasons behind the selection of Voith as the key supplier, Kiehlmann comments, "Our one face to the customer strategy, and the excellent relationship we had built with ENE during the Cambambe I project were key factors. An attractive, tailored financing package and the soundness of our technological approach and fulfill-

ment of our commitments were also extremely important." The first unit was commissioned at Cambambe II in July 2016, despite an extremely tough timeline, and the plant with all four units is foreseen to be fully commissioned in December 2016. As the client says: "From the day Unit 1 started commercial operation, the power cuts in Luanda disappeared. This led to a considerable improvement of the ecological balance due to the reduction of the use of diesel generators." ▷

**"Our one face to the customer strategy, as well as a tailored financing package, were extremely important to becoming the key supplier."**

**Patric Kiehlmann**  
Voith Hydro Project Manager for Cambambe

Workers measure a generator pit in the powerhouse of Cambambe II.



- 1 The Cambambe II powerhouse under construction.
- 2 A new generator being installed.



▷ Just like the Ingula plant, the project is very much an international affair, with the generator being supplied from Sweden, including a four-part stator that was put together on site. And just like Ingula, the project has had its fair share of challenges to overcome. Kiehlmann says, “Importing the materials alone took three months, ensuring they were able to handle the tropical conditions, and the bureaucracy involved in organizing visas for expat employees presented tough challenges. But together with the customer, we overcame these.”

The extension of the Cambambe site is vital for the future of Angola. The construction phase is providing much needed jobs and training and a permanent

“The reliable and stable supply of energy to the population and industrial sector is a fundamental prerequisite for improving living standards. Renewable energy is crucial for us.”

Ellen Johnson Sirleaf  
President of Liberia

the population. The even better news is that this will likely not be the end of the story. Angola has the potential to generate up to 18 GW of hydroelectric power, most of which remains untapped.

**High-level political engagement**

In recent years, several high-level delegations from Ethiopia, Liberia and other nations have visited Voith in Heidenheim to learn about relevant technologies and best practices. On her visit to Germany in 2015, Liberian President and Nobel Peace Prize winner Ellen Johnson Sirleaf commented, “For Liberia as well as many other African countries, the issue of energy supply is an essential item in the national growth strategy. The reliable and stable supply of energy to the population and industrial sector is a fundamental prerequisite for improving living standards. Renewable energy is crucial for us.” Proof, if any were needed, that hydropower will play a key role in African economic development for many years to come. //

training center is also planned. As Kiehlmann emphasizes, “Our commitment to Angola is a long term one. Through training in particular, we will ensure that the benefits of the project are sustainable for decades to come.”

Despite all the challenges it has faced since the end of the civil war, economic growth in Angola has been strong – over 11% per year up until 2010. The Cambambe II plant will play a significant role in helping the country grow its economy just as rapidly in the future. But perhaps most importantly of all, it will also help improve the daily lives of



- 1 In the Cambambe II powerhouse: generator covers of the installed machines 1 and 2.
- 2 Installing a turbine shaft in Cambambe II.
- 3 Damjan Vucko, Head of Operations at Voith Hydro, at Cambambe II
- 4 Installing the intermediate shaft at Cambambe II with view of the thrust bearing and distributor underneath.



FINANCING PROGRESS

Hydropower plants such as the ones at Ingula and Cambambe are a capital-intensive investment. Financial solutions ease the immediate financial burden by spreading the cost over a long period – especially in developing economies. Voith's Financial Services subsidiary creates tailored financing concepts in cooperation with private commercial banks and state-backed export credit insurers, which are usually based in the home country of the project's main supplier. Indeed, Long-term excellent relationships and cooperations with Euler Hermes Kreditversicherungs AG in Germany, the Oesterreichische Kontrollbank AG in Austria, and the Nippon Export and Investment Insurance company in Japan, among others, are the basis for this successful financing support.

Bernd Rieck, Head of Export and Project Finance, explains: “Our goal is to find the optimal financing solution for every customer that wants to use Voith as a supplier. Every concept is customized to specific customer needs, based on local variables, project details, the customer's financial situation, and the so-called Voith Sourcing Matrix, which analyzes the supply chain.”

**Customer benefits**

- Additional financing sources.
- Long payback periods.
- Attractive financial conditions at advantageous interest rates.
- Planning security for financing across the complete project timeline.



Heike Bergmann and Martin Andrä in discussion.

# OPPORTUNITY KNOCKS

**Voith is investing in its sales programs in Africa.** Martin Andrä, Chief Marketing Officer, and Heike Bergmann, Senior Vice President Sales Africa, discuss Voith Hydro's future strategy across the continent.

“We are developing our new Africa concept because we are positive that the African continent has tremendous development potential.”

**Heike Bergmann**  
Senior Vice President Sales Africa

**How did a renewed push to develop sales in the African market become part of your agenda?**

**Martin Andrä:** We are implementing this new strategic drive because we are convinced that Africa has very good future prospects and we need to tap into these opportunities. In Sub-Saharan Africa, many countries have economic growth rates of five percent and higher. These countries need to be supplied with reliable power so they can further pursue their social and economic development.

**Heike Bergmann:** I want to re-emphasize that. We are developing our new Africa concept because we are positive that the African continent has tremendous development potential. One also has to consider that in some African countries, only 20 to 25 percent of the population has access to electricity, and power outages occur on a regular basis. The latter presents an impediment to all industrial companies and thus also to economic development.

**Can you give us a rough estimate of the demand for power plants?**

**Andrä:** There is a huge demand for new

power plants. The following comparison illustrates what we are talking about. The hydroelectric capacity currently installed on the entire continent is equivalent to the installed capacity of Norway. However, we think another aspect is also interesting: In Africa, we are seeing a trend in which countries skip over the fossil fuel-based and nuclear power generation phases that are typical of the industrialization process, and enter directly into electricity production from renewable energy sources. The opportunities to make that happen are in place. Right now, Africa's untapped potential for hydroelectric power plants amounts to between 300 and 400 Gigawatts.

**Does Voith have anything to offer to this market?**

**Bergmann:** Yes, absolutely. On my delegation visits, I keep seeing that power plants built in Africa by European companies are held in high regard. European technology can serve as the backbone of the African economy, and that includes Voith, whose hydropower technology has been used on the continent for about 100 years. Africans value the quality and longevity of our prod-



**Heike Bergmann,**  
Senior Vice President Sales Africa,  
Voith Hydro



Martin Andrä,  
Chief Marketing Officer, Voith Hydro

“To win projects in Africa, it’s important to offer financing solutions.”

Martin Andrä  
Chief Marketing Officer

ucts. They want our technology, but need support in financing it.

**What does that mean for a technology supplier?**

**Andrä:** To win projects in Africa, it’s important to offer financing concepts and solutions. One of Voith’s advantages that benefits our customers is that we can offer tailored financing solutions for projects. That’s why we work with private commercial banks and governmental export credit insurance companies throughout the world.

**Where can one find Voith Hydro technology in Africa?**

**Bergmann:** There is a long list of African hydropower stations equipped with Voith technology. Installations extend from Aswan in Egypt to Drakensberg in South Africa. For example, Voith technology is installed at Gilgel Gibe (Ethiopia), Inga (Democratic Republic of Congo), and Cahora Bassa (Mozambique). New projects include those at Cambambe (Angola), Mount Coffee (Liberia), and the pumped storage power station in Ingula (South Africa), to name just a

few. Our footprint literally extends over the entire continent.

**What do you attribute that to?**

**Bergmann:** It’s based on the excellent quality of our products and services, as well as the fact that we keep working with our customers after a plant is commissioned. We provide extensive training for power plant operators and we have our own network consisting of maintenance facilities.

**Andrä:** We have always offered training programs and courses with our plants, and that has helped us establish a very good reputation in Africa. Now, we want to use our new concept to generate added value for customers by providing solutions customized to their respective needs. We have a global network and are able to combine system components from Europe, Brazil, India, and China with corresponding financing solutions. In this way, we can create the right package of technology, training, service, and financing for any operator, regardless of their location and the size of the hydropower station. //



# MODERNIZING MOUNT COFFEE

A significant hydropower plant modernization project is helping to **improve Liberia’s power infrastructure** following years of civil war.

Dam wall under construction on the Saint Paul River, with the powerhouse on the right.

The digital age is finally reaching Liberia’s Mount Coffee hydropower plant, thanks to Voith and its pivotal role in this historic project, together with other international companies. Built in the 1960s, this plant on the Saint Paul River was the West African nation’s largest at the time, but sustained extensive damage during the civil war (1989–2003). And the path to ruin continued when looting ravaged the electrical and mechanical components, leaving only parts of the dam and the steel penstock intact. This proved to be a huge setback to the country’s economic and social progress, leaving Liberia’s capital city Monrovia reliant on costly, non-renewable diesel-power generation to meet its energy needs from 2006 onwards. ▶



- 1 Reservoir at the Mount Coffee hydropower plant in Liberia.
- 2 The local community will benefit significantly.
- 3 Installation work at the Mount Coffee powerhouse.
- 4 Julia Holder, Field Service Engineer, Voith Hydro.



