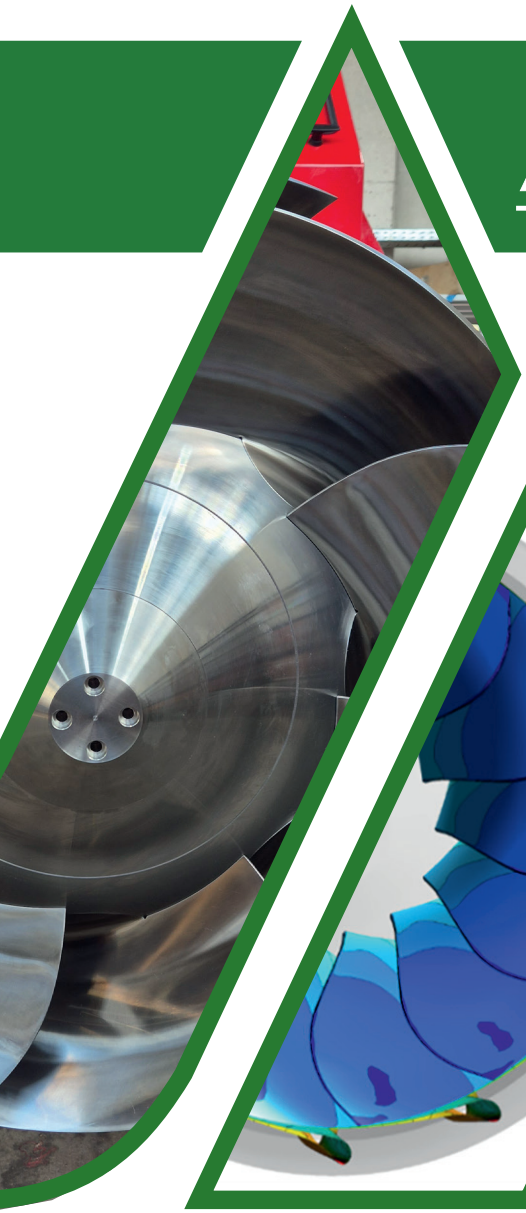
Prof. Dr.
Jaberg und Partner GmbH
Technologie und Strategie





ACTIVITY REPORT 2024 – 2025

ACTIVITY REPORT 2024 – 2025

OVERVIEW of our ACTIVITIES

- Hydraulic development of turbine designs with model test
- Refurbishment of existing systems with the help of CFD
- Piping systems / plant analyses
- On-site measurements
- Pumps & fans
- Valves
- Pressure surge calculations
- Launched projects

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EDITORIAL



Jürgen Schiffer-Rosenberger
Dipl.-Ing. Dr.techn.
CEO Prof. Dr. Jaberg & Partner GmbH

Dear Ladies and Sirs,

With our latest Activity Report, we would like to provide you with an insight into the diverse range of projects and tasks we worked on in 2024 and 2025. The selected examples represent only a small part of our overall range of services while also reflecting the international scope of our activities. Our projects take us to customers and partners in Austria and across the German-speaking region, as well as to various all over the world.

Our range of services covers numerical flow simulations and hydraulic optimisation, measurements and experimental investigations, transient analyses and system assessments, as well as the development and optimisation of turbines, pumps, valves and complete hydraulic systems.

Our guiding principle has always been the same: engineering expertise should not end with calculations but should deliver tangible results in practice. Whether in hydropower, pump technology, process engineering, water supply or thermal power generation, we support our customers from the initial analysis and conceptual design through detailed optimisation to measurement-based or experimental verification. In doing so, we combine sound technical expertise with many years of practical experience and work closely with our customers and project partners both locally and internationally.



The wide variety of challenges we encounter is what makes our work particularly interesting. Our activities range from small, highly specialised hydraulic machines to large hydropower plants, and from individual machine components to the assessment of complete plants and systems. This combination of detailed technical understanding and system-level expertise is one of the key strengths of Prof. Dr. Jaberg & Partner GmbH. It enables us to address technical challenges regardless of their scale, application or geographical setting and to develop practical solutions together with our customers.

Our technical portfolio is complemented by our Academy, which includes the practitioner conferences “Pumps in Process Engineering, Power Plants and Wastewater Technology” and “Hydropower, Turbines, Systems”, as well as customised training and consulting services. For us, sharing knowledge and promoting the exchange of experience within the industry are just as much a part of sustainable engineering practice as the successful implementation of specific projects. Here, too, personal exchange with experts from different countries, companies and fields plays a central role.

The following pages provide an insight into a selection of these projects and tasks. They highlight technical challenges, our approaches and, above all, the solutions developed together with our customers. At the same time, they illustrate the broad scope of our activities and the diverse requirements entrusted to us by customers around the world.

We hope you enjoy reading this report and find it both interesting and informative. We are pleased to give you an insight into the diverse activities of Prof. Dr. Jaberg & Partner GmbH.

Together with our experienced team, we will continue to support our customers with comprehensive engineering expertise, personal commitment and practical solutions – in Austria, across Europe and around the world. We would like to thank our customers and project partners for the trust they have placed in us and look forward to continuing to work together on challenging engineering projects and developing successful solutions in the future.

Kind regards

Jürgen Schiffer-Rosenberger



ABOUT US

We offer powerful numerical simulations for multi-dimensional calculations, extraordinary expertise in the design and optimisation of hydraulic turbomachinery and- thanks to our close links with research and educational institutions- experimental and metrological expertise and experience, particularly in the field of model measurements in accordance with IEC/ISO standards and plant measurements.

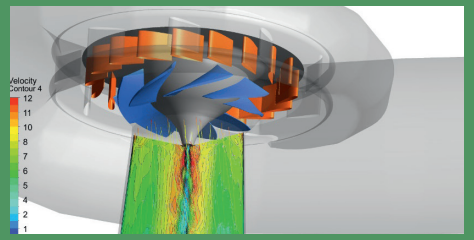
With our expertise and knowledge in “Numerical Simulations / 3D - CFD” we support our partners (manufacturers, operators, planners and authorities) in the field of fluid mechanics in general – and for pumps and turbines in particular. Our well-founded Know-how gained over decades of extensive experience is based on numerical flow simulation (CFD) as well as on experimental experience.

We subject our designs to experimental verification in accordance with IEC 60193 and preferably rely on the IEC test rigs of the Institute for Hydraulic Fluid Machinery of the Graz University of Technology, which Prof. Jaberg headed for over 25 years until December 2020.

In our tailor-made trainings in all fields of hydraulic fluid machinery, we provide user-oriented and profound knowledge. These programs are founded on our well-grounded Know-how and our expertise.

We are independent and work as a team with our partners and customers from industry, research and science. With our expertise, we cover the entire value-added process – from market requirements to implementation.

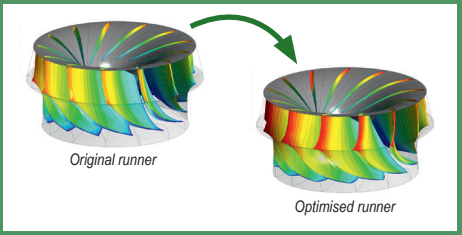
Numerical Simulation



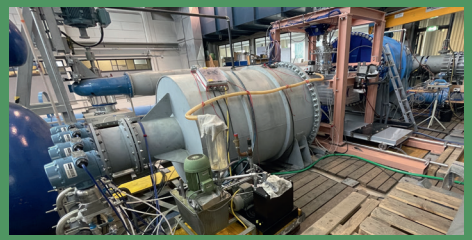
- *Analysis and design of hydraulic fluid machinery, components and systems*
- *Water hammer and pressure surge as well as transient conditions of fluid and gas flows*
- *Fluid structure-interaction*

Optimisation & Refurbishment

- *Potential identification study*
- *Damage analysis*
- *Customised design optimisation*
- *Reference runners based on model tests*



Model Test



- *Support in course of model tests acc. to IEC 60193, ISO 9906, IEC 60534*
- *Comparison of experimental data with numerical simulation results (CFD)*

On-Site Measurement Technology

- *Measurements of industrial plants and power plants acc. to IEC 60041 and IEC 62006.*
- *Thermodynamic efficiency measurement, Acoustic Doppler, etc., sound measurement, discharge measurement, vibration measurement*

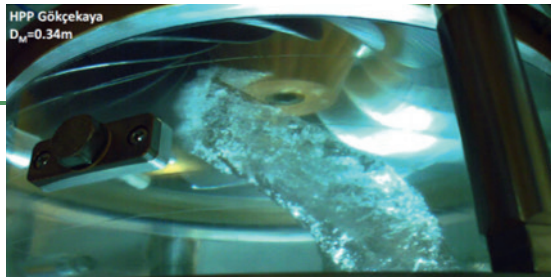


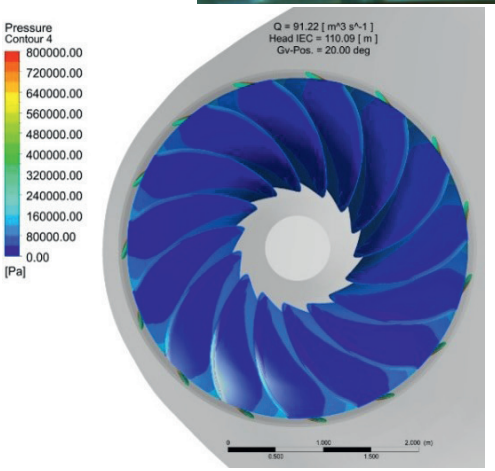
Assessments & Consulting

Our profound know-how, experience and well-established numerical as well as experimental methodology ensure the quality of our work on innovations and independent expertise.

- *Feasibility studies*
- *Modernisation of power plants and systems*
- *Product development potential*
- *Support with regard to Environmental Impact Assessments*

HYDRAULIC DEVELOPMENT OF TURBINE DESIGNS WITH MODEL TEST





Design verification, optimisation and model test for the refurbishment of a hydro power station in Turkey

The subject of investigation was a large hydro power plant located at the river Sakarya west of Ankara. The plant is equipped with 3 Francis units – each with a runner outlet diameter of around 3.6 m, which were manufactured by Allis Chalmer and brought into operation in 1973.

Jaberg & Partner was commissioned to support a Turkish consortium with consulting services with the aim of comprehensively refurbishing the power plant. The consulting activities were focussed on the

- CFD-Simulation and design verification
- Optimization of the Francis runner and guide vanes
- Mechanical calculations
- Basic design review
- Witness test on the model test rig

In general, the 3 units were in quite poor condition when a first inspection took place. Due to a fire caused by a transformer, one of the turbines had even been out of service for quite some time.

While maintaining the embedded components like the spiral case with its stay vanes, the draft tube cone and the main part of the draft tube, a new distributor and new runner needed to be optimized for an operation between H = 100 – 110 m and a discharge between Q = 86 – 98 m³/s.

Within the given operation range, an efficiency weighting was defined. The challenging target of the optimization was to achieve a weighted averaged efficiency of 94.5%.



Powerhouse location below the barrier



Spare runner in front of powerhouse

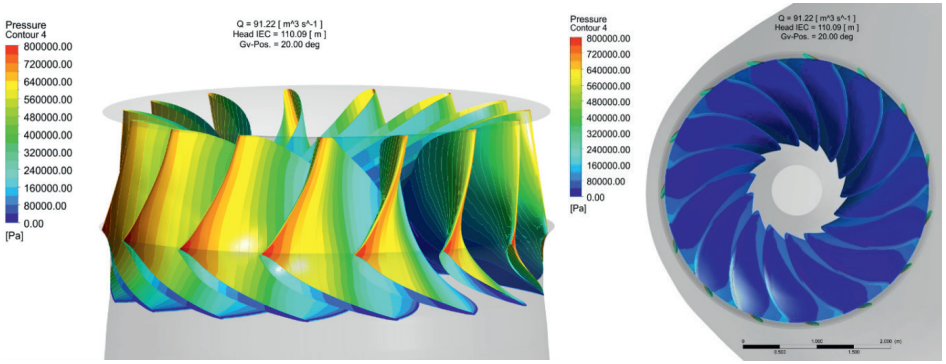
According to the given specifications, the specific speed nq of the turbine is calculated as:

$$\rightarrow n_{q,\,BEP} = n \cdot \frac{\sqrt{\frac{Q_{BEP}}{Q_{ref}}}}{\left(\frac{H_{BEP}}{H_{ref}}\right)^{0.75}} = 187.5 \cdot \frac{\sqrt{\frac{0.9 * 103}{1}}}{\left(\frac{107}{1}\right)^{0.75}} \approx 54.3\ rpm$$

At the beginning of the study, the main dimensions of the entire turbine were analysed, which showed that the turbine was initially designed clearly too large for the given operating conditions. This initial assumption was confirmed by CFD-simulations of the existing turbine configuration. It was therefore reasonable to assume, that the system was mainly operated in the partial load range of the hill chart, which also explains the damages found on the runner and the obviously big problems with vibrations.

To shift the Best Efficiency Point of the turbine to the right range of operation, several measures were required. While the shape of the hub- and shroud-contour of the runner were almost retained, the meridional section of the runner was significantly changed. Furthermore, the wrap angle of the blade profiles was strongly increased, and the exit angle of the blade was strongly decreased.

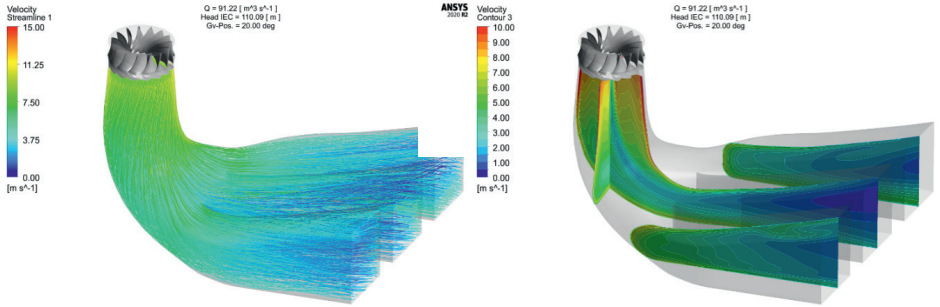
A visualization of the optimized runner design is presented with the following Figure. The pressure distribution plotted on the surface of the runner refers to the Best Efficiency Point of the turbine.



Pressure plotted on the optimized runner at the Best Efficiency Point

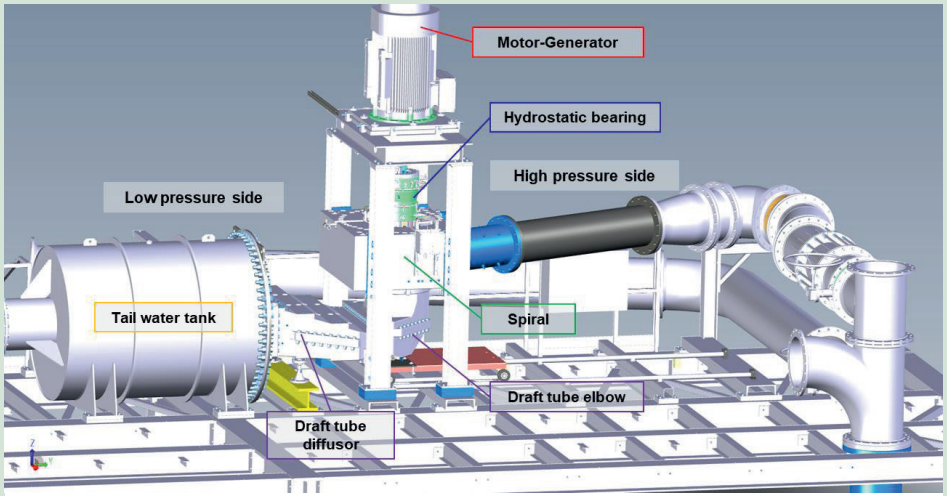
Furthermore, the following Figure presents the velocity distribution plotted on several cross sections in the draft tube as well as 3D streamlines. The visualization also shows the unique design of the draft tube, featuring two vertical support walls and three discharge channels.

By applying a full 360° CFD-model the simulations were extended from standard operation conditions to extreme off-design conditions, to be able to capture even the runaway-curve of the turbine. To calculate the prototype efficiency, the efficiency determined in course of the simulation was corrected by empirical data for the losses occurring in the runner side spaces of the runner. At the end of the optimization process, a peak efficiency of around 95% was achieved at H = 110m and Q = 91 m³/s. Based on this finding, the model test of the optimized turbine configuration was initiated.



Visualization of the draft tube flow at the Best Efficiency Point

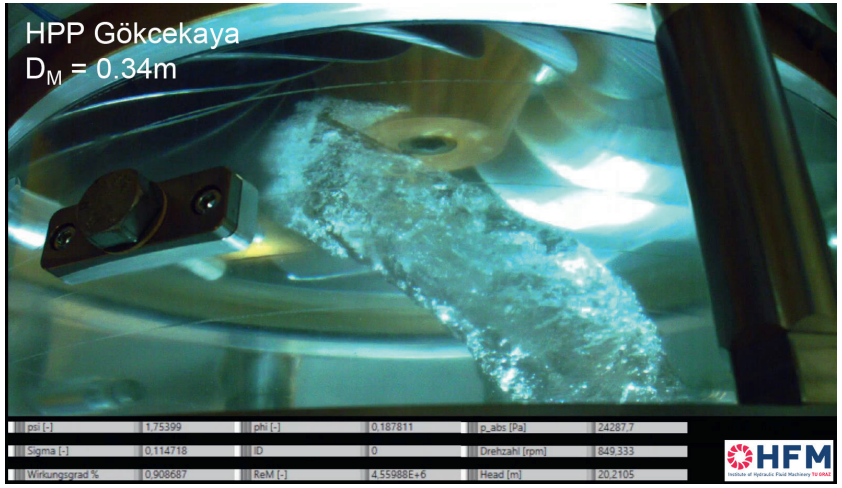
The homologous model test was finally performed at the laboratory of the Institute for Hydraulic Fluidmachinery at Graz University of Technology. An overview of the test rig design and the installed model turbine is presented with the Figure shown below.



Overview of the test rig design and the installed model turbine

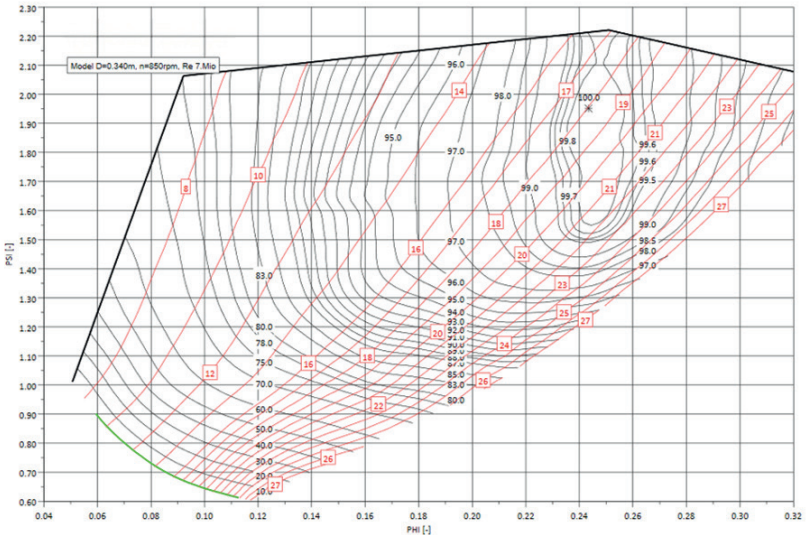
In course of the model test the operation parameters were extended to the same range as previously used for the CFD-simulation. In addition to the standard measurement quantities – like the discharge, head, runner torque, system pressure, …. – also, the hydraulic torque acting on the guide vanes and the axial force acting on the runner were determined. Furthermore, special attention was paid to the investigation of the speed-no-load conditions. Additionally, efficiency drop curves resulting from cavitation effects were measured at several operation points. To gain a better insight into the cavitation effects to be expected, a high-speed camera was used for the purpose of visualizations.

As an example, the following visualization presents the cavitating part load vortex investigated on the test rig at part load operation at the critical Thoma-value of the plant.



Visualization of the cavitating part load vortex on the model test rig

Finally, the measurement campaign once again proved how close the simulation results are to reality. The comparison of the hill chart predicted based on the CFD-study and the one created based on the measurement results (see normalized hill chart in the Figure below) shows an excellent agreement of the turbine efficiency and cavitation characteristics. The main difference found between the results of the CFD-study and measurements is that the location of the Best Efficiency Point was slightly shifted to lower discharge in case of the experimental study.



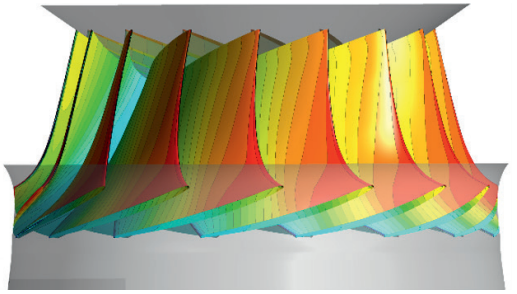
Hill chart of the optimized prototype turbine created with the measurement results

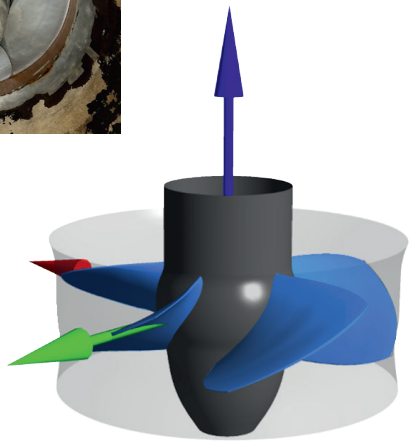
The fact that the results achieved during the optimization process fully met the expectations of all project partners helped to ensure that the project was completed on schedule to the customer's complete satisfaction.

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REFURBISHMENT







Design adaptation of Francis runners of existing power plants for the future operation at reduced flow due to climatic conditions



Dam and power station

Climate change is not only affecting the lives of humans, wildlife and vegetation but also having an increasing impact on the operation of hydropower plants. Dry periods are becoming longer and more intense, and extreme weather events with flooding more frequent. While hydropower plants of all types were designed for somewhat even discharge decades ago, today, they must be operated more frequently at low partial load and full load conditions. At the same time, operation in the medium load range is becoming increasingly rare. If power plants are operated at larger reservoirs and if the dam also has irrigation purposes to fulfil, it can also be observed that the available head decreases because of insufficient inflow. These facts not only lead to operation at reduced efficiency. Reduced head and comparably low discharge are typically associated with rough operating conditions accompanied by cavitation and vibration.

One possibility of adapting existing hydropower systems to changes in the operational management is to customize the design of the runners, which quite often have already reached the end of their service life. With Francis-turbines in particular, it is possible to shift the Best Efficiency Point and the entire efficiency curve by adapting the blade design to a reduced flow rate and/or reduced head. The advantage of a subsequent design customization of existing Francis runners is, that the main outer dimensions of the runner (inlet diameter, outlet diameter, height at the runner inlet and overall height of the runner) can often remain unchanged, which facilitates the overhaul of the affected systems. Successful design customization of hydropower plants is achieved by many years of experience in turbine design and numerical flow simulation.

Using a Turkish reference project as an example, we hereby present the results of such a study. The case study is related to a hydropower plant located on the Zamanti river in the Pınarbaşı district of Kayseri / TURKEY and was commissioned in May 2006. The dam (see Figure) was constructed between 1996-2002 and originally, hardly any water extraction was planned for irrigation. The 2 horizontal Francis-turbines were thus designed for a net head of H = 50 m and a maximum discharge of Q = 5 m³/s each.

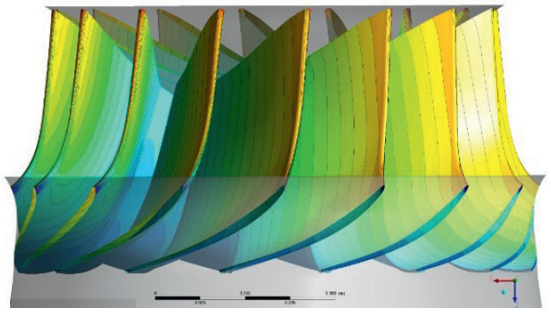
Since the commissioning of the power plant in 2006 the operation conditions have now changed due to climatic conditions. Today, irrigation is the primary objective of the reservoir management. Thus, the reservoir is actually operated with water levels which are quite different to the original ones. Consequently, the new operation data of the turbine are Q_{Max} < 4 m³/s and H = 16 – 40 m. It is obvious that the combination of reduced flow and greatly reduced head leads to harsh operating conditions for the original turbine configuration.

The new operation conditions apply for at least 8 months per year. For this reason, the idea of an interchangeable runner specially adapted to the new operating conditions was also considered in this case.

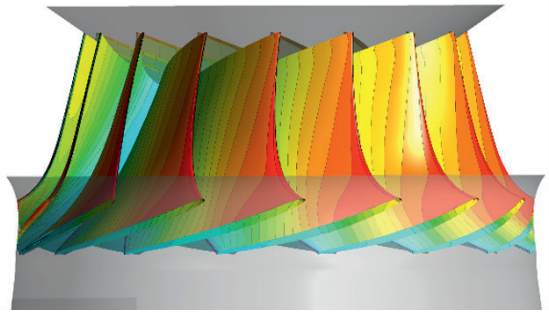
The customized new runner design optimized for reduced discharge AND head was developed based on the findings of the CFD-simulation of the original turbine configuration. The commercial software package CFturbo© was used as the design tool for the new runner.

Especially the adaptation of the blade design to the strongly reduced head was a challenging task. For this purpose, the leading edge had to be shifted to a lower diameter and the blade inlet angle needed to be strongly decreased. Furthermore, the necessary measures led to an extension of the runner blades.

A comparison of the original runner and the runner optimized for the changed operation conditions is presented with the Figures below. Both visualizations show the pressure distribution plotted on the runner blades at the Best Efficiency Point. The geometric difference of the two designs is obvious.



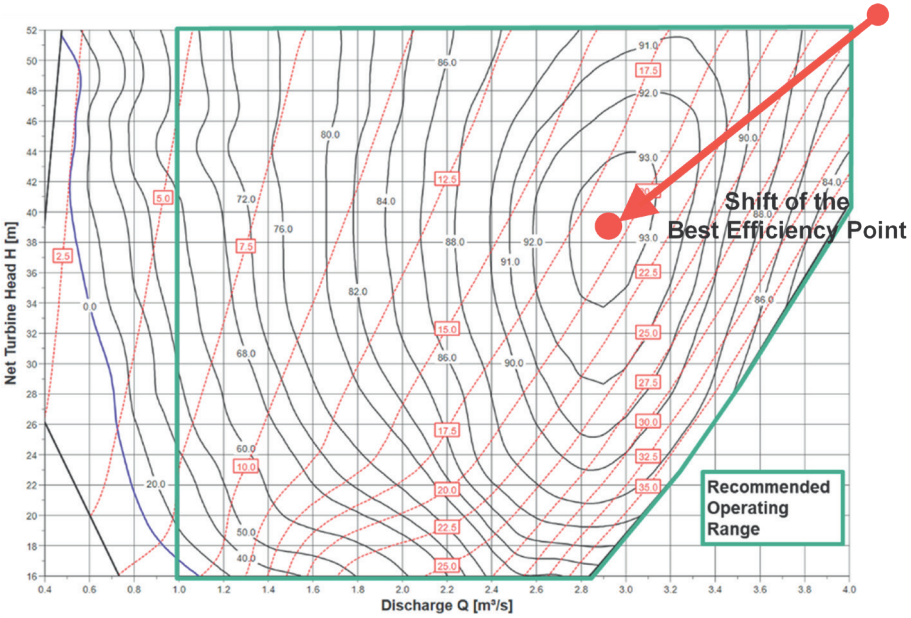
Blade pressure distribution on the original runner at BEP



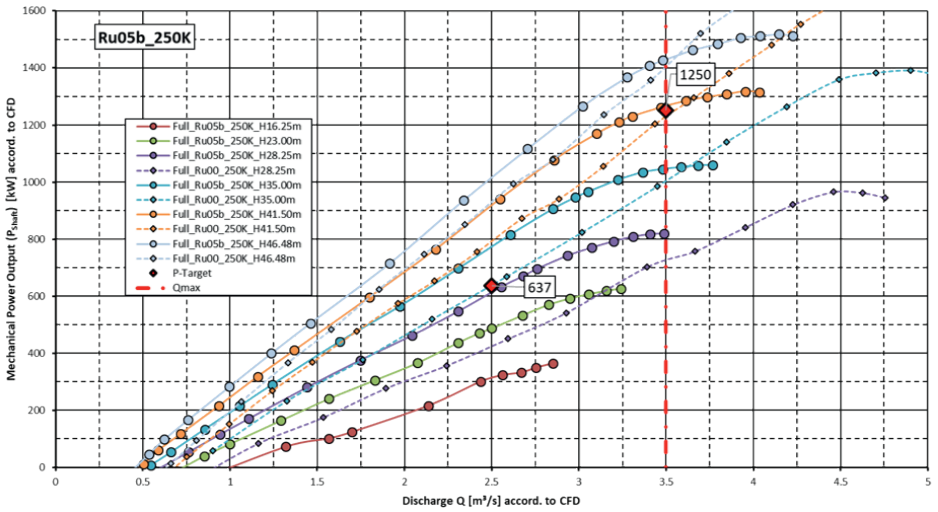
Blade pressure distribution on the runner optimized for changed operation at BEP

The final runner design optimized for reduced discharge and head was not only investigated at nominal operation conditions, but also at off-design conditions. Finally, the simulation results achieved in course of a strong variation of head and discharge were used to create a turbine hill chart which is presented in the following Figure. While the solid black curves represent the turbine efficiency, the dashed red curves refer to the corresponding opening of the guide vanes (in degrees). The losses occurring in the runner side spaces (due to disc friction and leakage) were considered with 0.75 percentage points of the power generated at the best efficiency point (see IEC 62256).

It turns out, that the new Best Efficiency Point is located at H = 39 m and Q = 2.9 m. In comparison, the Best Efficiency Point of the original turbine configuration was at H = 52.5 m and Q = 4.5 m³/s.



Turbine hill chart of the runner optimized for new operation conditions calculated by means of CFD



Comparison of the power output achieved with the original and new runner at various head levels

However, the benefits of the new runner design are best illustrated by the Figure shown below. The diagram presents a comparison of the power output achieved with the original and new runner design at various head levels shown in different colours. While the dashed curves refer to the original runner design, the solid curves represent the power output to be expected with the optimized runner design. Especially at low head levels, the improvements achieved with the runner adapted to the changed operation conditions are remarkable.