The Mount Coffee site is situated near the Liberian capital, Monrovia.

▷ **Mutual trust is the prerequisite**

Trust in Voith's long-standing presence and vast experience on the African continent was key to its selection by the Liberian Electricity Corporation (LEC) to rehabilitate the run-of-river plant in 2013. Now, the huge task of successively installing four new Francis turbines and generators equipped with control technology, a 95-ton overhead crane, as well as the auxiliary electrical and mechanical plant equipment is nearing completion. The plant is scheduled to commence operations in late 2016.

Financed by the Liberian and Norwegian governments, the European Investment Bank, Germany's KfW Bank, and the Millennium Challenge Corporation of the US government, the modernized units are forecast to raise power output to 88 MW, a 33 percent increase on the plant's capacity in the 1960s. As a result, Monrovia's population of over one million will have access to reliable, clean and renewable energy.

**Overcoming significant challenges**

However, the path towards rehabilitation has had its fair share of obstacles, such as the condition of ten spillway gates that were destroyed during the civil war. The operating mechanisms to open the gates had been destroyed, leaving the powerhouse flooded. Keeping the powerhouse dry became imperative, and that meant reopening the gates so that a cofferdam could be built to prevent water flowing into the powerhouse. This daunting task was a major milestone in the reconstruction of the Mount Coffee power plant, says Project Manager Harry

“At the customer’s request, Voith took on the challenging task of opening the spillway gates without causing any damage to the civil structure and components. All ten gates were reopened ahead of schedule.”

**Harry Kathirvel**  
Project Manager Voith Hydro

Kathirvel: “At the customer’s request, Voith took on the challenging task of opening the spillway gates without causing any damage to the civil structure and components. All ten gates were reopened ahead of schedule.”

Poor road conditions between the site and the Port of Monrovia, which is about 25 kilometres away, posed a challenge to the transportation of sensitive equipment. Not only that, the heavy rain from April to October further disrupted operations. This meant that for certain plant systems, Voith had to commence with the design and manufacturing phases early enough to complete local transportation during the dry season. The thorough and detailed work plan that addressed all these challenges resulted in a flawless execution of the entire supply chain, without a hitch.

**Road survey and simulation run for powerhouse crane transportation**

One of the major hurdles that had to be factored in during the local transportation of the 95-ton powerhouse crane was a Bailey bridge. Given its rusty condition, doubts arose about its structural integrity, and whether the bridge could withstand such a heavy load. Furthermore, using an existing alternative bridge that was being renovated was out of the question. To prevent any risk to the powerhouse crane equipment, Voith carried out a thorough road survey and simulated transportation over the bridge using dummy cargo. Based on the simulation results, significant measures were implemented to ensure the bridge was up to the task.



**Acknowledgement by the President**

Voith's long working tradition in Africa dates back to the 1950s, a factor that helped build up trust at the start of the project. Together with the customer, LEC, a cohesive, vital, one-team approach has been adopted.

Moreover, not even unpredictable events such as the spread of the Ebola virus in 2014, and a high incidence of malaria in the team later on have thwarted the rehabilitation works, which are on schedule, as Franz Bayrle, Site Manager, explains: “This year, we have had 35 cases of malaria in my team alone. But work within the culturally diverse team who ▷

“Voith is supporting Liberia with an important step in the fight for the development of the Liberian economy.”

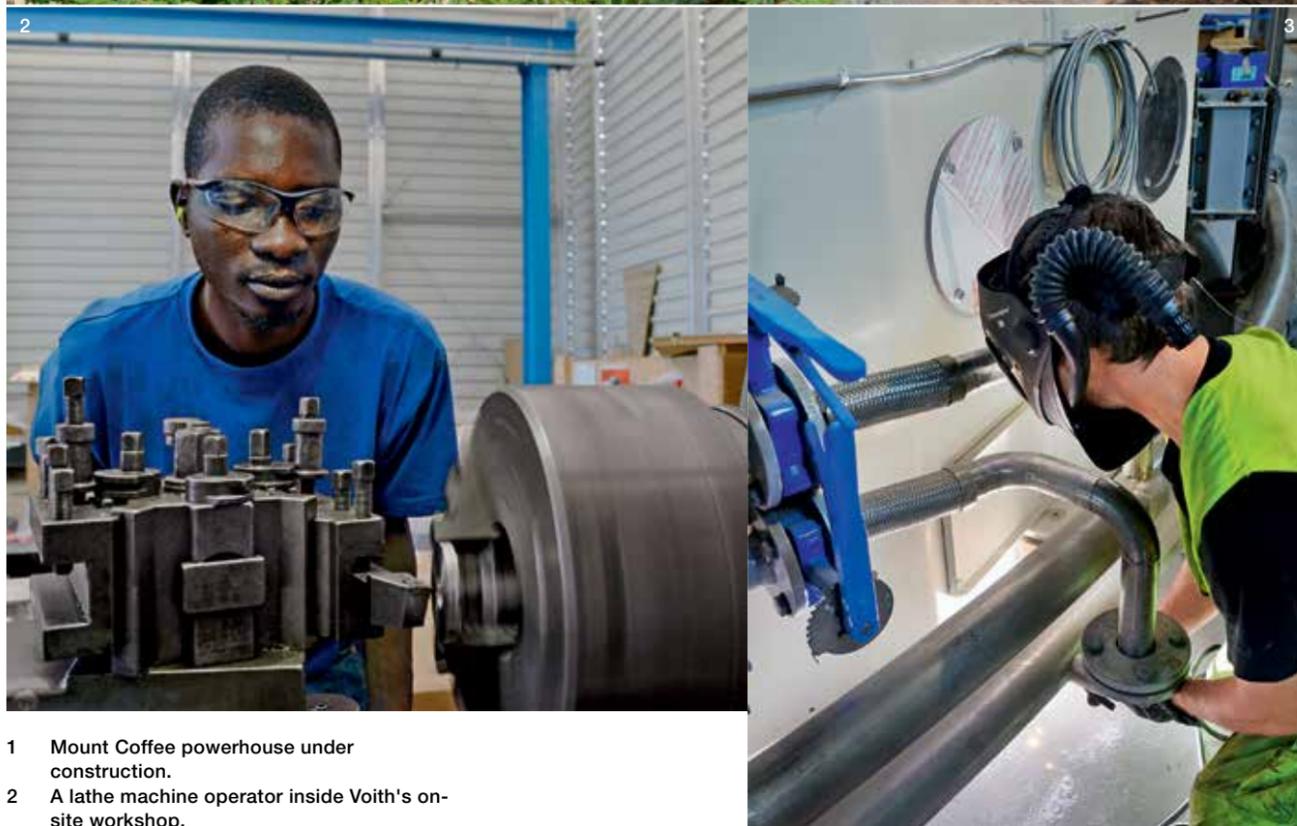
Ellen Johnson Sirleaf  
President of Liberia

▷ hail from Liberia, Pakistan, Indonesia, Germany, Norway and Sweden, is going well. I'm very pleased with them. They have all fitted well into the work schedule.” Their performance was even acknowledged by the President of Liberia, Ellen Johnson Sirleaf. When visiting the Voith headquarters in Heidenheim last year, President Sirleaf, who is also Liberia's Nobel Peace Laureate, said: “I am delighted that Voith and LEC have found a secure and pragmatic way for the further development of the project, despite the recently overcome Ebola epidemic. With this, Voith is supporting Liberia with an important step in the fight for the development of the Liberian economy and combating national poverty: with the repair of the Mount Coffee power plant, one of the key facilities in the Liberian energy supply network is being reconstructed.”

Another interesting aspect of the project is the contribution of the project's female engineers, in an industry where women are under-represented. Julia Holder, Field Service Engineer, comments, “There is definitely a collaborative working atmosphere at Mount Coffee, and all the staff are friendly and helpful. The fact that myself, two Norwegian engineers and many of the local staff are women is not really an issue. We have a good team spirit and always support each other.”

**The final steps to success**

On completion, the modernized plant will be fitted with Voith's automation system, including a digital governor and state-of-the-art control system. The training of skilled personnel is already underway and the first team of new LEC employees being trained for eventual operation and maintenance of the plant will arrive in Heidenheim in fall 2016 for further instruction. This is where they will become familiar with the design software, and gain in-depth exposure to the scope of the Mount Coffee plant, its machinery and workings, while the finishing touches are being applied to this mammoth project on site. Thanks to Voith and its project partners, it will fulfil President Sirleaf's mission to improve the reliability and scope of Liberia's electricity supply. //



- 1 Mount Coffee powerhouse under construction.
- 2 A lathe machine operator inside Voith's on-site workshop.
- 3 Final adjustments being made to the generator.