Based on the findings of our CFD-based development work, it is expected that there will be a considerable benefit for the existing power plant. The presented study impressively demonstrates how existing hydroelectric power plants can be adapted to new operating conditions resulting from climate change.

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Potential Assessment Study as a Basis for Decision-Making on Refurbishment Measures for a Vertical Kaplan Turbine

For a renowned German energy utility, we carried out a multidisciplinary potential assessment study for a hydropower plant equipped with two vertical Kaplan turbines. The results and findings of the study served as a basis for decision-making regarding various refurbishment options.

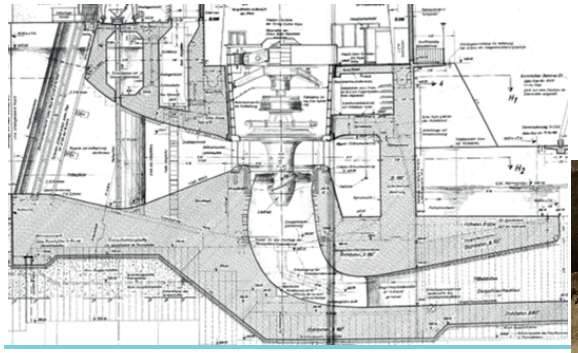
The plant, whose sectional view is shown in the figure below, has a net head of approximately 8 m and a maximum flow rate of around 80 m³/s per turbine. The five-bladed Kaplan turbines have an original runner diameter of D = 3.7 m and a guide vane system with 20 guide vanes. The turbine speed is n = 125 rpm.

Commissioned in 1961, the plant and its two vertical Kaplan turbines were still more or less in their original condition and were therefore scheduled for comprehensive refurbishment. Due to significant cavitation damage to both the runner blades and the shroud ring, three optimisation options were considered:

Option 1: Blade optimisation while retaining the existing hub and the existing turbine shroud contour

Option 2: Blade optimisation while retaining the existing hub, combined with a NEW, enlarged turbine shroud contour

Option 3: Development of a completely new runner with a reduced hub and an enlarged turbine shroud



Cross section of the turbine

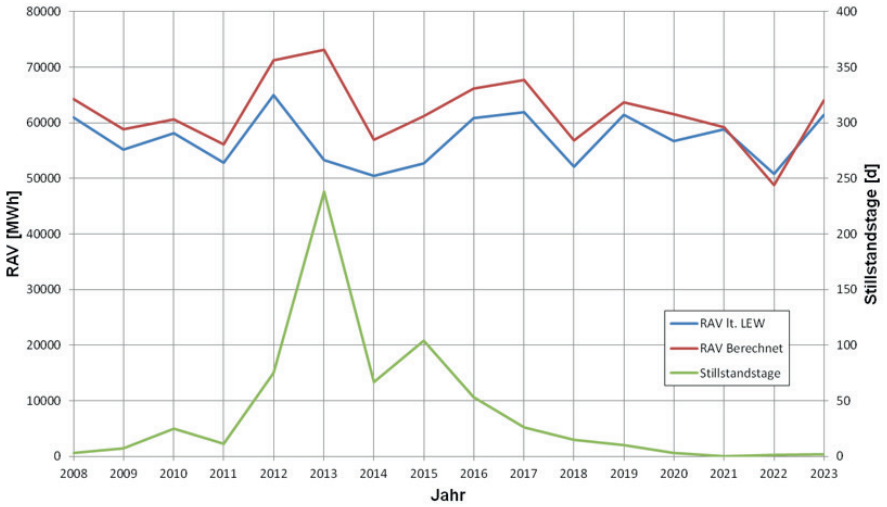


Photograph of the original runner

As the starting point for the investigation, the complete flow passage geometry of the turbine was measured on site using a 3D scanner and subsequently modelled based on the scan data. In the next step, a 3D CFD study of the existing turbine configuration was carried out to identify the deficiencies of the current design. This also enabled the performance of the existing turbine design to be determined.

Based on the annual flow duration curves from the previous 15 years, the annual energy yield was then calculated and compared with the recorded actual production data.

The following figure shows, as an example, the annual energy yield determined for the period from 2008 to 2023 based on the production data (blue) and based on our analysis (red). The minor differences between the analytical results, which are particularly noticeable between 2012 and 2018, can be attributed to the unplanned downtime days identified retrospectively (green).



Calculation of the annual standard working capacity for the past 15 years

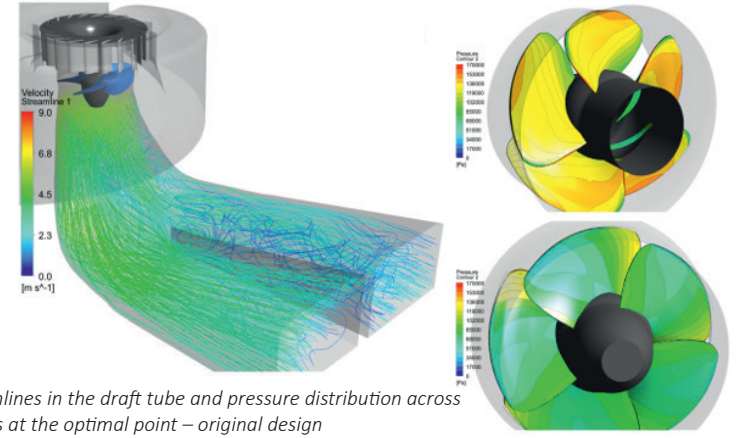
After a very good correlation had been established regarding the annual energy yield, optimisation variants were developed for the three options described above. Their efficiency characteristics were calculated using repeated CFD analyses. Based on these results, a new annual energy yield was determined for each variant. The calculated increase in annual energy yield for each option ultimately served as the basis for selecting the most economically viable refurbishment concept for the plant.

To keep the scope of the refurbishment measures as small as possible while still maximising the annual energy yield, the operator ultimately decided to retain the existing hub and, consequently, the existing number of blades. The heavily damaged turbine shroud was to be replaced by a new and enlarged shroud, while a new, tailor-made runner was to be manufactured accordingly (see Option 2).

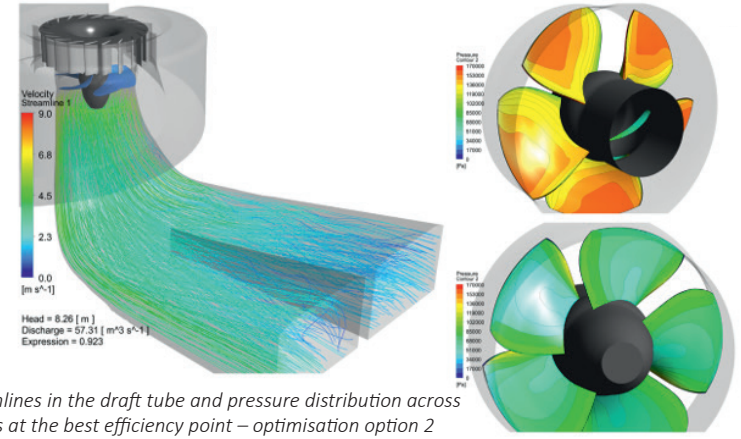
The CFD simulations demonstrated that this concept would increase the peak efficiency by approximately 2.5 percentage points and raise the cavitation-safe flow rate from currently around Q = 85 m³/s to approximately Q = 95 m³/s per turbine. The final economic assessment consequently indicated an increase in annual energy yield of just under 4%.

Based on the findings of this study, the operator has since decided to refurbish the first of the two turbines and bring it up to the latest state of the art.

For the best-efficiency point at rated head, the following figures compare the flow conditions in the draft tube and the turbine runner for the current runner design (top) and the optimised runner (bottom). Through the tailored optimisation of the Kaplan runner, an improved pressure distribution over the significantly shortened runner blades and a separation-free flow in the draft tube were achieved.



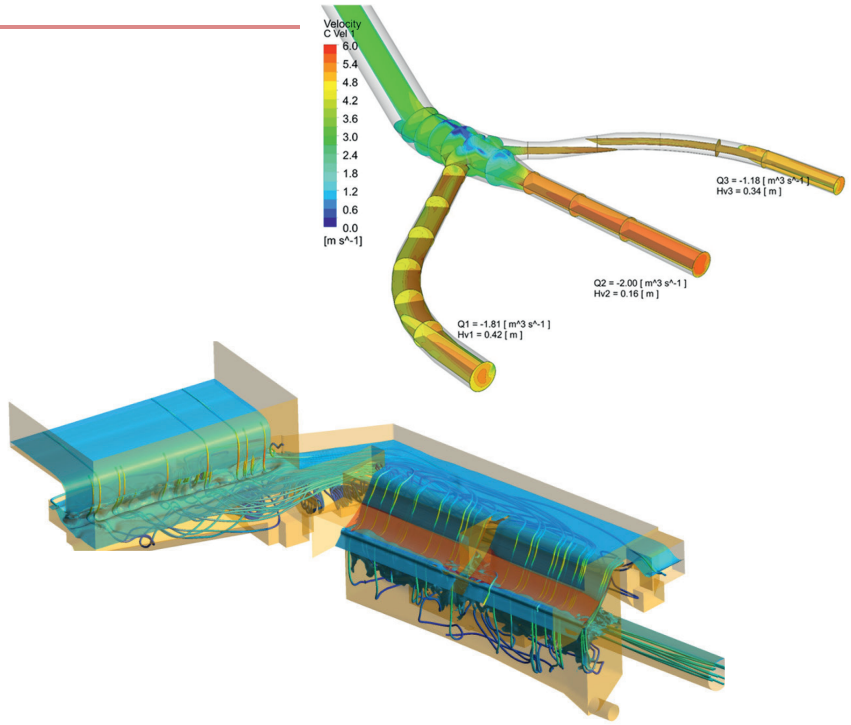
3D streamlines in the draft tube and pressure distribution across the blades at the optimal point – original design



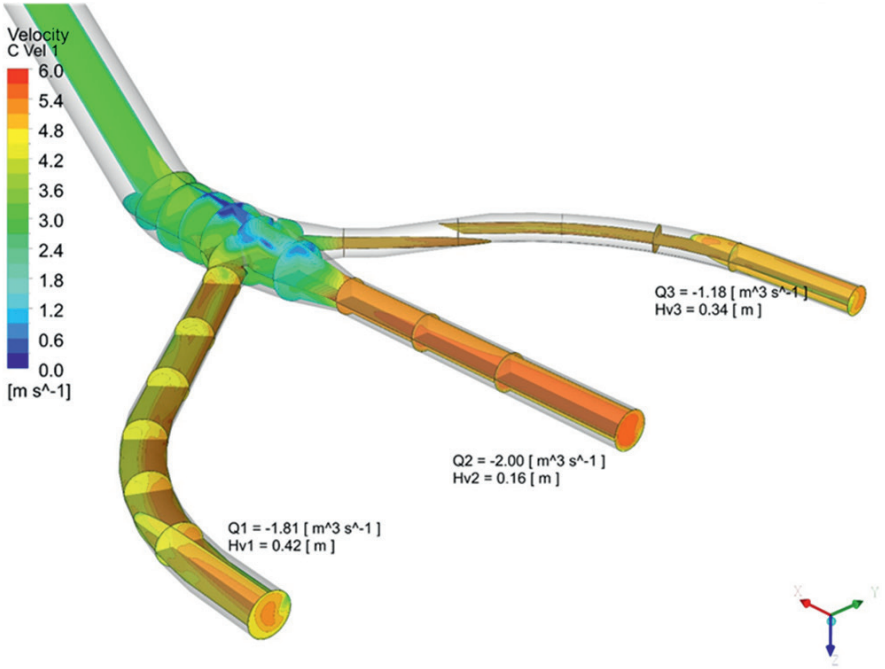
3D streamlines in the draft tube and pressure distribution across the blades at the best efficiency point – optimisation option 2

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PIPING SYSTEMS AND PLANT ANALYSES



Flow analysis and optimisation of a trifurcation as a distribution pipeline for a high-pressure hydropower plant



Velocity distribution at different section planes in the distribution pipe referring to the initial design proposal

For a newly constructed high-head hydropower plant equipped with three Pelton turbines (2 × 8.4 MW, 1 × 5.4 MW), the distribution pipeline was to be designed as a trifurcation.

At first glance, the design of such a pipe junction may appear to be a straightforward task. However, experience has shown that the flow conditions in these junctions can often prove challenging. The inevitably decelerated flow at the junction of the three-way branch is highly susceptible to flow separation. This can result not only in increased hydraulic losses, but also in flow pulsations within the individual pipeline branches. For this reason, distribution pipelines with three or more branches have in the past often been designed with staggered branch connections. While this approach can improve the flow conditions, it generally also results in higher manufacturing costs.

On behalf of a manufacturer of small hydropower plants, we recently carried out a flow analysis and optimisation of such a distribution pipeline. The following figure shows the velocity distribution at different cross-sectional planes for the initial design, assuming full-load operation of all three turbines. The unfavourable flow conditions identified at the trifurcation junction are clearly visible, particularly in the dark-blue zones.

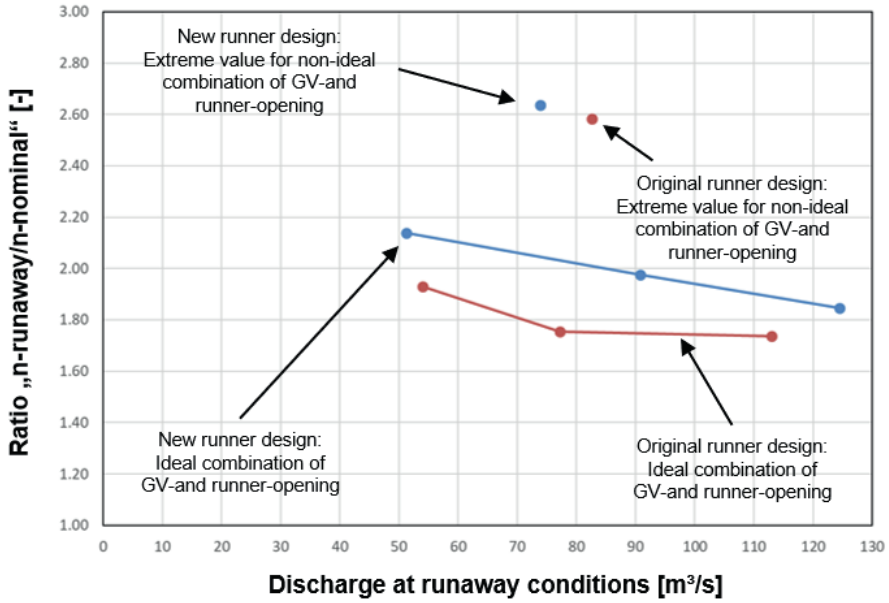
Through several successive design modifications, the flow conditions were ultimately significantly improved for different operating modes, resulting in a satisfactory overall solution.

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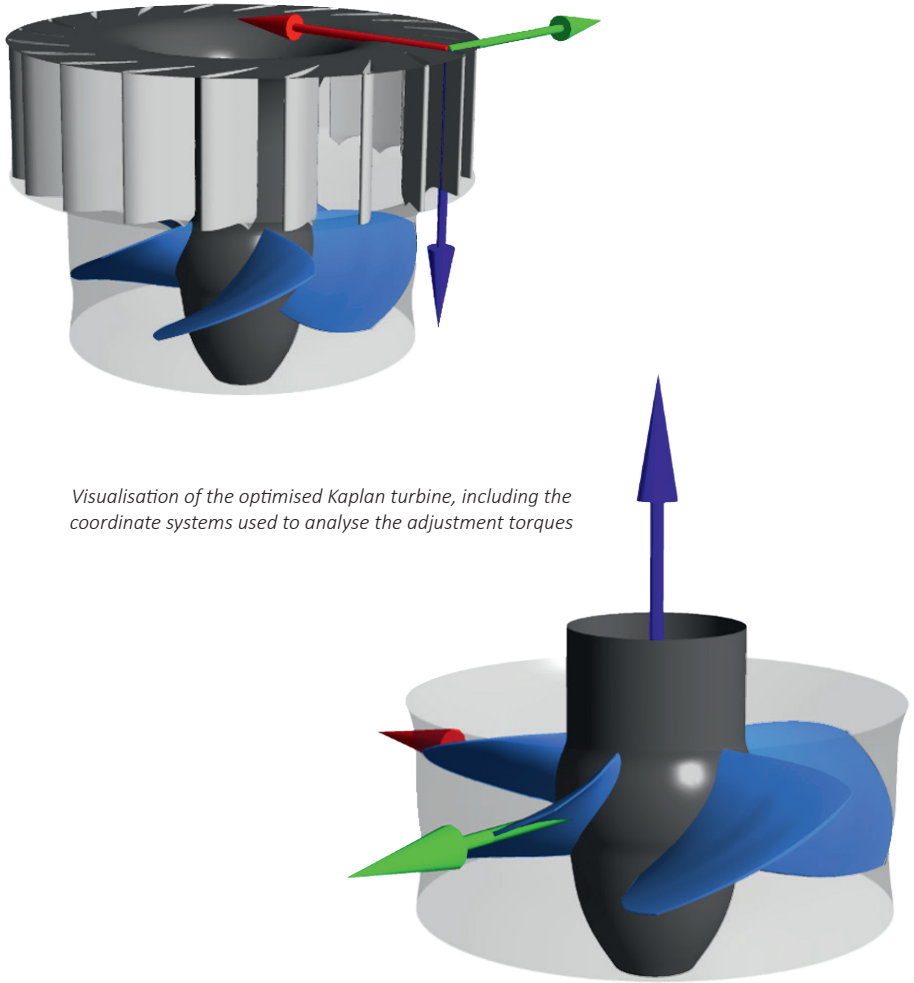
Simulation of the Runaway Behaviour of a Kaplan Turbine as Part of a Refurbishment Project

In order to determine the runaway speed of a turbine and to dimension the adjustment mechanisms of the guide vanes and runner blades for extreme load cases, the hydraulic behaviour of the turbine during load rejection must be known. This can be determined either on a model test rig or by means of CFD simulations. The latter is often the only viable option, particularly for the refurbishment of small- to medium-sized hydropower plants.

Based on a CFD model that had already been developed as part of the optimisation project, flow simulations were carried out in the runaway operating range. In this particular case, the simulations were performed for both the original runner and the newly developed runner, in consultation with the customer, for selected combinations of runner blade and guide vane positions. For each design, runner blade positions covering full-load operation, the best efficiency point and part-load operation were considered. For the smallest runner blade opening, the maximum possible guide vane opening was additionally investigated in order to determine the extreme values for off-cam operation.



Example of the ratio of runaway-speed to nominal speed as a function of flow rate during load rejection



Visualisation of the optimised Kaplan turbine, including the coordinate systems used to analyse the adjustment torques

The investigation showed that the use of the new runner design results in a slight increase in runaway speed following load rejection from rated operation with an ideal guide vane/runner blade combination. However, the resulting ratio of nDG/nNominal does not reach the original manufacturer's specified value of nDG/nNominal = 2.5 stated on the turbine nameplate.

The maximum runaway speed is reached at a relatively small runner blade opening combined with the maximum guide vane opening, i.e. with the guide vane/runner blade relationship decoupled. Under these conditions, both the new and the original design reach an extreme value of approximately nDG/nNominal = 2.6.

The evaluation of the guide vane adjustment torque showed that the extreme values following load rejection from full-load operation are approximately twice those occurring under rated operating conditions. In contrast, the mechanical runner blade actuating torque increases much more significantly during load rejection. The investigation demonstrated, however, that the increase in runner blade adjustment torque is considerably greater for the original design than for the newly developed runner design.

The investigation therefore provided important insights for the dimensioning of the new turbine components, ensuring their safe and reliable operation in the future.

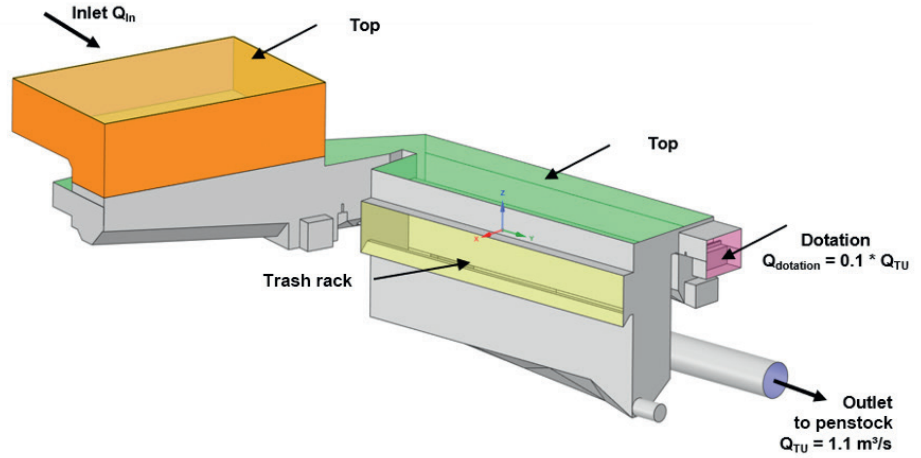
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Analysis of the Flow in a Water Intake Structure and Development of Improvement Proposals

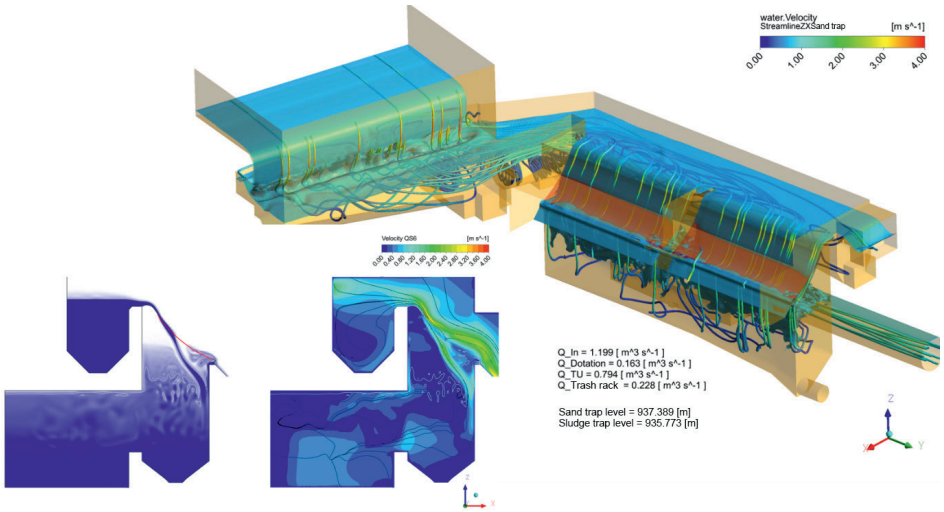
A renowned Austrian energy supplier has been operating a high-pressure hydropower plant in an alpine region for some time. The investigated plant is equipped with a vertical 6-jet Pelton turbine with a rated output of approximately 1.1 MW at a net head of around 112 m.

During operation, an increasing amount of sediment was observed in the headwater, with sludge being partially forced out through the shaft penetration of the turbine casing. Deposits of fine sediment were also found in the tailwater channel. This occurred particularly frequently following shutdowns, suggesting that sediment was also settling in the penstock during these periods.

For this reason, the water intake structure, located approximately 1 km from the powerhouse, had to be investigated in detail. In addition to a gravel and sand trap, the intake structure comprises a Coanda screen and a sediment trap for separating particles transported by the water. Several on-site inspections revealed that the separation efficiency of the structure was insufficient and that relatively coarse solids were repeatedly transported as far as the actual intake. To analyse the problem in detail and derive suitable countermeasures, the flow conditions within the intake structure were investigated using CFD.



Flow volume of the water intake, extracted from the client's CAD model



An example result from the CFD simulation

Based on the CAD model of the intake structure provided by the client, the hydraulically relevant volume was extracted for the CFD simulations (see figure). The geometry of the gravel and sand trap was incorporated into the simulation model in detail. To obtain a realistic representation of the flow conditions, the Coanda screen, which is typically designed with very narrow slots, was also included in the simulation. It was modelled as a porous medium. The dynamic residual flow release at the sand trap (10% of the design flow rate), the opening at the coarse screen and, of course, the headwater conveyance to the turbine were also included in the simulations.

The 3D CFD simulations were carried out using ANSYS CFX with a transient two-phase modelling approach. This was essential for realistically resolving the phase separation between air and water and obtaining simulation results that were consistent with the observations made on site.

The following figure shows an example of the results obtained from the simulations. The upper right-hand image shows a 3D representation of the simulation with the air/water phase boundary and 3D streamlines. The two lower images show sections through the intake structure in the region of the Coanda screen. The left-hand section again shows the air/water phase boundary, while the corresponding flow velocities are displayed in the image on the right. These detailed evaluations also provide a clear visualisation of the operating principle of the Coanda screenw.

Based on the findings of our flow simulations, simple countermeasures were ultimately developed that could be implemented with relatively little structural effort and have since proven successful in operation.

What initially appeared to be a relatively straightforward task for a small hydropower plant ultimately involved a considerable amount of numerical effort. Furthermore, the study demonstrated that solving such flow-related problems requires extensive experience and expertise in flow simulation in order to correctly interpret the simulation results and derive the appropriate conclusions.

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ONSITE MEASUREMENTS







Index Measurement of a Kaplan Turbine before Rehab

Headwater area of the power plant and turbine intake area of the two turbines (on the right)

Jaberg und Partner was consulted for the refurbishment of a run-of-river power plant with two vertical-shaft Kaplan turbines. Our tasks were to analyze the existing hydraulic turbine design, design new turbines using numerical flow simulation, and conduct field measurements of the old turbine's hydraulics. After installing and commissioning the new turbines, further measurements should be taken to evaluate their Performance improvement.

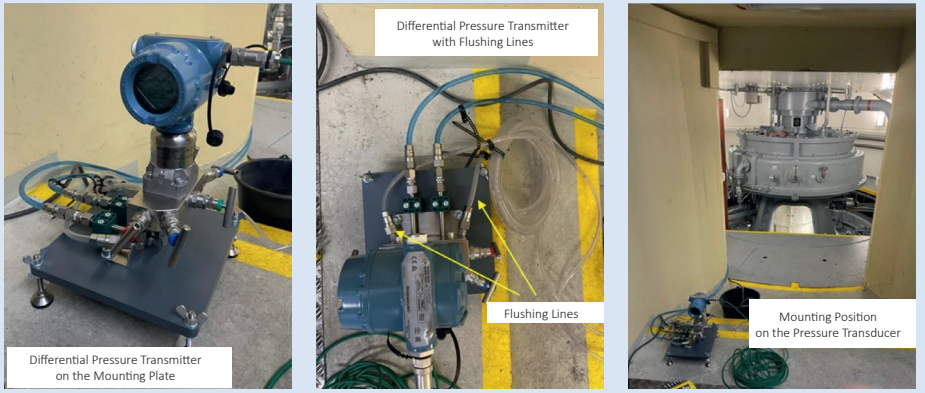
The contract documents specified that only an index test was necessary to compare the existing turbine with the new one. A comprehensive discharge measurement was not conducted. Instead, we determined relative discharge using differential pressure measurements at designated pressure taps on the turbine. This method, also known as the Winter–Kennedy method, or index test, was used.

A historical index test along with measurement data and a report from 1956 already exists for the plant and turbines. The recent index test, conducted prior to the turbine's conversion, was meant to be compared with this earlier measurement and should serve as the basis for comparing with the new turbine design. The index test for one of the two Kaplan turbines followed IEC 60041 standards.

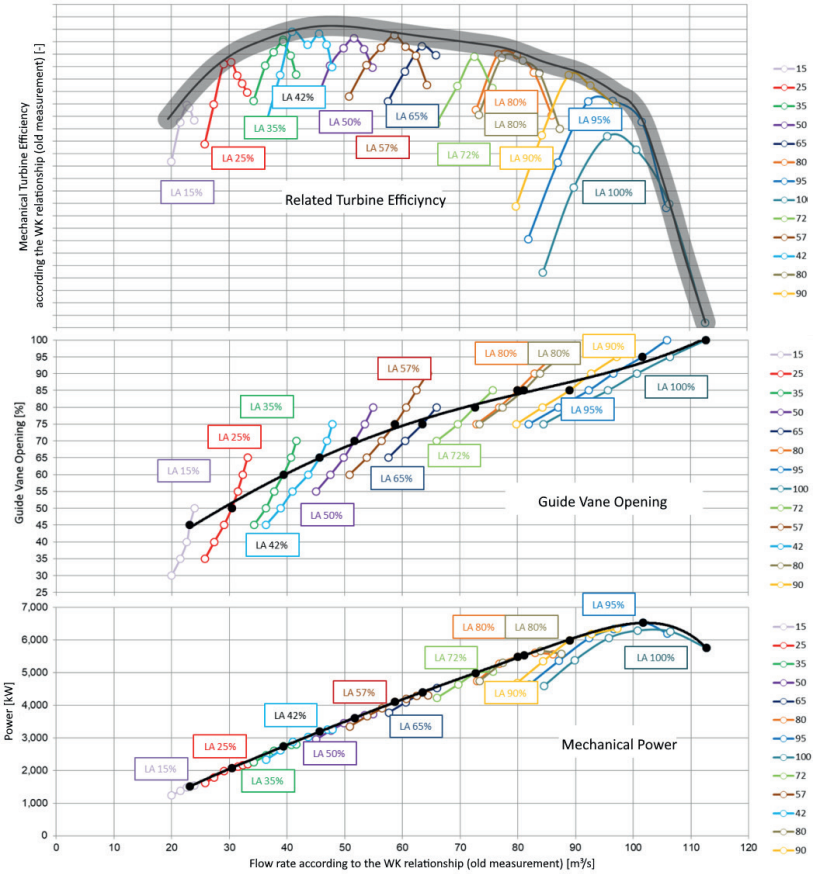
The measurement setup for the index test was straightforward: it required only a high-precision differential pressure sensor calibrated for the expected pressure difference between the two measurement taps—located on the outside of the spiral casing and on the stay vanes of the spiral casing. All other measurements, such as head levels (to determine the turbine head) and generator power, were taken using the existing instrumentation installed in the power plant, which proved sufficiently accurate upon inspection.



Measurement equipment for the Index-Test of the Kaplan-Turbine



High Precision Differential Pressure Transmitter for the Index-Test



Analysis and Processing of Measurement Data from the Index Measurement

Additionally, we cross-checked the level measurement with reference points from a land survey on both the headwater and tailwater sides.