# CONTINUOUS COLLABORATION

GIZ supports the German government and other organizations in executing energy generation projects in Africa and around the world.

The energy department of the German Association for International Cooperation (GIZ) supports the German Federal Ministry for Economic Cooperation and Development and other organizations in identifying, financing and executing new energy generation projects in over 120 rapidly developing countries. Projects using renewable energy sources such as hydropower are very much in focus, as Jens Burgdorf, Head of Technology Cooperation for the Energy Sector at GIZ, explains.

**How have energy projects in developing countries changed in recent years?**

“Today, our clients want integrated energy generation concepts that are CO<sub>2</sub> neutral. That's a significant and very positive change but it also brings challenges. Specifically, power supplied from some renewable sources such as solar and wind power is unpredictable. If the sun doesn't shine, or the wind doesn't blow, power can't be produced.”

**How important is hydropower in this context?**

“Hydropower's advantage is that it is stable. Pumped storage plants are particularly important because they can store energy that can be used to fill the gaps when solar and wind resources fall short. In other words, hydropower can form a core, stable power supply that can then be extended through solar and wind-based power.”

**How does this relate to Africa in particular, and what are the challenges?**

“Hydropower is very significant in Africa because the continent is so large, and the grid infrastructure is so patchy, especially in rural areas. In every project, protecting and enhancing the livelihoods of the communities affected, and ensuring enough water is available for multiple purposes are paramount. We work closely with all the parties involved to ensure that.”

**What is the future for hydropower in Africa in your view?**

“Small, localized hydropower projects that bring energy to people outside the large population centers and which use existing infrastructure will play an important part because they minimize the capital investment required. They can also be completed faster, so people benefit from the power they generate more quickly.”

# GLOBAL TRAINING, LOCAL BENEFITS

Voith is committed to the **transfer of in-depth technological knowledge and skills to local employees**, thereby securing the successful operation of hydropower plants for generations to come – in Africa and around the world.

**With less than one in three** Africans having access to electricity, it's clear that there's an urgent need for efficient power plants across the continent. But even the most modern hydropower plants can't simply run themselves – they need teams of skilled people to manage and maintain them. That's why Voith provides training to the African companies and governments who own and operate the plants. Voith's HydroSchool contributes to the reliable production of electric-

ity in the long run, which is a decisive factor for economic and social development.

#### **Flexible approach to accelerate progress**

Every project is different – in Africa, as it is everywhere else. That's why the Voith HydroSchool offers a wide range of training options. Hydropower plant operators can order a selection of training modules as part of their installation or refurbishment project. Or Voith engi-

neers might notice signs of operational errors affecting the components they are replacing, and suggest some extra courses to get on-site engineers up to speed. In the case of a completely new plant designed and installed from scratch, Voith can offer more detailed and intensive training. This covers each technology, how it works and how it is integrated into the plant as a whole, then moves on to how to look after and maintain the components correctly. Many organizations opt for extra training to ensure they're getting the best value and most reliable service out of their installation.

#### **Market maturity levels define needs**

Aside from the technical aspects, Voith HydroSchool training is structured differently depending on market maturity. North America and Europe are mature markets, where refurbishment of very old plants is key, and where the impending retirement of baby-boomer engineers makes knowledge transfer important. These markets are served well with public courses where several customers attend the same course. The Chinese market is younger – with 25-year-old hydropower plants where the "original" engineers are still working and are actively training younger staff. Here, operators can book seminars for staff with Voith's subject experts to top up their knowledge. In contrast, Africa is a greenfield market with a lack of skilled engineers. "In these cases, our training program can ensure a skilled workforce," comments Cherie Ferrari, Manager of Customer Education and Training at Voith. "We often design completely customized courses tailored to the plant operator, staff, project and even the actual equipment in use."

#### **Mount Coffee: challenges overcome**

The Mount Coffee project in Liberia is a case in point. This hydropower plant, built in the 1960s, is located close to the



**Customer staff members in a training session at the Cambambe II hydropower plant, Angola.**

Liberian capital, Monrovia. However, it was damaged during the course of two civil wars. Liberia had been dependent on expensive diesel-generated power since 2006, and Voith was tasked with renovating the plant, which is due to be put into service at the end of 2016. Voith developed special courses that Liberian engineers will complete before the plant is commissioned, an aspect that proved to be of great interest to Liberian President Ellen Johnson Sirleaf and her energy minister, Patrick Sendolo, when they visited Voith headquarters in May 2015. "We're looking forward to welcoming Mount Coffee engineers to the HydroSchool training center in Heidenheim this fall," notes Cherie Ferrari. "This project is an excellent example of how reliable electrification

from hydropower in combination with skilled engineers on site can really strengthen the economic and social fabric of countries like Liberia."

#### **More African projects underway**

The Voith HydroSchool will also provide training services following the implementation of the Cambambe II project in Angola, and the Inga I installation in the Democratic Republic of the Congo. Cherie Ferrari adds: "Along with technical training, we can also deliver mentoring. At a recent pole replacement project in Mozambique, we simply 'shadowed' local engineers and helped them with some tips and tricks. That's the main point about the HydroSchool – training is always exactly what each individual customer needs. One size doesn't fit all!" //

# SMALL PROJECTS, BIG RESULTS

Small hydropower installations are **often the only practical and economic option** – but their impact can still be significant.

A coastal country on the Indochina Peninsula, Vietnam is one of Southeast Asia's fastest-growing economies. The country's numerous rivers are an important transportation route with over 17,700 kilometers of navigable waterways – and they are also an important source of renewable energy. Vietnam has a theoretical hydropower potential of approximately 300,000 GWh annually, 100,000 GWh of which is economically viable. Until recently, just 15,211 MW had been installed, leaving plenty of room for growth.

### Small hydro success in Vietnam

As part of the new Renewable Energy Development Strategy 2030, unveiled in December 2015, the Vietnamese government has prioritized renewable energies and plans to increase hydropower generation from 56 TWh in 2015 to 90 TWh in 2020. Voith Hydro Private Limited, based in Vadodara in northwest India, which launched in the Vietnamese market in 2011, is supporting the country in building and renewing its hydropower infrastructure, which features a large number of relatively small-scale installations. This commitment is reflected by numerous already commissioned projects and others which are currently underway.

Dak Ter-1 was the first project commissioned by Voith in Vietnam, located

in the Tu Mo Rong District. The contract's scope involves the supply of turbine and generator, automation, E-BOP, M-BOP and supervision of installation and commissioning the project. The system and component engineering of the turbine was undertaken by Voith's local engineering center, and the turbines were manufactured in Vadodara, India. This was the first pilot project using the cost-effective Standard Small Hydro Automation Scheme. This scheme combines the functions of digital governor, control system, and excitation and protection system in one common panel, and delivers it within a compact solution. Both units in the project were handed over to the customer in February 2015, leading to a third project, Dakpsi 2B, being recently awarded to Voith Hydro.

Meanwhile, the contract for Dak Ter-2, which is in the cascade of the Dak Ter-1 project and on a similar scale, was signed in October 2013. Work com-



1 Manufacturing small hydro turbines in Vadodara, India.  
2 Local technician inspects turbine quality.



PROJECT	CAPACITY
Dakpsi 2B	2 x 7 MW
Dak Ter-1	2 x 1.8 MW + 10% COL
Dak Ter-2	2 x 1.7 MW + 10% COL
Thanh Thuy-1	2 x 6 MW + 10% COL
Alin B1 hydroelectric project	2 x 23 MW + 10% COL
Son Tra 1A	2 x 18 MW
Son Tra 1B	2 x 18 MW
Kurhed	2 x 2.25 MW + 10% COL
Behna	2 x 2.5 MW + 10% COL
Gullu	2 x 12 MW + 10% COL
Lake Mainit project	3 x 8.333 MW + 10% COL
Asiga	2 x 4 MW
Semangka	2 x 28.3 MW + 10% COL

menced in April 2014, and since commissioning in September 2015, both Dak Ter-1 and Dak Ter-2 have been performing to the customer's full satisfaction.

A contract for Thanh Thuy-1 was signed in May 2015 with twin-jet Pelton turbine generating sets and complete water-to-wire scope. Thanh Thuy-1 Hydropower Joint Stock Company selected Voith to deliver all the power plant equipment at Haiphong port within 14 months of the commencement date, followed by commissioning.

Voith was also chosen to work on the Alin B1 hydroelectric project in March 2016, following a tough bidding process. Located in the A Luoi and Phong Dien districts, this is the company's seventh successful Vietnamese project, which is being developed in cooperation with Truong Phu Hydropower Joint Stock Company.

And finally, another recent important milestone was the securing of a contract for the Son Tra 1 project in April 2016. Located on the Dak Se Lo River

in Quang Ngai province and southwest of Quang Ngai City, the scope includes supplying a complete set of equipment for two powerhouses in cascade formation – Son Tra 1A and Son Tra 1B. The 30-4 Quang Ngai Joint Stock Company is developing the project.