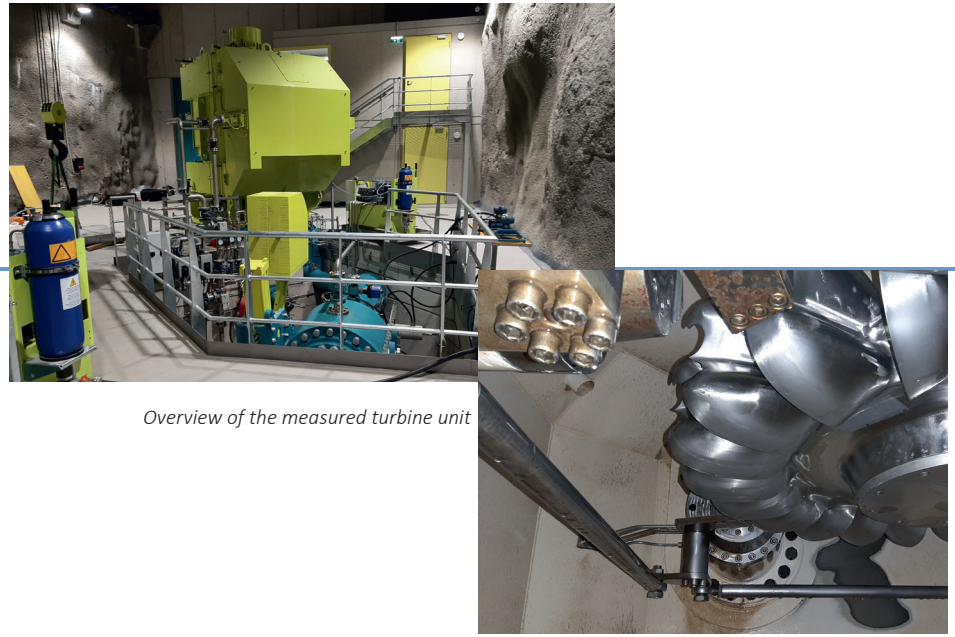
When assessing the measurement data and aiming for better comparability, the relationship between discharge and differential pressure from the original 1956 measurement report was used. The data collected prior to the power plant's general overhaul—before the installation of new turbines—still needs to be compared with the new data gathered after the conversion. This follow-up measurement is scheduled for 2027.

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Thermodynamic efficiency measurement of a 4-nozzle Pelton Turbine

Increasingly, field measurements are also being carried out at smaller hydropower plants following completion or successful commissioning. These field measurements can be performed using various measurement methods.

Jaberg und Partner was engaged as an independent, neutral body to conduct field measurements of a cavern-type hydropower plant in the Tyrolean mountains, which was suggested by the HFM Institute of TU Graz. The cavern power plant is equipped with two 4-nozzle Pelton turbines, and we carried out a thermodynamic efficiency measurement on one of the two turbines (fully compliant with IEC 60041). This measurement was intended to confirm the specified turbine efficiency.

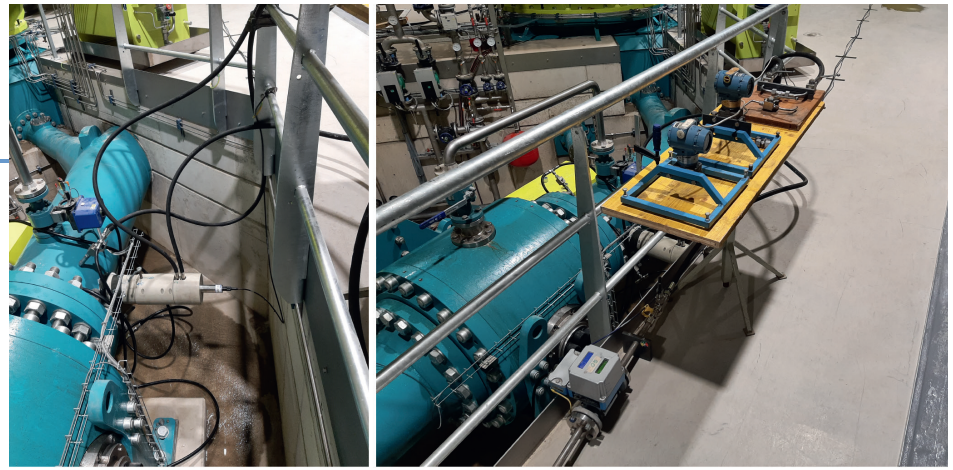


Overview of the measured turbine unit

The Pelton turbines are operated under the head of 390 m, a nominal discharge of 1.8 m³/s, and a maximum output of 6.27 MW.

In very simplified terms, the basic principle of thermodynamic efficiency measurement is that all flow losses in the water (turbine losses) increase its temperature (in the mK range, depending on head and turbine efficiency). The absolute turbine efficiency can therefore be determined from the temperature difference between the high-pressure side (upstream of the turbine) and the low-pressure side (downstream of the turbine), using ultra-high-resolution temperature sensors, without measuring the turbine discharge, which is always the most crucial variable with the highest measurement uncertainty.

The figure below shows the high-pressure-side measurement location upstream of the turbine, with the installed Sea-Bird temperature sensors in the insulated chamber, together with the pressure measurement via the ring manifold. The right-hand side of Figure shows the pressure sensors (relative and absolute pressure) for the headwater-side measurement on the leveling table, as well as the flow measurement of the extraction water via the measurement chamber.



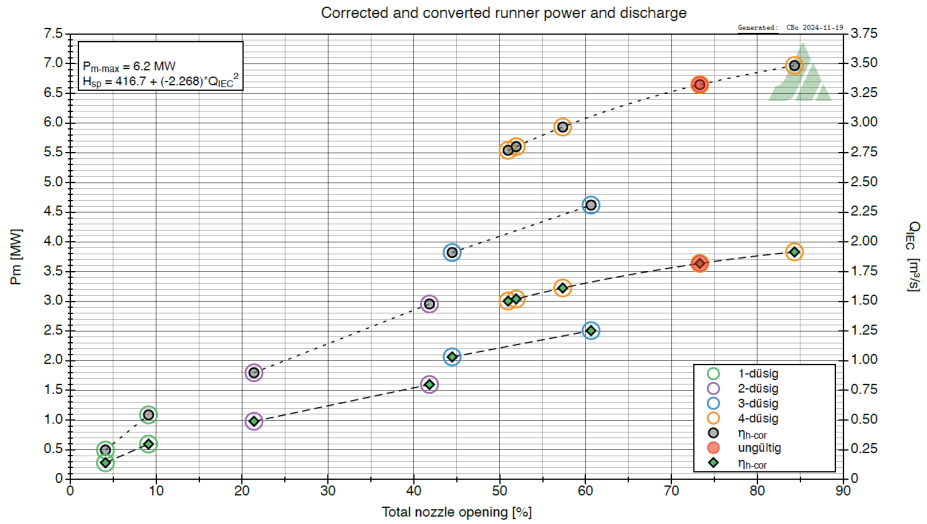
High pressure side measurement section: Penstock with applied temperature sensors (measurement chamber) and Pressure sensors (right)

The following figure shows the tailwater-side measurement location in the outlet channel directly downstream of the turbine, where a measurement frame was installed to mount all tailwater-side sensors. Six high-precision Sea-Bird sensors were used to measure the tailwater temperature. In addition, two level probes are mounted on the measurement frame to determine the turbine head.



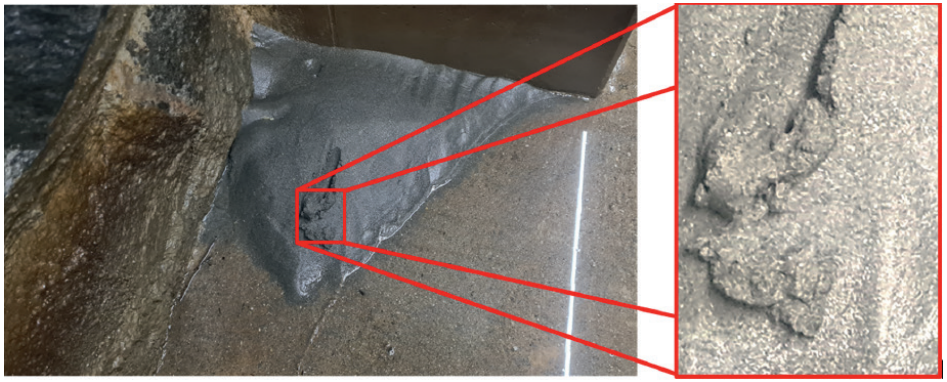
Downstream measurement section with 6 Sea-Bird temeprature sensores and two level probes

The measurements carried out by Jaberg und Partner confirm the contractually specified efficiency curve. At deep part load (single-nozzle operation), the measured efficiency clearly exceeded the specified values. Furthermore, the maximum output power could theoretically increase to up to 7 MW if necessary (see the chart on the right).



Because the power plant encounters significant glacial silt in the water, it is assumed that the runners will require replacement every year. As a result, in addition to evaluating the thermodynamic efficiency during the measurement campaign, we also calculated the generation losses and identified the optimal timing for runner replacement.

This calculation was based on the annual load duration curve, wear rates on the bucket geometry, and the resulting efficiency decrease over time. By deriving monthly degradation factors from the load duration curve, we determined monthly generation losses. This process identified the optimal month for runner replacement to minimize annual losses.



Glacial silt accumulations inside the tailwater channel of the turbine





Damage caused by glacial abrasion to the buckets of the Pelton turbine, the injection needle and the mouthpiece

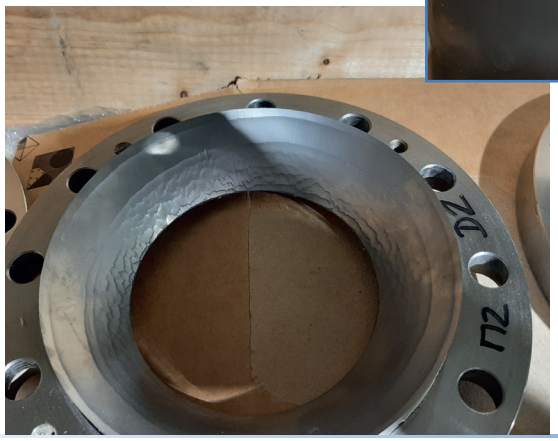
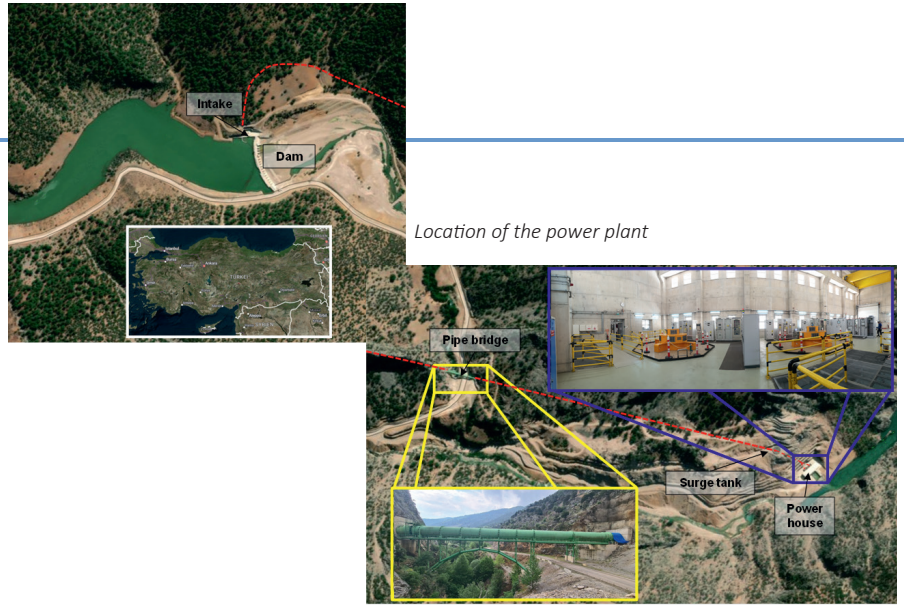


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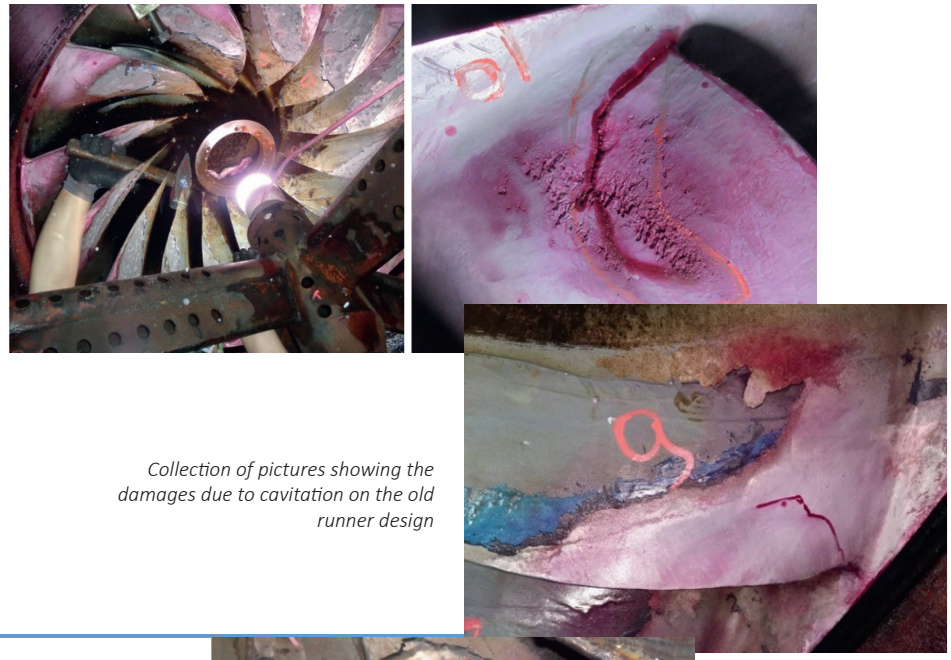
Thermodynamic measurement campaign after turbine rehab

During a refurbishment project in Turkey managed by Jaberg und Partner, who developed a new runner design and conducted field measurements, thermodynamic efficiency tests were performed on both turbines at the site after the project was completed.

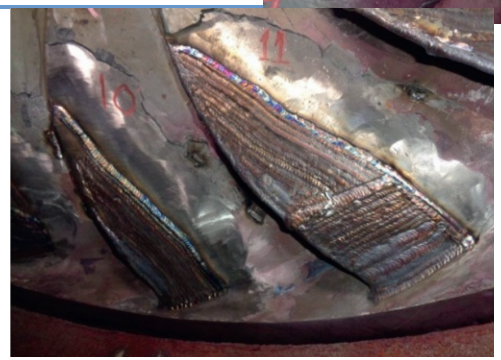
Besides the direct thermodynamic method, an ADM (acoustic discharge measurement) system was used alongside for these measurements. The discharge readings from the ADM system were compared to those obtained via the thermodynamic method. The primary reason for this was the low turbine head and significant temperature fluctuations on the tailwater side (low-pressure measurement side), which sometimes exceeded the deviation limits set by IEC 60041, making those measurements invalid. Consequently, the ADM system served as an extra backup method.