### Serving all of Asia

Voith's manufacturing facilities in Vadodara serve India, Nepal, Bhutan, Indonesia, Laos and the Philippines.

For instance, in April 2016, Voith commissioned the Kurhed project in Himachal Pradesh, India; the installations at Behna and Gullu are slated for commissioning in late 2016.

Meanwhile, in the Philippines, the Lake Mainit project is being built on the northeastern section of the island of Mindanao. Voith has also supplied the electromechanical equipment for Asiga, also located in Mindanao.

And in Indonesia, the supply of equipment for the Semangka project is underway, as well as installation of the turbine components. The project is due to be commissioned in 2017.

Importantly, all of Voith's activities in the region are driven by close customer relationships, and regular face-to-face meetings between customers and senior Voith managers. This demonstrates the company's commitment to hydropower projects of all sizes. //



# MEETING THE LARGE HYDRO CHALLENGE

Today, major hydropower projects involve combining components that arrive from all over the world. **Optimizing speed, quality and cost-efficiency is a tough balancing act.**



- 1 The cavern of the world's third-largest hydropower plant at Xiluodu on the Jinsha River, China. Voith delivered three of the 18 machines for the site, which has a total capacity of 13.86 GW.
- 2 A Voith employee inspects the installation to ensure maximum quality.

**Preparing a bid for a large hydro-power facility** is a major project in its own right. It requires patience, attention to detail, and investment. According to Björn Reeg, Voith Hydro's Head of Project Management, constructing a scale prototype of the plant is often the first step. "The miniature version helps us to optimize and to achieve the required performance and efficiency." The team assesses the project's technical feasibility and finds the right balance between efficiency, longevity and performance.

Working on a project that takes a decade to complete is normal for Reeg and his team. "The assessment process takes time, because there are so many factors – the country and its regulations, the plant's location and logistical needs, and all the technical and customer-related specifics. The longest project I've worked on was Iberdrola's La Muela II installation in Spain – it took eight years! Even after all that time, despite some delays outside of our control, the customer was delighted with the project management. I'm very proud of that."

"I think there are four key criteria for ensuring the success of a large-scale project," says Reeg. "A good relationship with the customer is probably the most important – without that, everything else is more difficult. Outstanding change management skills and reacting quickly to unexpected events are also vital, because unpredictability is a given. Thirdly, leadership skills, especially the coordination and management of multinational and multicultural teams. And of course, quality – our reputation depends on it."

### Close collaboration

In Canada, a project for BC Hydro at Site C, a large-scale plant on the Peace River in British Columbia, provides a good example of transferring this theory into practice. "We set up a project team to work solely on this offer," says Laurent Bulota, Head of Proposals at



**"Outstanding change management skills and reacting quickly to unexpected events are vital, because unpredictability is a given."**

**Björn Reeg**  
Head of Project Management, Voith Hydro

Voith Hydro in Montreal. "Several of the customer's criteria were soft factors like customer references and methodological details." The team then performed several simulations to optimize the balance between the units' performance, the amount of rock to be excavated out of the river and the Amount of concrete in the plant. The entire offer process took over three years, culminating in the contract signature in March 2016. "When BC Hydro awarded us the contract, they thanked us for the close col-

laboration," adds Bulota. It was a real marathon, but it paid off in the end!"

### A strong foundation for success

On the other side of the world, another large-scale project is taking shape that also relies on close collaboration. The Wudongde hydropower station is the fourth largest in China and its turbine generator units will be amongst the largest worldwide in terms of power output. Zhang Min, project manager of Voith Hydro Shanghai for Wudongde, echoes the experience of Björn Reeg and Laurent Bulota. "We won this pro-

ject because we built a good relationship with the customer and because we had access to global expertise from across the Voith Group," he says.

In fact, the recipe for success in large hydropower projects is quite similar wherever the site, as Zhang concludes: "This project is already progressing well and we are very focused on achieving the best result for the customer. Diligence, confidence and great teamwork: that's the secret to succeeding in large projects." //



Iberdrola's La Muela II installation in Spain took eight years to complete.



The spectacular dam on the Zambezi following completion in the late 1970s, before it was ruined during the civil war.

## TECHNICAL DATA

5 Voith Francis turbines with 415 MW each;  
turbine runner diameter: 7 m

**Dam Wall:**  
height: 164 m  
width at the base: 23 m  
width at water level: 4 m

## 103.5 METERS HEAD

5 generators with 480 MVA each;  
rotor diameter: 13 m

**Cavern:**  
length: 220 m  
height: 57 m  
width: 29 m

# TRUE SURVIVOR

“Cabora Bassa” – a name that demands superlatives: a **164-meter-high dam wall on the Zambezi River**; a 250-kilometer-long reservoir lake; a 1,500-kilometer-long high-voltage line between Mozambique and South Africa; and a total power output of 2,075 MW.

Mozambique was still a colony when the tender was sent out for the construction of a hydropower plant on the Zambezi River in November 1967. The Portuguese “Minister for overseas territories” was planning “Cabora Bassa” as the largest hydropower plant in southern Africa. Five turbines were meant to generate the electricity that was largely intended to be sold to South Africa. For electricity transmission, a 1,500-kilometer-long high-voltage line was built between the site and Pretoria.

In September 1969, roughly two years after the tendering process began, the contract for the underground hydropower plant was awarded to an international consortium that included Siemens, Voith, AEG, BBC and the construction company Hochtief – all German companies. Voith provided the five Francis turbines for Cabora Bassa. While the turbines were being constructed in Heidenheim, robust roads and bridges were built in Mozambique so that machines and equipment could be transported to the construction site. On the high plateau, a runway for propeller-driven aircraft was built, and the region was equipped with a new telecommunications and telex system.

### Ambitious goals versus critical voices

The Cabora Bassa construction site was situated at the end of a gorge that is 18 kilometers long, 250 meters wide and 700 meters deep. Ambitious goals were attached to the construction of the reservoir and power plant. The Zambezi had been made navigable over a length of 320 kilometers in order to allow for the transport of natural resources such as coal, iron, titanium, manganese, chromium and bauxite. There were

plans for the construction of an irrigation system to serve huge agricultural areas. A total of 15,000 km<sup>2</sup> was supposed to be harnessed for the cultivation of fruits for export. And the revenue generated from this was intended to boost economic development.

However, there were also dissenting voices and protests. The Mozambican freedom movement Frelimo, which had been fighting for political freedom from Portugal since 1964, criticized the project, as did various student movements across Europe. Their argument was that Cabora Bassa would only benefit the apartheid regime in South Africa and the dictatorship in Portugal. During the construction and installation period, civil war and violence dominated the country. The construction site and the camp, which housed more than 3,000 engineers and construction workers at the time, had to be secured by the military.

### Technical innovation lowers costs

In the meantime, the engineers were mastering technical challenges. They erected a six-kilometer-long overhead line from the platform at the cavern surface to the Songo plateau 600 meters above it, and connected it to a three-phase current substation and a converter station. Here, 220 kV three-phase current was converted into 533 kV direct current for transport. A new

technique was developed for this: high-voltage direct-current transmission. With this new technique, the engineers were able to cut the transmission costs in half.

### Independence without peace

In April 1974, the “Carnation Revolution” in Portugal ended the Caetano dictatorship and also paved the way for the independence of the colonies. Mozambique became independent in 1975. Frelimo became the ruling party and began to support the construction of the power plant. The first expansion stage with 1,224 MW capacity was completed as planned and the hydropower plant began commercial operation on 26 March 1977. In June 1979, the last expansion stage was completed and Cabora Bassa was finished on schedule after 10 years of construction.

The political turmoils on the Zambezi, however, were not over yet. Now the guerrilla movement Renamo, supported by the South African apartheid regime, began fighting the Marxist-Leninist Frelimo government. What followed was a bloody, 16-year-long civil war. Around 900,000 people died and 1.7 million fled the country. Renamo also repeatedly attacked the infrastructure at Cabora Bassa, which became a ruin. Only in 1997, after the end of the civil war, was Cahora Bassa (as it is spelled today) repaired and returned to operation. //

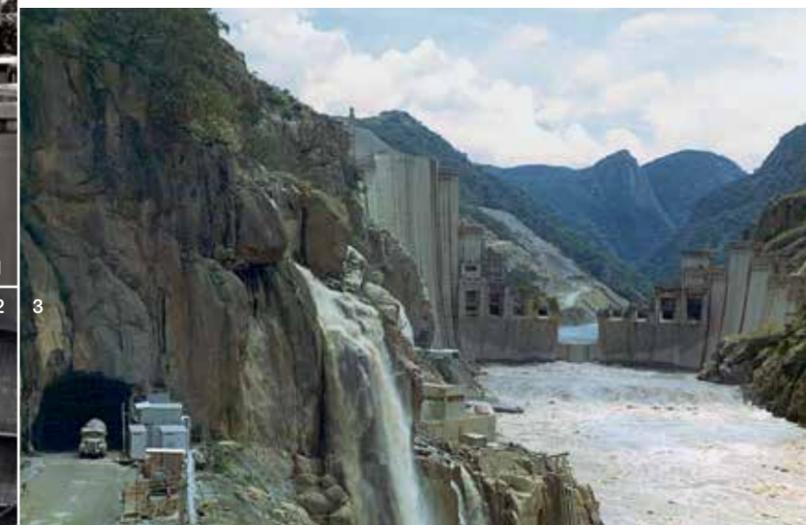


1 Manufacturing the turbines for Cabora Bassa at the factory in Heidenheim.



2 The efforts of local workers were key to completing the plant on schedule.

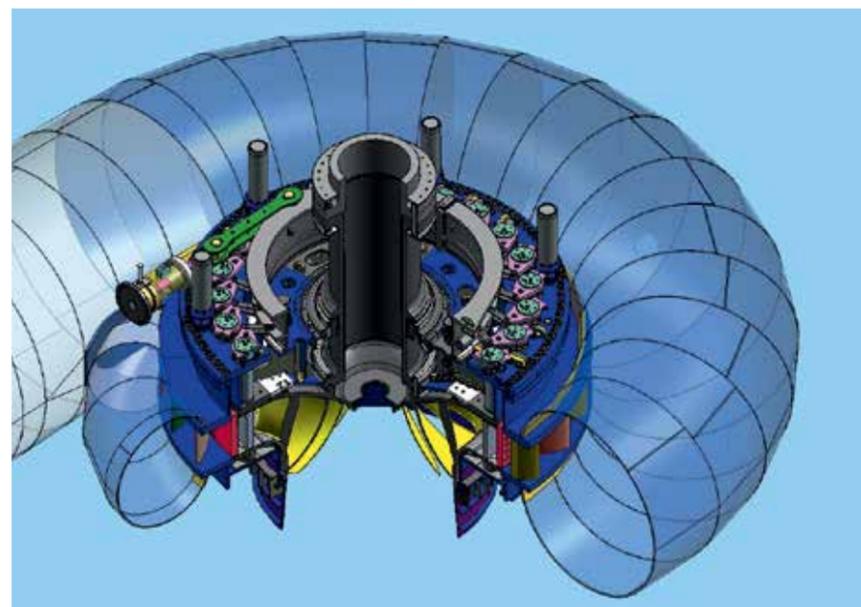
3 New roads and tunnels were constructed to provide easier access to the dam site during construction.



# STOPPING THE FLOW

By controlling the movement of ring gates electronically, Voith is ensuring **the water flow through large turbines can be stopped more effectively** when required.

**Voith has been successfully** manufacturing and installing the ring gates that stop water flowing through large Francis turbines for over 20 years. It is also responsible for the key innovation in that time – electronic control of the opening and closing mechanism.



Ring gates (here in red) provide a useful addition for large Francis turbines, where a spherical or butterfly valve would be too large.

## Essential stopping power

In some situations, such as a unit standstill or emergency failure, the flow of water through a Francis turbine must be stopped. The distributor and wicket gates act as a regulating and stopping device, but to reduce leakage and deal with a distributor failure, a second device is used – usually a spherical or butterfly valve. However, fitting these valves to very large Francis turbines is impractical, because the size of the valve required makes them too heavy and difficult to transport and install. This is why spherical valves are only manufactured up to a diameter of not much more than three meters. In addition, butterfly valves, which can be built to a larger size, can hinder the flow of water when they are open and therefore reduce the effectiveness of the turbine. The solution, when appropriate: the ring gate, a compact steel cylinder that is lighter, easier to transport, and can be put together on site. It also allows water to flow freely through the turbine when open, enables a tight seal when closed, and eliminates leakage through the distributor and the associated erosion it causes. This ensures full turbine efficiency, and prevents loss of energy when the ring gate is closed, thereby saving the plant owner money.

## A tough engineering challenge

Designing and installing a ring gate and the mechanism that moves it is a real challenge, as Dr. Alexander Jung, Head of Turbine Development Methods, explains: “Opening and closing a ring gate requires the balancing of pressure above and below the gate. Understanding the relationship between the speed and pressure of water flow through the

ring gate, and the static and dynamic forces that are created, is essential for calculating the dimensions required for the space between the ring gate and its housing, and the forces that the different components must be designed to withstand. Maximum reliability and control are essential.”

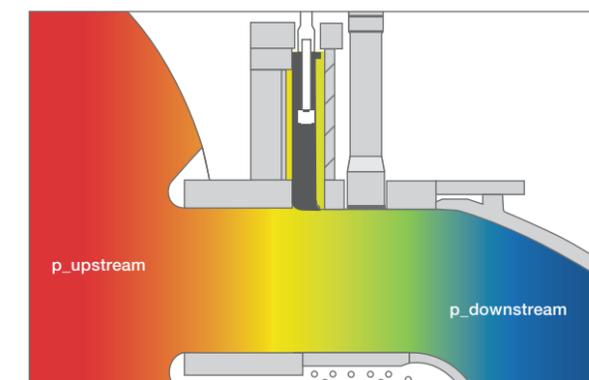
## Precise electronic control

In the past, ring gate movement was controlled mechanically, with several spindles connected by a chain that ensured they rotated at the same speed. However, this solution was sub-optimal, as Thomas Neidhardt, Voith’s Head of Turbine Basic Engineering explains: “The mechanical system was labor-intensive and expensive, and was less reliable than customers wanted. That’s why we developed an electronic system to control odd or even numbers of oil-driven servomotors that raise and lower the ring gate. It’s a more efficient, precise and reliable solution when customers decide to use a ring gate.”

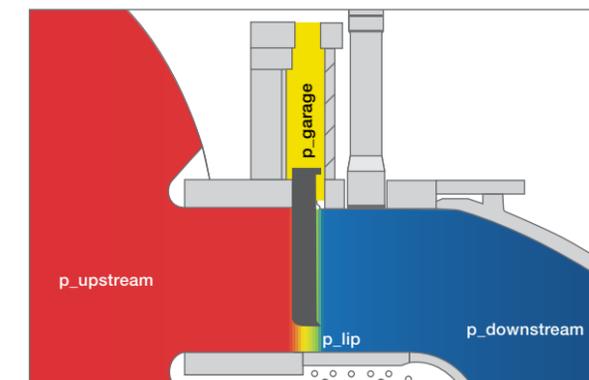
## High demand from China

The first installation of the electronically controlled system was in 1999 at the Xiaolangdi plant in Jiyuan, Henan Province, China. Since then, it has been refined and installed at six other large hydro plants in China. The largest of these, installed at Xiluodu, is around 10 meters across. “Our customers in China demand the highest standards, and require the ring gates to be easily and completely closed in full flow conditions, even with a failing distributor. That’s why they prefer our electronically controlled system. They say they have never seen another that is so precise,” confirms Neidhardt. //

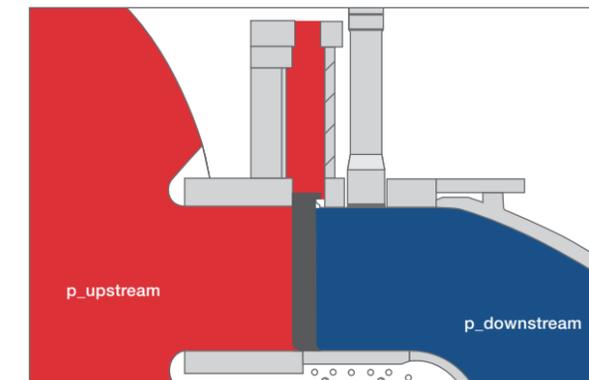
## RING GATE PRESSURE DISTRIBUTION <sup>1</sup>



The ring gate is lowered through its housing by the electronically controlled servomotors. The pressures above and below the ring gate must be equalized.



The pressure in the ring gate housing (garage) is determined by the design and size of the gaps (deliberate control of the pressure differentials through leakage flow regulation).