Location of the power plant



Collection of pictures showing the damages due to cavitation on the old runner design

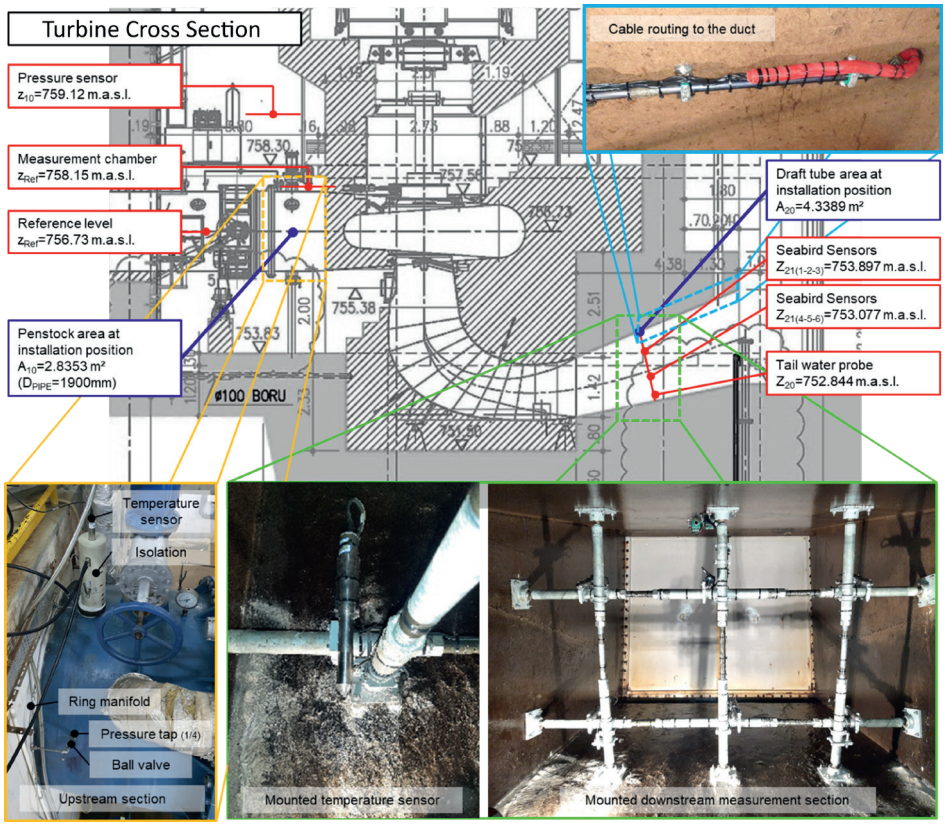




New runner design at the workshop

The extensive cavitation damage on the old runner and the fact that the turbines are operated at a quite low head (H = 80 – 95 m), made thermodynamic measurements particularly difficult. Consequently, some measurement points did not meet the strict validity criteria outlined in IEC 60041. A key problem was the deviation in temperature readings among the six sensors at the downstream (tailwater) section. In contrast, measurements with the new runner design revealed a significantly different scenario, featuring a much more uniform temperature distribution in the tailwater measurement area.

The high-pressure side measurement section features an insulated measurement chamber at the penstock, from which a small water sample is taken to measure upstream temperature. Also, both absolute and relative pressures are recorded at this point. On the low-pressure side, within the turbine's draft tube, Sea-Bird sensors are mounted on a frame monitor temperature at six locations. In addition, two level probes are positioned on the frame inside the draft tube. Three more level sensors are installed in the tailwater area downstream of the turbines to monitor conditions there. An extra differential pressure sensor measures the differential pressure of the turbine's index pressure tabs, enabling index measurements.



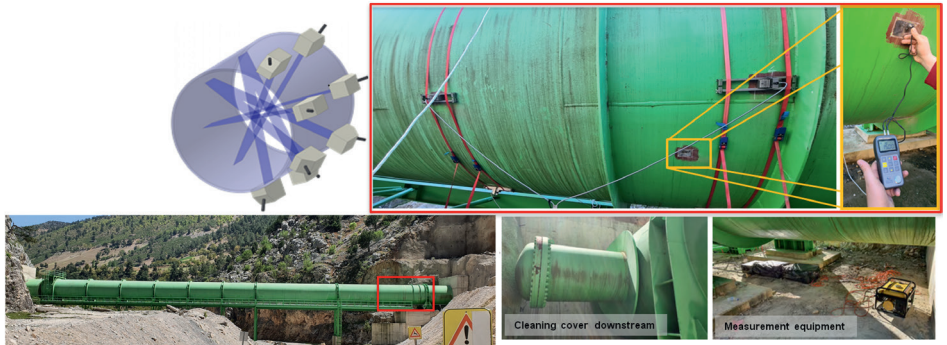
Thermodynamic measurement setup

An ultrasonic flow measurement device from Emerson Flexim® with four beams (transducer pairs) was used to measure discharge at a pipe bridge section upstream of the surge tank and powerhouse. All four sensor pairs operated in reflected mode.

The setup, including the penstock bridge, pipe wall thickness measurement, and installed discharge system, is shown in an accompanying figure. The pipe surface was cleaned before sensor installation to ensure optimal signal quality.

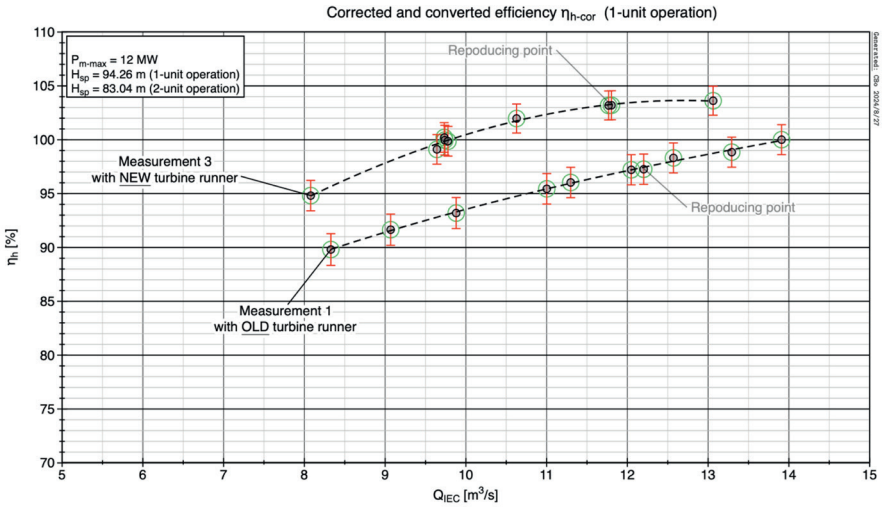
The measurement campaign verified all contractually agreed points, such as the location of the Best Efficiency Point, the improved cavitation behavior, and the overall efficiency gains. With the new and optimized runner design, a significantly higher annual energy production is possible, with a relative efficiency improvement of over 7% across the entire normal operating range. Under overload conditions, the new design matches the performance of the original turbine configuration. The impact of the turbine ventilation system, intended to address cavitation issues with the old runner design, was found to be negligible based on measurements.

Additionally, the installed ventilation system on the draft tube side can be completely removed with the new runner design.

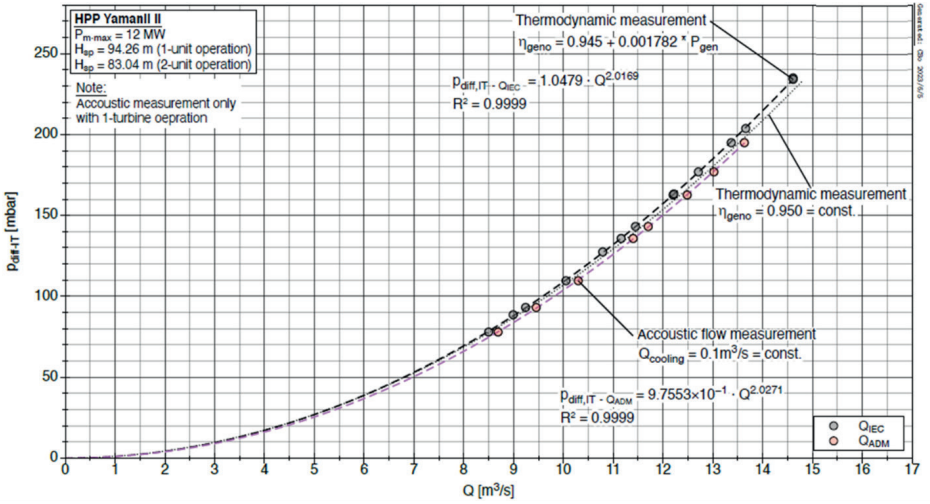


Flexim Fluxus, 706, 4 Channel (Elaborated by Medon and TU Graz)	
Sensor type	Shear wave-type
Sensor frequency	0.5 MHz
Diameter range	100-6500 mm
Flow velocity range	0.01-25 m/s
Measurement uncertainty	±1% of reading ±0.005 m/s

Measurement set-up for clamp-on ultrasonic measurement



Result of thermodynamic measurement, old versus new runner

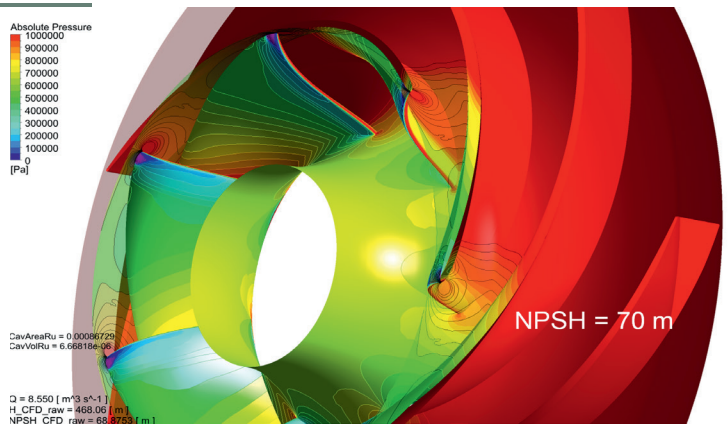


Comparison between THDM and ultrasonic discharge measurement

When comparing the THDM discharge with ultrasonic measurement using differential pressure of the index measurement, a small offset is noted. Several factors contribute, primarily generator efficiency, which plays a significant role. The flow rates recorded by the acoustic flow meter are slightly higher than those from the thermodynamic method. This difference could stem from variables like the turbine cooling water flow, flow through the pressure relief valve, and leakage water between the ADM measurement section and the turbine.

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PUMPS & FANS

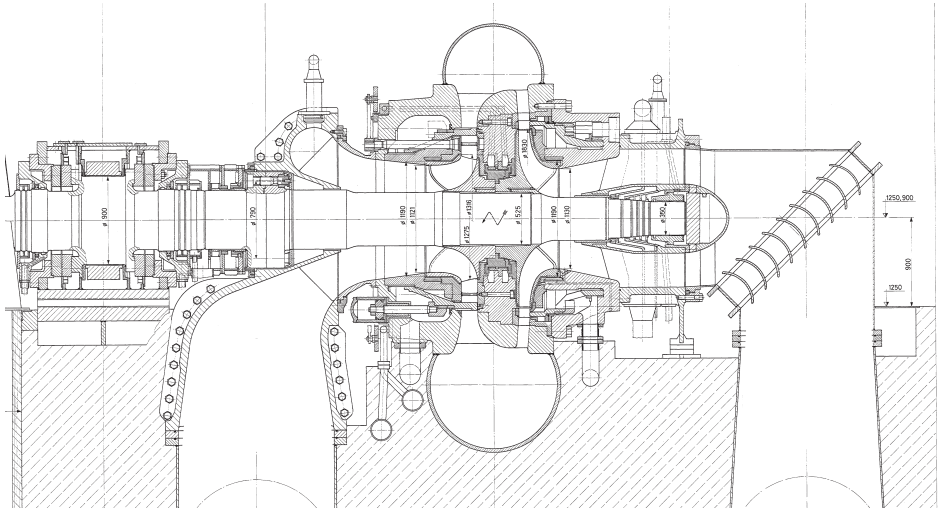

Absolute Pressure
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
[Pa]
NPSH = 70 m

Investigation and Optimisation of the Cavitation Behaviour of an Isogyre Pump-Turbine in Pump Mode

On behalf of a renowned power plant operator, a CFD study was carried out on the pump impeller of a rather exotic type of hydraulic machine. An Isogyre pump-turbine is a rare special configuration of a Francis machine designed for use in pumped-storage hydropower plants. It features a double impeller arrangement within a common spiral casing, consisting of a Francis turbine section and a radial pump section. The turbine and pump operate hydraulically independently of each other, despite being housed within the same casing. The direction of shaft rotation remains the same in both pump and turbine modes.

This design was developed in the 1970s to better accommodate switching between operating modes and varying heads. Today, only a small number of such hydraulic machines are still in operation.

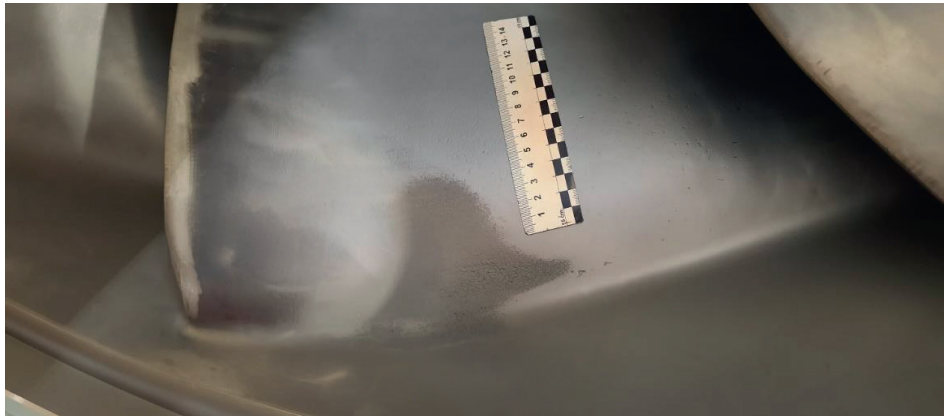
The following figure presents a sectional view of the investigated machine, illustrating the principal design features of the unit. Operating at a head exceeding 400 m and a rotational speed of 1,000 rpm, the machine represents a high-head reversible pump-turbine with a rated power of more than 40 MW in both pumping and generating mode.



Cross-section of the investigated Isogyre pump-turbine

Since its commissioning in 1975, the pump impeller has been affected by cavitation-related damage. In view of the increasing utilisation of the unit in pump mode over recent years, a detailed assessment of the cavitation behaviour and the associated damage mechanisms became essential. The objective of the present CFD study was therefore to identify the root causes of the observed cavitation phenomena and to develop suitable modifications of the impeller leading edge geometry aimed at mitigating cavitation and improving the long-term operational reliability of the machine.

Photographic inspection revealed significant cavitation damage, particularly on the outer shroud side immediately downstream of the leading edge, as illustrated in the following figure.

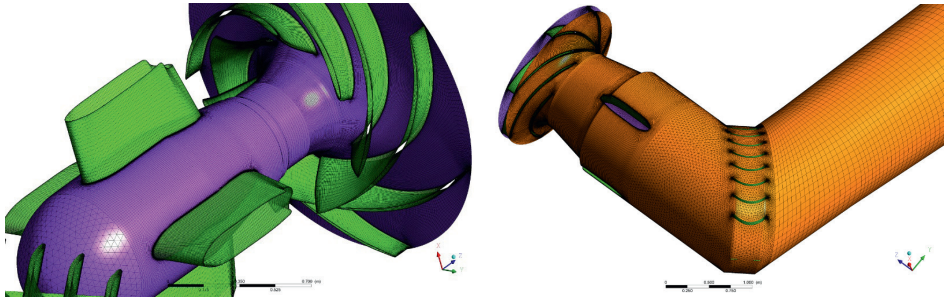


Photographic documentation of cavitation damage at the inlet of the pump impeller

Based on the operating data provided at the outset of the project, the pump operating range of the machine was analysed in detail. The assessment identified two representative operating conditions characterised by distinctly different flow rates. These differences are primarily attributable to the operation with different tailwater reservoirs and consequently varying hydraulic boundary conditions.