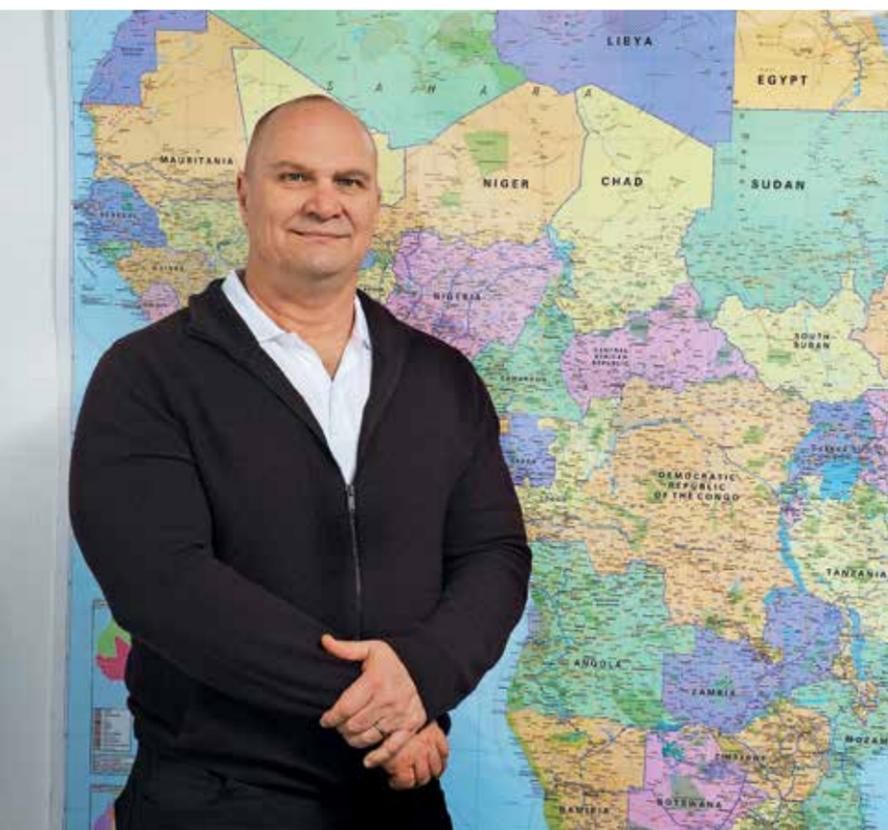


There is a strong suction peak at the bottom as the ring gate closes. The design and precise position of the seal prevents leakage and unintentional opening.

<sup>1</sup> simplified schematics

## SERVICING AFRICA

Voith is investing in local African service personnel, to provide hydro customers with **rapid support across the continent.**



**Randal Enns,**  
Managing Director, Voith Hydro in South Africa

Originally from Winnipeg, Manitoba, in Canada, Randal Enns has invaluable experience working on hydropower projects in Africa. Appointed to the role as Managing Director of Voith Hydro in South Africa in January 2016, one of his most important current tasks is to build a service team with the potential to cover small hydro installations across the continent. “Of course, there are some countries we don’t focus on, due to safety and security issues, or simply because the northernmost countries in Africa are actually closer to Europe than we are. However, the clear aim this year is to make sure Voith can start covering as many service requirements as possible for our customers with a locally based team,” says Enns.

By the end of 2016, Enns’s team will consist of two service engineers and two sales engineers. He comments: “Our principle task is to establish our presence with potential clients, who will be dependent on the talents of the team in Johannesburg.”

“We spent some time working with the Chattanooga division, and they helped us plan what equipment we might need,” Enns explains. “What we’re trying to do is anticipate the work that we’re going to get over the next few years and have the equipment ready.” This means that for the rest of 2016, the team is purchasing “machining tools,” to machine typical components for refurbishments, along with tools for workers.

This preparation will help ensure Voith customers in Africa can benefit continuously from Voith’s expanding capabilities. Enns concludes: “As time goes on, we will develop our capacity to serve customers optimally with offers and implementation, and develop specialisms as customer needs dictate.” //



The HyService Bus, packed with tools and the experts to use them, is ready to go to the aid of Voith customers all over Europe.

## 24/7 MOBILE SERVICE

When its customers in western Europe have an issue, Voith Hydro springs into action, thanks to the HyService Bus. The brainchild of Florian Philipp, Engineer After Market Business, the specially converted Mercedes van contains every tool and instrument required for hydropower machinery servicing. Each item is intelligently and securely stored, but still easy to access for Philipp and his four colleagues, ensuring they can get to

work as quickly as possible. As soon as a call comes in, Philipp or a colleague is ready to jump into the van and go. And, with 40,000 kilometers traveled since its introduction in summer 2015, the HyService Bus has already fulfilled the urgent servicing needs of Voith customers all over the region. It has been so successful that another service bus has already been ordered. All Florian Philipp needs to know now is: where to next? //



1 The run-of-river plant at Tulila.  
2 The new machine unit on commissioning day.

# THE POWER TO CHANGE LIVES

Sponsored **small hydro projects** have transformed the lives of the Benedictine Sisters of St. Agnes in Tanzania and the local communities they serve.



The Tulila site is located near the town of Songea in southwest Tanzania.

It's difficult for many of us who live in industrialized nations to imagine daily life without instant access to electricity. But even in 2016, living without a regular power supply is still a reality for hundreds of millions of people. Until the turn of the 21st century, it was also a fact of life for the 370 Benedictine Sisters of St. Agnes at the Chipole Convent in the Ruvuma district of southwestern Tanzania. All the more astonishing given that they have devoted their lives to supporting the local population with health, educational and social services – without receiving anything in return.

### Small beginnings

Around 15 years ago, Swiss benefactor Robert Fuchs used his foundation to build a small 400 kW hydropower facility at the convent, to ensure the sisters had a reliable flow of electricity. The facility proved to be more than adequate

for their needs – so much so, that following the death of Fuchs, his daughter asked Albert Koch, a family friend, hydropower expert and private investor, whether he could take a look at the site and come up with ways of using the full potential of the plant. What happened next turned out to be much more transformative than anyone involved could have imagined.

### Thinking bigger

By the time Albert Koch arrived in Chipole, the sisters had bought a corn mill which was enabling them to make full use of the power available to them. But so inspired was he by the commitment of the sisters and their willingness to work unpaid, he decided to investigate the possibility of a larger plant that could potentially transform the financial situation of the sisters and the lives of the local population. After consulting with Sister Yoela Luambano, who en-

“Before the plant was built, the power was unreliable. Life is just so much easier for everyone now.”

**Sister Yoela Luambano**  
Benedictine Sisters of St. Agnes, Chipole Convent, Tanzania

thusiastically assumed much of the responsibility for the project, it became clear that she would be able to secure water rights from the government for a second plant, if a suitable location could be found. After a couple of false starts, they found what they were looking for within a few hours drive of the convent – a cascading river in the Tulila region.

With the location identified, the next challenge was financing. Fortunately, the state-owned electricity supplier Tanesco was already planning to purchase power from external sources to feed the main grid. Combined with a

multi-million-dollar personal investment from Koch, and a loan financed by Credit Suisse Bank and insured by Swiss Export Risk Insurance (SERV), the project quickly became viable.

### Construction begins

With all the financing and licenses in place, construction on the run-of-river plant, featuring an earth-filled dam and weir, could begin. The plant was to be powered by up to three double regulated Kaplan turbines and electro-mechanical equipment, all supplied by Kössler, a subsidiary of Voith in Austria. ➤

▷ In addition, Swiss consulting firm AF-Consult (formerly ITECO), which had already been involved in project planning, took overall charge of the realization phase, right through to commissioning. The remote location of the construction site brought quite a few challenges, as Kössler Project Manager Karl Henninger remembers: “The arrival of people and the transport of goods had to be arranged in different stages. All the parts were shipped from Hamburg to Dar es Salaam, where they were put onto trucks and taken to the site. The installation team, once they arrived in Dar es Salaam, had to fly to Songea, the capital of the Ruvuma district, and then be driven to the site by Jeep.” In fact, the whole construction

phase was very much a team effort, with the sisters themselves providing support with import and customs formalities and logistics coordination, and by providing food and accommodation for visiting European experts. They even conducted blasting operations, as one of the sisters is a trained explosives engineer.

**From installation to commissioning**

Initially, two turbines, delivered in September and October 2014, respectively, were installed, with a total capacity of 5 MW (2 x 2.5 MW), and there is capacity for a third turbine to be installed, when the demand for power justifies it. An important aspect of the installation is its capacity for isolated operation.

The plant must serve the local grid covering the rural surroundings, and the turbines must keep running at minimum performance in outage situations, in the event that the grid fails – a frequent occurrence. Commenting on the solution to this challenge, Karl Henninger says: “Our constructing engineers have enabled isolated operation by using enormous mechanical centrifugal masses, a complex control system and an electronic load controller.”

**Changing lives forever**

Despite the challenges, installation began in January 2015 and, thanks to the excellent collaboration between all the project partners, the first electricity was produced at the end of the summer. Currently, around 20 GWh are consumed from the total of 36 GWh produced annually by the two installed turbines – this explains why the installation of the third turbine is still on hold. But even though all the power is not yet being used, the Tulila plant has changed the lives of people in the region, and especially in the Ruvuma regional capital, Songea, beyond recognition. Sister Yoela comments: “Before the plant was built, Songea was not an attractive destination, because the power was so unreliable. People had to work in half-day shifts, and it sometimes took days before surgical operations at the hospital could be performed. Now the doctors can work much more quickly, and we have new equipment such as X-ray machines, which help with diagnoses. Reliable electric light also enables local children to study anytime, rather than only during the day. Life is so much easier for everyone now.”

And the good news doesn't stop there. Sister Yoela is hopeful that she and the sisters will soon be able to receive a salary thanks to the sale of excess power to Tanesco. And she is currently discussing plans with Albert Koch to help other convents in Tanzania achieve a similar transformation. //

# THE BIG QUESTION: REPLACE OR REFURBISH?



BC Hydro's powerhouse at Ruskin, in British Columbia, Canada.

- 1 The delighted local team at the completion of the project.
- 2 Construction was a challenge in this remote region.



1



2

Choosing to refurbish a power plant rather than replace it – even one which is decades old – **can offer hydropower firms significant benefits.**

**Refurbishing equipment** rather than replacing it can reduce project costs and disruptions, and improve performance. Even with machinery that is 60 or 80 years old, many parts can be upgraded and reused. As a recognized expert in refurbishment, Voith is working on two such projects in Canada.

**Hydro-Québec's Rapides-des-Quinze: careful planning**

Founded in 1944, Hydro-Québec operates 63 power stations throughout Québec, some of which have been running since the 1920s. One of these is Rapides-des-Quinze, which was built in 1923 and extended in 1949 and 1954, with a fifth and then a sixth turbine. These later extensions are the two ▷

“We proposed reusing [the part], realizing associated cost savings for the customer.”

**Pierre-Alexandre Proulx**  
Voith Project Manager for Ruskin

► areas Voith engineers have been working on. Time was limited for each operation, but the machinery was over 60 years old and needed significant upgrades.

The first step, conducted by the customer, was to analyze the state of each main component and opt for replacement or refurbishment. The team found that the generator was still in reasonable condition, although about 70% of its components needed to be replaced. The turbine, with its 4.1 meter diameter, 17 runner blades and operating speed of 105.88 rpm, was at the end of its lifecycle and needed to be replaced completely, and the same applied to the high-pressure pumps. In fact, all the turbine components, with the exception of the turbine shaft and its seal, which could be refurbished, are new.

**Fast reconstruction required**

Voith specialists conducted an in-depth inspection of the parts to be refurbished to assess what actions were required, and how they should be executed. They then proposed an optimized hydraulic profile that required some turbine parts to be replaced, rather than refurbished as originally planned. Once the Voith specialists had taken delivery of the replacement parts, they quickly rebuilt the machine using a combination of these new parts and other refurbished components.

“Because the site installation schedule required in the request for a proposal was very challenging, Voith suggested that a two shift schedule of specialists worked 20/6. This was a big differentiator for Voith in winning the project,” says Wandrille de Saint Louvent, the Voith project manager heading up the team. “Hydro-Québec was very happy about this as it met their own production requirements.”

**Hydro-Québec: better performance with lower costs**

The Rapides-des-Quinze project is on the home stretch now, with the first machine commissioned in September 2016 and the second planned for an outage in March 2017. “The component of the second unit will be completed more quickly as it



1 The powerhouse at Ruskin is narrow – a big challenge when disassembling and assembling machinery.  
2 Voith engineers conducted an in-depth inspection at the beginning of the project.

needs the same refurbished and new parts as the first – and the experience we’ve gained pays off in speed,” adds Wandrille de Saint Louvent.

The principal benefits for Hydro-Québec include a performance increase of 8% from each of the two refurbished machines, along with reduced maintenance costs and effort.

**Ruskin: only Voith proposed refurbishment**

In British Columbia (BC), BC Hydro is working with Voith to refurbish their Ruskin powerhouse. Built in 1930, Ruskin is older than the extended areas of Rapides-des-Quinze that Voith worked on in Québec, and it had barely been modernized since its construction. The plant’s three power units needed a significant overhaul, including new turbine runners, new wicket gates and operating system, a new stator (frame, core and winding), and rotor refurbishment. One of the biggest challenges at Ruskin was that the powerhouse is very small, complicating disassembly and reassembly. While BC Hydro always preferred refurbishment over replacement for the project, Voith was the only supplier to recommend reusing the rotor frame, rather than replacing it. “We could see that not every part of it was damaged, so we proposed reusing it, realizing associated cost savings for the customer”, says Voith project manager Pierre-Alexandre Proulx.

**Close collaboration with the customer**

The first step in 2012 was close collaboration between Voith and BC Hydro teams to perform an in-depth inspection of one of the units. Voith provided BC Hydro with a detailed report on every part of the machine and recommendations for replacement or refurbishment. Based on that knowledge, BC Hydro was able to define the exact project scope. The second phase, initiated in 2013, comprised the design, manufacturing, supply and installation of components for each of the three machines. Despite the lack of space and the proximity of the machines to one another, at the time of publication, the first unit is ready for final commissioning, and the second unit is scheduled for commissioning by mid-October 2016. The third unit is scheduled for commissioning in early 2017.

**Competitive pricing – but it’s the value that counts**

“Our proposal was competitive, but apparently we weren’t the least expensive,” notes Pierre-Alexandre Proulx. “For BC Hydro, the added value aspect was key.”

These two projects help to demonstrate the many benefits of refurbishment – even on very old units – for hydropower companies who may not have considered this. Voith has completed so many of these projects that it is a leader in the field, further reducing cost and risk for customers. //



A turbine distributor is removed from the powerhouse at Rapides-des-Quinze in Quebec, Canada.



Operator stations for sound-based monitoring.

## SAFE AND SOUND

In the very near future, **unmanned hydropower plants will get first-hand remote support**, thanks to a Voith innovation: sound-based monitoring.

**Keeping an eye on** how a plant is operating is vital for all Voith Hydro customers. However, keeping an ear on it is even more important, as mechanical problems can often be heard before they can be seen. The issue is, sending technicians around a plant to listen for anything unusual is time-consuming, expensive and intermittent – especially if the plant is in a very remote location.

### Listening is the key

One of HyGuard's key developers is Rudolf Münch, and he uses the comparison of a mechanic assessing a car to describe the approach he and his colleagues have taken. "About 50% of what a mechanic finds out about your car comes from listening for potential

problems. HyGuard applies this principle to hydropower plants."

HyGuard technology works through a series of sensors installed at strategic locations around a remote, unmanned power plant. The system records sounds, which operators – perhaps based hundreds of kilometers away – can assess for any abnormal noises. And if, for example, one of the sensors sets off an alarm, the operator can make a quick assessment, and immediately send the recording to an expert for analysis anywhere in the world.

### Self-learning systems

So far, so clever – but there is more. "The second part," says Münch, "is that if the same problem occurs repeatedly,

the system will recognize the sound from previous failures." In short, the system has "self-learning" capabilities.

"Sounds have different properties, and in the case of the rotating machinery in a hydropower plant, a lot of information is hidden in lots of different frequencies," explains Münch. "The application checks for general patterns in the frequencies, such as those that work together or don't. These patterns are learnt, along with new patterns. Subsequently, the application compares the patterns to discover what is abnormal."

### Pilots already planned

The first series of tests, consisting of microphones recording sounds for several days at a time, have already been carried out successfully at a hydropower plant in Germany. The next stage is to install the technology permanently at a pilot plant later this year, also in Germany.

Once the experts have sufficient experience with the pilot, the technology can be offered worldwide including in remote plants in Africa as part of our new service concept. "With long distances and variable transport infrastructure, remote monitoring there makes perfect sense," concludes Münch. //

# WORLD OF VOITH

The latest news from **across the divisions** of the Voith Group.

## DIGITAL SOLUTIONS

**The date:** 1 April 2016. The occasion: The official start of operations for the new Group Division Voith Digital Solutions. With a mission to consolidate all of the Group's know-how in the field of automation and digitalization, the focus will be on the development of new digital business models for industries that Voith currently serves, as well as for completely new ones. Dr. Roland Münch, President & CEO of Voith Digital Solutions, is excited about the future: "I'm looking forward to working with an excellent team of experienced colleagues who are making the new Group Division into an important pillar for Voith." //