Based on a 3D surface scan, the pump operation was investigated in detail as part of an extensive CFD study. Since complete data for the diffuser and spiral casing were not available, the analysis was limited to the impeller itself. The sidewall clearance gaps were also not taken into account. Based on our experience, these details have only a limited influence on the assessment of the cavitation characteristics. Omitting them, however, significantly simplifies the mesh generation, allowing a structured hexahedral mesh to be used in each computational region.

The CFD simulations were ultimately performed using a simplified single-passage model without the spiral casing, but including the entire inlet section and the inlet bend. A visualisation of the generated computational meshes and the simulation model used is shown in the following figure.



Visualisation of the meshes used for the CFD-study

The main objectives of the study were to reproduce the pump head characteristic and NPSH curve, visualise low-pressure regions on the impeller blades, and develop design modifications to the leading edge that could be implemented easily to improve the cavitation behaviour.

The following figures illustrate how the cavitation behaviour can be improved by modifying the blade geometry in the leading-edge region of the pump impeller. At the same operating point, the visualisations show the pressure distribution on the impeller blades calculated at an NPSH of 70 m using a two-phase cavitation simulation, including the cavitation zones shown in pink. While the image on the left already shows pronounced cavitation on the original pump impeller, only incipient cavitation can be observed on the optimised impeller shown on the right.

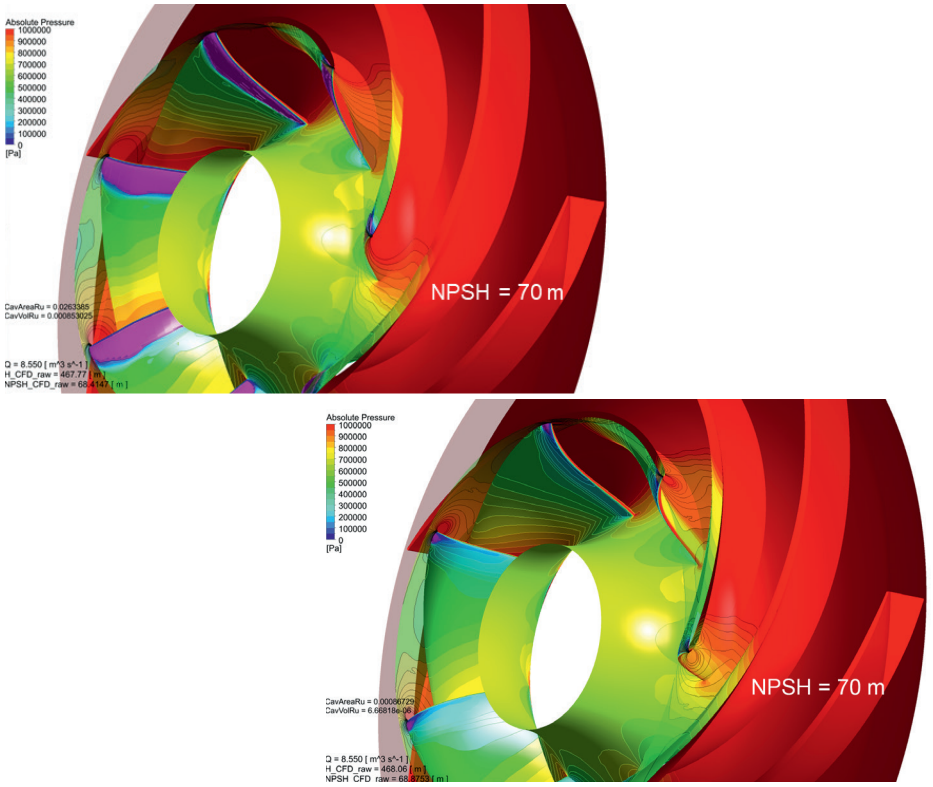
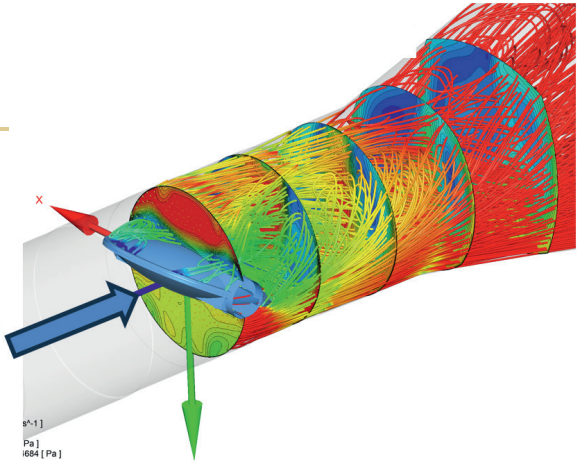


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VALVES





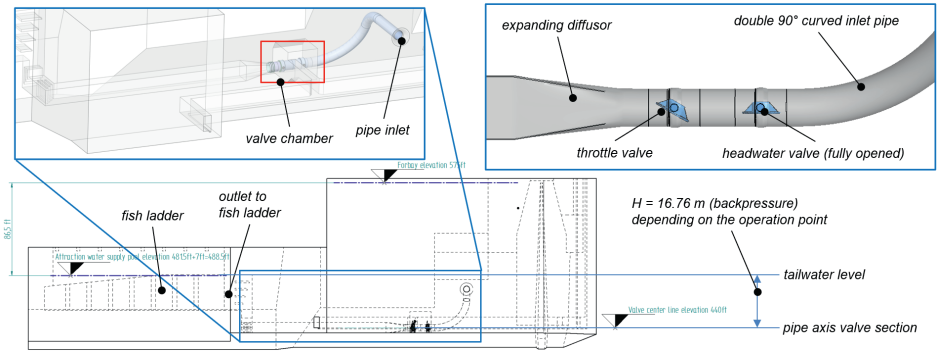
Challenging rehab of huge valves to regulate the flow of a fish ladder



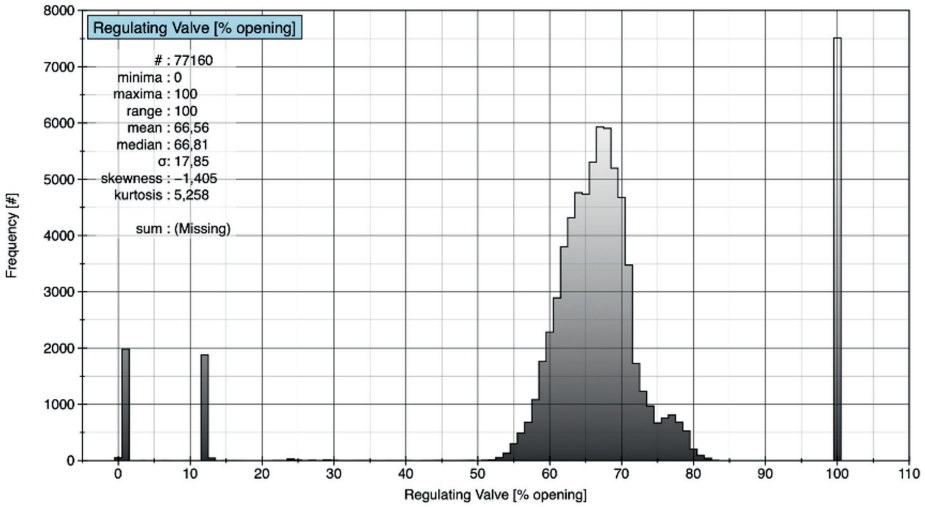
Cavitation Damaes on the second valve (downstream)

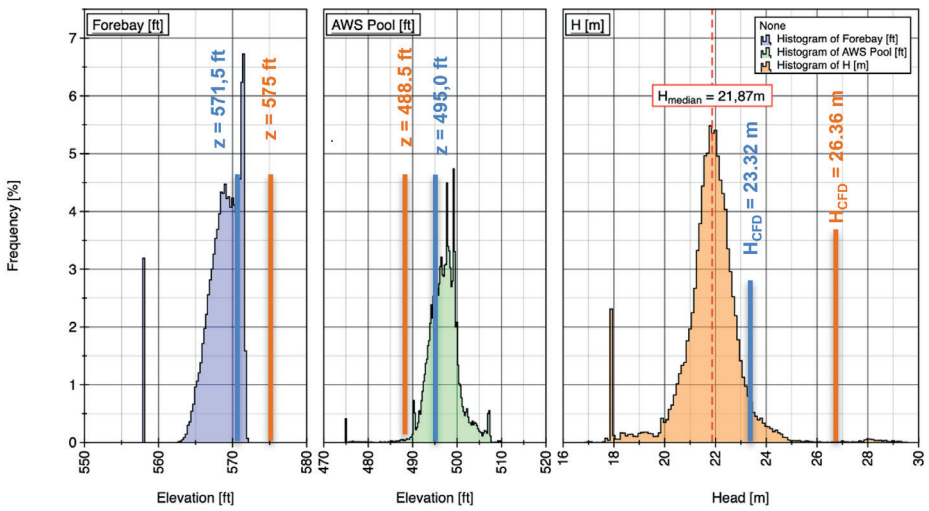
At a large dam in the USA, two existing control valves for the fish ladder were scheduled for replacement. They are being replaced with two new valves installed in series: the first, viewed in the flow direction, functions as an inspection valve and stays open during normal operation, while the second regulates flow to the fish ladder during operation. Both valves share the same design. The existing valves and the downstream pipeline section had sustained cavitation damage.

The client provided a detailed 3D model of the gates and the associated piping system for the assessment.

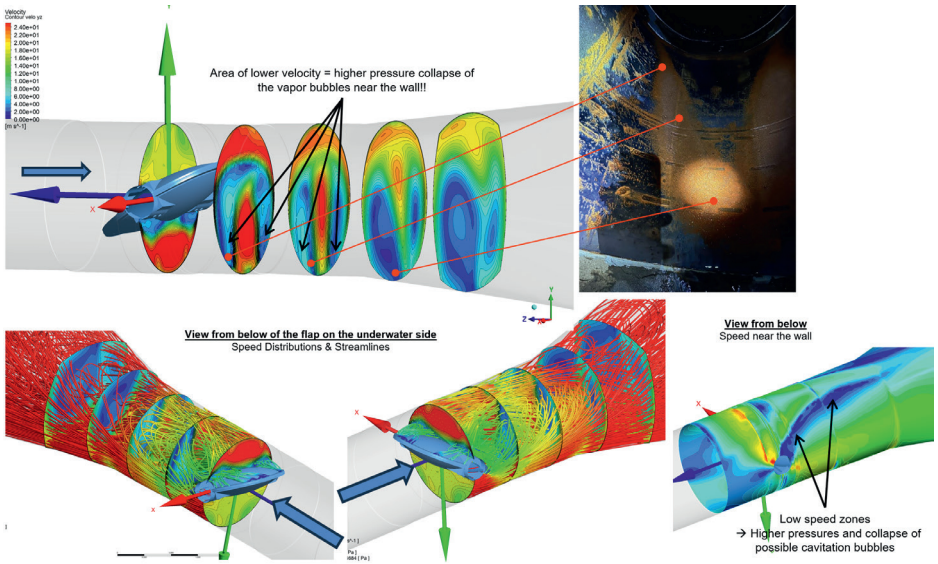


In addition to the 3D geometry, operating data and regulations were provided, which were reviewed. The boundary conditions for discharge and water levels were applied in the numerical calculations. However, during the valve recalculations, doubts arose about the physical plausibility and accuracy of the specified operating data. To clarify this, the client supplied over 10 years of measurement data documenting the valves' real-world performance, including water levels and discharge rates. This extensive dataset was analyzed to determine the actual operating conditions, independent of the original design documentation. The analysis showed that the flow control valve was mostly operated within a 60–70% opening range.





Using these measured operating conditions as inputs for the recalculation, the resulting damage pattern aligned closely with the 3D CFD simulation results, accurately pinpointing the locations where cavitation damage had actually occurred.



The combined effects of the operating conditions and system design indicate, for valves of this size, cavitation cannot be entirely prevented within the current system constraints. This is because the backpressure on the control valve is naturally low, and the submergence remains limited below the tailwater level. Consequently, the system's design results in inherently low pressure near the control valve. Additionally, since the valve operates within a 60–70% open range, some cavitation is inevitable under these circumstances.

Sensitivity analyses during the calculations identified ways to increase pressure levels, such as installing an orifice plate. This plate was designed to ensure the necessary discharge through the fish passage is maintained even at the minimum head. This approach effectively raises the pressure, reducing cavitation risk at the control valve. However, due to structural boundary conditions, the new valves must also function under this inherently low pressure level.

Therefore, the new valves were optimized for cavitation resistance within the existing design margins: the flow around and through the valve was adjusted to reduce low-pressure zones as much as possible. Additionally, choosing materials with higher resistance to cavitation erosion helped prolong the service life.

Despite the project's highly challenging boundary conditions, we developed the best possible solution. It also increased awareness of the valves' operating behavior and the physical conditions, such as cavitation, impacting the control valve.

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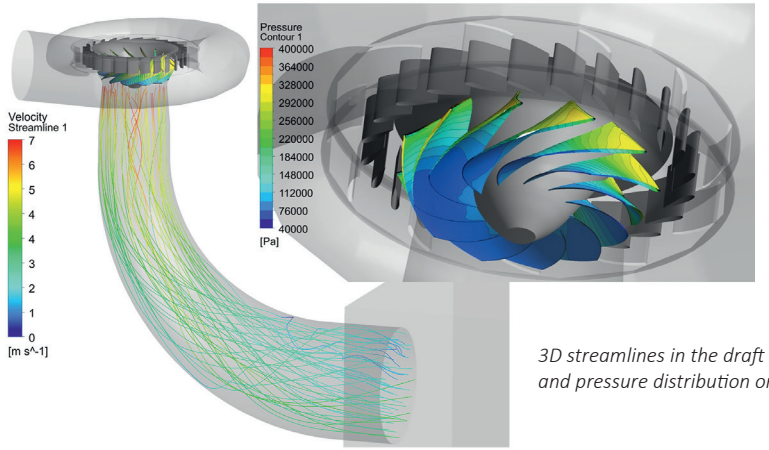
PRESSURE SURGE CALCULATIONS & TRANSIENT SYSTEM ANALYSIS

Transient simulation for a Diagonal-Turbine in Colombia

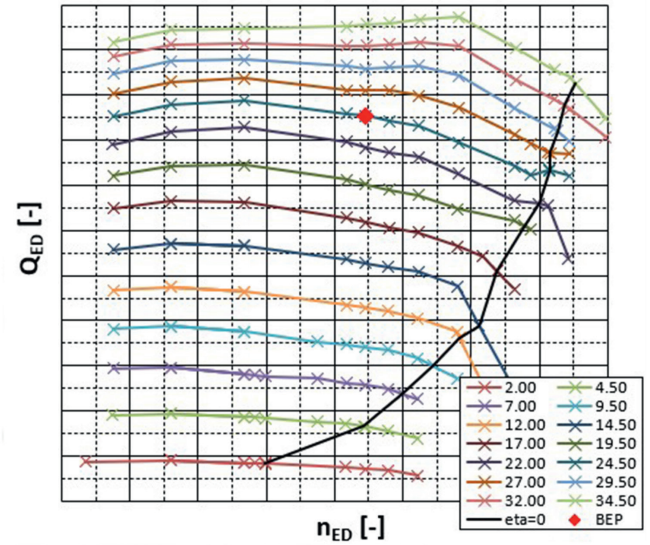
In 2022, we had the honour of developing the hydraulics for a diagonal turbine for a long-standing customer. For a new project in Colombia, the turbine design developed back then was to be reused for an application with a maximum output of more than 2 MW. Unlike the original project, however, variable-speed operation will now be possible. Furthermore, the new turbine will be operated on an approximately 2 km long penstock, which requires extensive consideration of the pressure surge issue. Jaberg & Partner was therefore consulted to analyse the suitability of the originally developed turbine design in terms of variable-speed operation and to investigate the pressure surge risk of the new turbine.