## COOL DESIGN

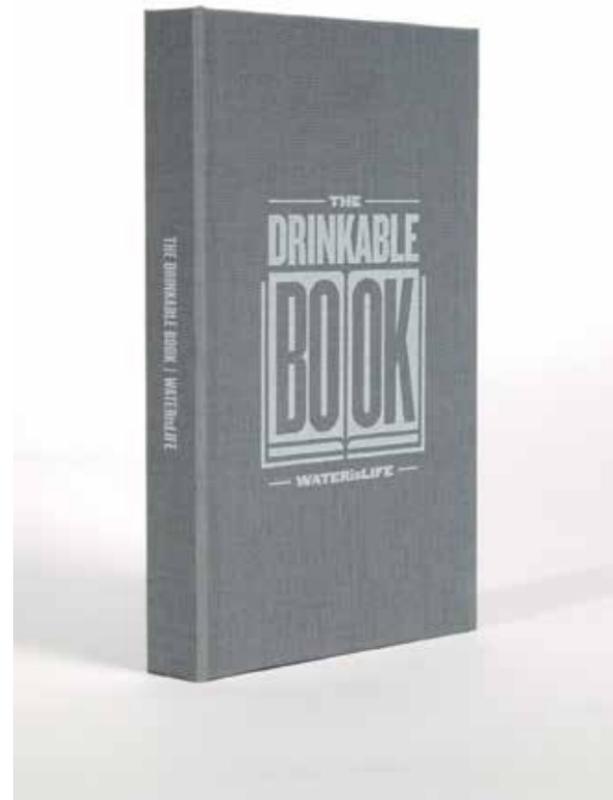
**Tractor manufacturer Fendt** is using a new cooling technology in its latest 1000 Vario series tractor – powered by a high-performance fan designed by Voith. With up to 500 HP on tap, the Fendt 1000 Vario is the world's most powerful standard tractor, and that generates a lot of heat. The Voith fan is positioned in front of the cooler unit and the engine, drawing higher-density cold air from outside the vehicle and further compressing it through the high aerodynamic efficiency. This increases the pressure in relation to the intake configuration and produces an enormous air flow of up to 7m<sup>3</sup>/s for enhanced cooling – and all using less than half the energy of a standard fan. Together with the company's established Hydrodamp vibration damper, Voith technology is making a big contribution to the operating efficiency and longevity of Fendt's latest and greatest tractors. //



## PAPERMAKING: NEXT LEVEL

**Voith Paper** certainly had the hot topics covered at the recent Voith Paper Customer Symposium in Hamburg. Under the banner "Transformance – Papermaking 4.0," 18 speakers explored the opportunities that new technologies bring when it comes to producing paper more profitably and competitively. The key ingredient to maximizing these opportunities, according to Bertram Staudenmaier, Chairman of the Management Board of Voith Paper: "A strong partnership with our customers for shared success." Innovations in improving performance, transforming existing production methods, guaranteeing efficiency and availability through modern servicing, and the impact of digitization on paper manufacturing were all discussed in detail. "There are exciting tasks and challenges ahead of us that we will approach and master together," concluded Bertram Staudenmaier. //

# CREATING THE SAFE WATER BOOK™



Each filter is printed with usage instructions. A family of four needs roughly one filter per week.



Materials and environmental chemist **Dr. Theresa Dankovich has created a paper-based water filter**, delivered in book form, that could give hundreds of millions of people access to safe drinking water.

**Dr. Dankovich started out as a materials chemist**, rather than an environmental one. While studying for her PhD, she joined the Sentinel Bioactive Paper Network, a research network connecting Canadian universities that are investigating ways of adding value to paper. These potential value adds include, for example, using paper as a dipstick for pathogens or eliminating toxins from agricultural runoff. But Dr. Dankovich had a specific interest, as she explains: “My focus was on the antimicrobial applications of paper for water filtration. I started the project in 2008.”

**The Safe Water Book™ is born**

Over several years, Dr. Dankovich experimented with different types of papers and a biocide containing silver nanoparticles to create a filter paper that eliminates bacteria from water sources. Her laboratory experiments consistently proved that the filters were removing 100% of the bacteria in the water samples. After graduation from McGill University in 2012, Dr. Dankovich joined the University of Virginia as a postdoctoral researcher in 2013, where she conducted field trials for the first time.

**Test case: South Africa**

“In 2013, we took the filters, which look a bit like orange-colored tortillas, to a range of natural water sources in South Africa. We sampled water from a number of places and took bacteria counts before and after filtration. We then repeated the

tests in Ghana, Bangladesh and Honduras. And we got the results we wanted. That’s when I knew we had a product with the potential to save lives.” Importantly, Dr. Dankovich has consistently asked people in each community about their needs, and how they would use the product, because assumptions and customs in every country are so different. And this knowledge has been instrumental in turning her work into a potentially viable commercial product – the Safe Water Book™.

**A book that can literally save lives**

The Safe Water Book™ binds multiple “pages” together, each of which can be torn out and used to filter up to 100 liters of water at a rate of two liters every 10 minutes. “At typical consumption rates, each page enables a family of four to filter all the drinking water they need for a week. Each page is also printed with information on why it makes sense to filter drinking water, and how to use the book to do so,” says Dr. Dankovich.

In a world in which hundreds of millions of people don’t have regular access to clean drinking water, the potential of such a simple idea to prevent illness and save lives is obvious. And importantly for developing countries, where clean drinking water is often particularly scarce, the filters are also affordable. Dr. Dankovich comments, “We are producing the paper on pilot-sized paper machines, where the cost of producing each page is only between 10 and 20 cents. Once we have even greater scale, we expect this cost to fall significantly.”

**Commercial launch planned for 2016**

In 2016, Dr. Dankovich formed a Pennsylvania Benefit Corporation, Folia Water, to bring the Safe Water Book™ to market. A pilot project is currently running in South Africa, and this will be followed by a similar project in Honduras, where Dr. Dankovich is collaborating with local doctors. “We’re also working with non-profits like Water is Life to spread the word, and we have a sponsorship program, where people can buy the books to donate to communities in need. Right now, it’s all about building awareness, getting samples out there and collecting final feedback before the launch, which we hope will happen by early next year,” she adds.

The only other immediate challenge is fulfilling all the relevant regulatory requirements. But Dr. Dankovich is hopeful that this will be achieved soon – not least because she sees huge need for the product all over the world. “I hope that in 5 years we will be distributing the Safe Water Book™ globally, including in rural regions of India and China, where the populations and demand for clean drinking water are so vast.” A bold ambition, and one that deserves all the attention it receives. //

<http://www.foliawater.com>



**Dr. Theresa Dankovich** is the co-founder, chairwoman, and chief scientist for Folia Water, a benefit corporation dedicated to the scaling and distribution of a new technology, The Safe Water Book™, which uses silver nanoparticles to filter out bacteria from natural water sources, making that water safe to drink and providing educational text on water safety.



# FIVE QUESTIONS FOR ...

**Dr. Tobias Keitel**  
New Chief Operations Officer of Voith Hydro

**1 What new perspectives on the hydro business have you gained since becoming COO, and how has your previous hydropower experience helped you?**

The basic principles of project business don't change, no matter how many projects you are responsible for, so my experience is definitely helping me in this respect. The new role has given me a more global perspective, as I am now responsible for all projects across the different Operating Units, and I am more aware of market differences. The US is definitely leading in the modernization business and we have a very strong presence in this sector. In China and Canada, the sheer size of the plants and the market volume are impressive.

**2 What do you think are the industry's biggest challenges?**

Energy is one of the most important issues of our time. One global challenge in the coming decades will be generating more energy while keeping CO<sub>2</sub> emissions low. This is related to a second major challenge; ensuring the stability of the grid, despite the growing but fluctuating input from solar and wind energy. Hydropower offers an excellent solution to both issues.

I believe that a prerequisite for this is to improve the often conflicting image of hydro plants. On the one hand, hydropower is seen positively, because the energy comes from renewable resources. On the other, hydropower plant construction attracts protests, and hydropower is not classified as 100% renewable. I hope that, together with our customers, we can strengthen a more positive public image for hydropower.

**3 What makes you passionate about hydropower?**

The huge dimensions and often beautiful surroundings of our construction sites. As an engineer, it is fascinating to be involved in these projects, and it's rewarding to work in a sector that produces clear value: hydropower plants generate clean and sustainable electricity from renewable resources.

**4 What do you like best about Voith Hydro?**

Our history and pride in what we have achieved over the years. We are a market leader, and we can solve any technological problem. I also like Voith's medium-sized-company character, and the strong bonds between employees who have worked here for many years. This creates a pleasant working environment and a strong foundation.

**5 The main focus of this edition is Africa. What connects you to the continent?**

I was very involved in the Ingula project last year, a pumped storage plant in South Africa, which we managed to turn into a fantastic success after striving long and hard together with our customer. That was a good feeling. //

**Dr. Tobias Keitel** studied industrial engineering and holds an MBA. Previously, he was with Boston Consulting Group and MAN Ferrostaal AG, before joining Voith Hydro as a project manager in 2011. He held various management positions before he was appointed Chief Operations Officer of Voith Hydro in January 2016.

## VOITH HYDRO PROJECTS IN THIS ISSUE

Throughout Africa, **Voith is leading hydropower** projects that help local governments and communities drive economic growth and social improvements.



Helping Liberia rebuild its power infrastructure after years of civil war. [> PAGE 19](#)

**MOUNT COFFEE**



Expanding hydropower capacity in Angola to support rapid economic growth. [> PAGE 12](#)

**CAMBAMBE**



Helping a convent in Tanzania generate its own electricity and transform the community. [> PAGE 36](#)

**TULILA**



The turbulent history of a plant in Mozambique. [> PAGE 30](#)

**CAHORA BASSA**



**BOKSBURG**

**INGULA**

Investing in local service teams that will cover many countries in Africa. [> PAGE 34](#)



Improving power supply reliability with a pumped storage plant in South Africa. [> PAGE 8](#)

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