A complete turbine hill chart is required to estimate the runaway speed and the resulting flow rate as well as to perform a pressure surge calculation. For example, in order to be able to check the load rejection at full load as part of a 1D transient simulation, at least the operation range up to the runaway curve (= ISO line with 0% efficiency) must be represented.

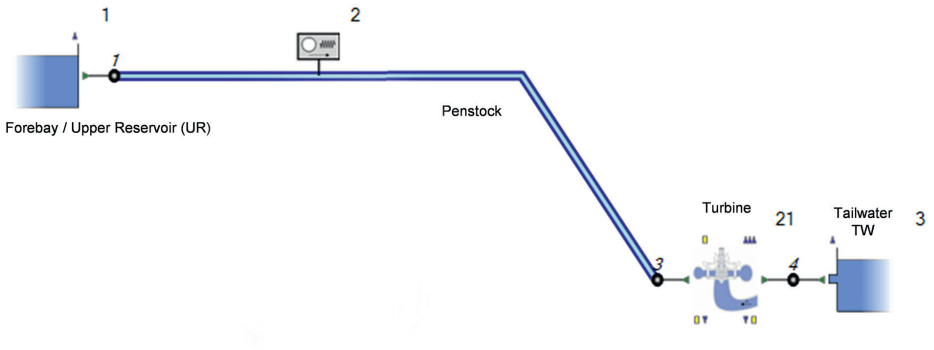
In a first step, 3D CFD simulations in a full 360° model were used to calculate the required operation range in several steps at different heads and speeds. The extended hill chart was then transferred to the customer in a standardised representation and prepared for the subsequent pressure surge calculation.



3D streamlines in the draft tube and pressure distribution on the runner



Complete turbine hill chart in QED-nED representation based on 3D CFD simulations



1D numerical model of the Colombian power plant

In the second step, a pressure surge analysis had to be carried out to determine the transient behaviour of the Colombian hydropower plant, for example in the event of a load rejection of the turbine. This involves modelling the headrace from the water intake to the powerhouse. For this purpose, all hydraulically relevant system components were modelled using the Flomaster simulation software with our extensions for hydraulic systems and hydropower plants. The turbine's behaviour was considered in a specially created numerical model. This required the complete turbine hill chart described above.

The investigation aimed to determine the relevant system and machine parameters (maximum internal pressure on pressurised components, any negative pressure that may occur, maximum turbine speed, maximum flow rate, etc.) in the event of load rejection of the turbine and thus the dimensioning of the turbine operating times.

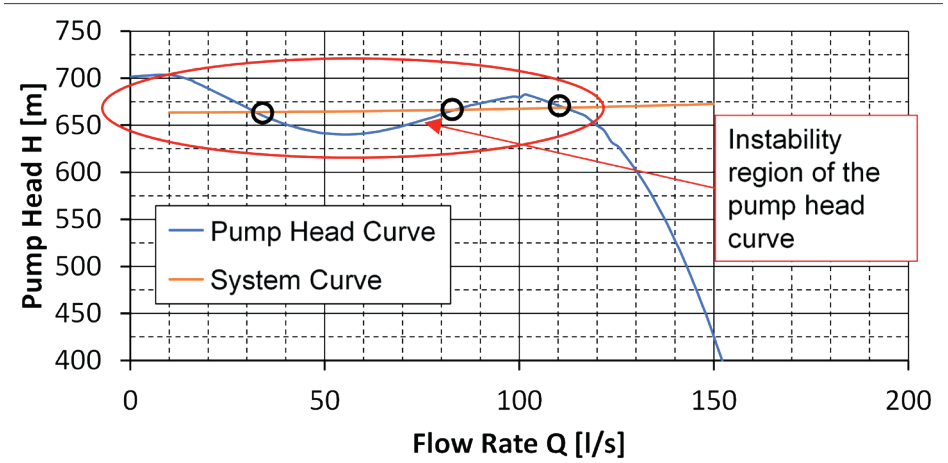
In the end, we found a solution that enables safe system operation without a cost-intensive surge tank. Our analyses also identified a potential planning error in the penstock, that was corrected in timely manner as a result of our investigation.

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CFD and Transient System Analysis for Geothermal Pumping Systems

Geothermal energy is developing into a key technology for climate-neutral heat supply across Europe. Regions such as Bavaria and Upper Austria have been utilising naturally occurring geothermal resources for decades, while large urban centres are increasingly turning to deep geothermal reservoirs to meet their heat demand. In Austria, the regions of Vienna and Graz are currently at the centre of several development projects. With its favourable geological conditions, the Graz Basin is considered a particularly promising region for the sustainable supply of renewable district heating. Utilising this locally available energy source offers the potential to increase security of supply, achieve a sustained reduction in CO_2 emissions and reduce dependence on fossil fuels.

Although the electric submersible pumps (ESP) used in geothermal applications are based on proven technologies originally developed for oil and gas production, the pumping of thermal water presents a unique set of challenges. High temperatures, significant pumping depths, varying operating conditions between summer and winter, as well as the chemical and mineral constituents of the pumped fluid place high demands on the hydraulic design and long-term reliability of the pumping systems. Detailed analysis of the internal flow phenomena and the resulting loads is therefore becoming increasingly important and provides the basis for developing efficient and durable pump solutions for geothermal energy systems.



In particular, the seasonal variations in heat demand pose challenges to geothermal pumping systems that are only encountered to a limited extent in conventional oil and gas applications. The resulting variation in flow rate may require the pumps to operate across a wide range of their characteristic curves. In regions with a negative slope of the pump characteristic curve, i.e. under unstable operating conditions, multiple intersections with the system characteristic may occur. This can result in sudden changes in pump flow rate, potentially affecting the operational reliability and service life of the system. A detailed understanding of the internal flow phenomena and their interaction with the respective operating conditions is therefore of central importance for the safe operation of geothermal pumping systems.

The combination of detailed CFD analyses of individual pump components with transient system simulations of the entire thermal-water circuit enables a comprehensive assessment of the system as a whole. While the CFD analyses provide insights into local flow phenomena and potential causes of hydraulic instabilities, transient system analysis allows the dynamic interaction between the pump, wells, piping system and heat consumers to be investigated under realistic operating conditions. This provides the basis for the design of robust pumps and efficient, reliable geothermal systems capable of operating safely across the entire seasonal operating range.

With its expertise in hydraulic engineering, CFD and transient system analysis, Jaberg & Partner contributes to the development of reliable and efficient geothermal systems and thus supports the further expansion of geothermal energy as a key technology for sustainable, climate-neutral heat supply.



Multistage pump and
CFD of the first stage ot the multistage pump

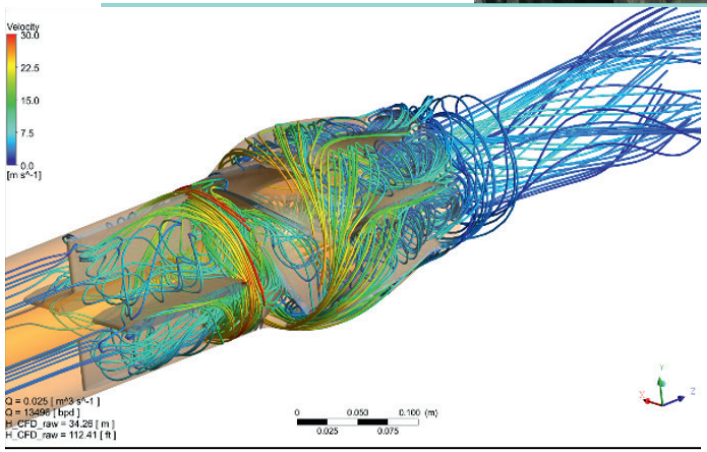
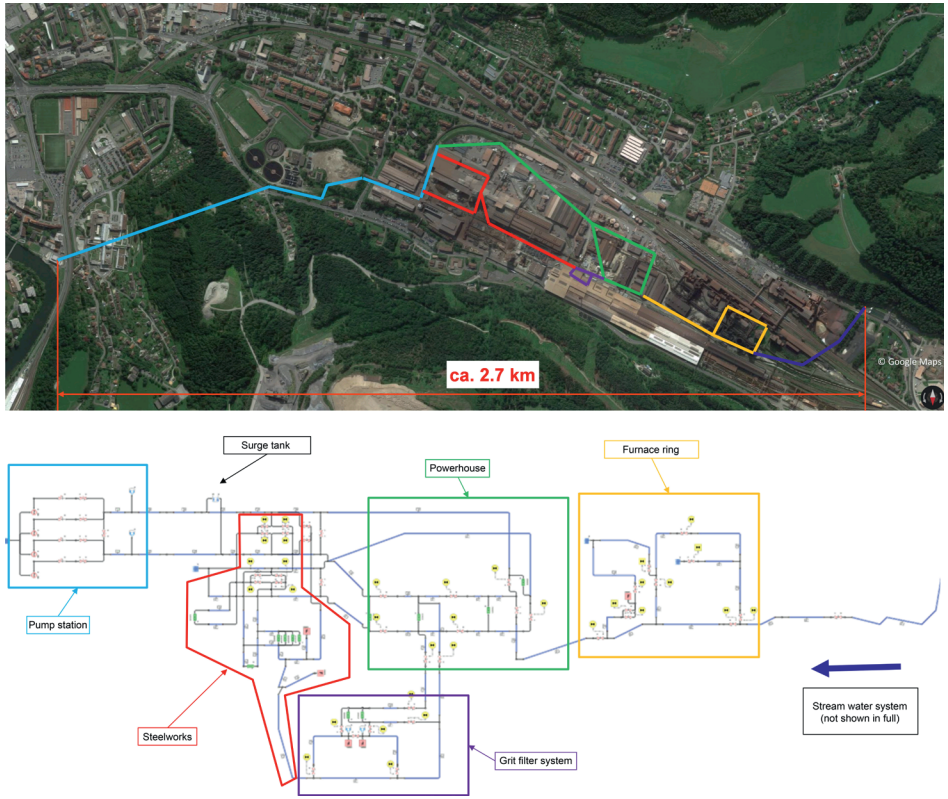


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Water-Hammer Analysis for the Cooling Water System of a New Electric Arc Furnace



Satellite image of the steelworks and numerical model of the cooling water system

From 2027, a new electric arc furnace at the a steelworks in Austria will significantly reduce greenhouse gas emissions from steel production. The conversion to electric steel production represents an important step towards more sustainable steelmaking and also places new demands on the associated infrastructure and auxiliary systems. To ensure safe and reliable operation of the new production facilities, the existing cooling water supply must be adapted to the changed operating conditions.

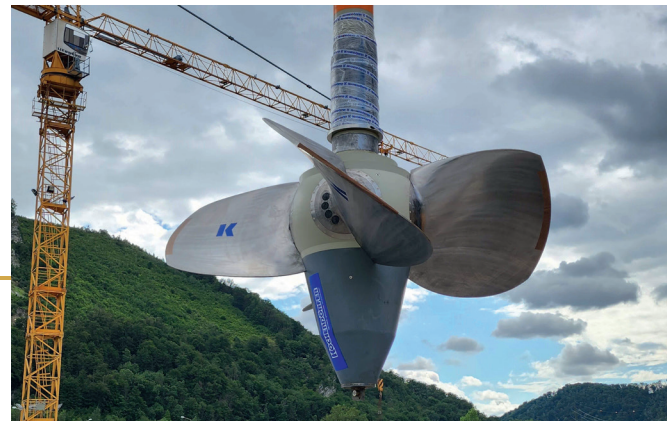
Jaberg & Partner was commissioned to carry out a comprehensive water-hammer analysis for the upgrade of the complex hydraulic cooling water system. The objective of the investigation is to assess the transient behaviour of the system and to identify potentially critical pressure conditions resulting from operational changes and various failure scenarios.

Particular attention is being paid to the safety concept of the cooling water supply. As part of the ongoing investigation, the hydraulic system behaviour is being analysed for control errors and other relevant incidents, including power failures and operation with an emergency power supply. The resulting transient pressure fluctuations, flow conditions and interactions between the individual system components are evaluated to identify potential critical operating conditions.

The results of the water-hammer analysis will provide an important basis for assessing the safety and reliability of the upgraded cooling water system. The investigations support the verification and optimisation of the protection concept and help ensure reliable cooling under both normal and exceptional operating conditions.

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LAUNCHED PROJECTS

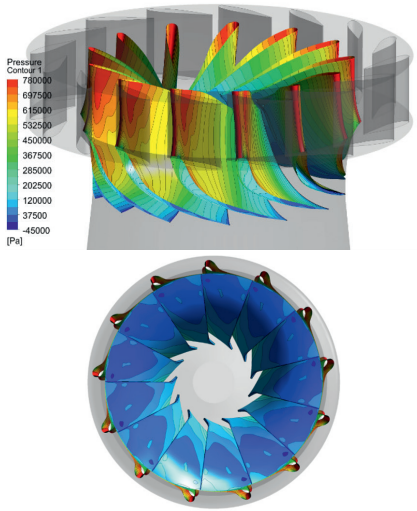




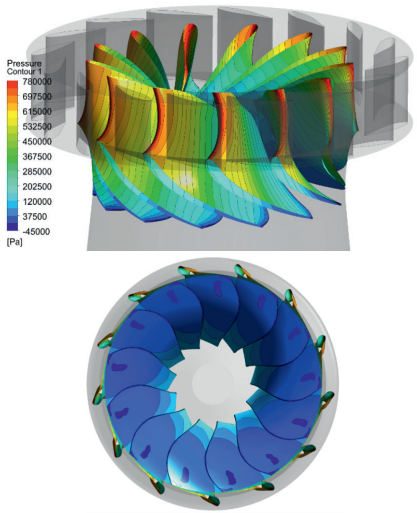
Bağışlı Hydropower Plant, Türkiye
Customised design optimisation of a Francis turbine

In the far south-east of Türkiye, on the Çataksuyu River, the Bağışlı hydropower plant has operated with three horizontal Francis turbines for around 15 years. High sediment loads repeatedly caused severe erosion damage to the runners and required regular maintenance.

For the planned refurbishment, we created a detailed CFD model of the complete turbine from existing drawings and 3D scans. Based on this, we developed one runner for high-load operation and a second for deep part-load operation; wider, stronger blade channels reduce erosion-relevant flow velocities. The tungsten-carbide-coated runners installed since 2022 confirm the improved service life.



Pressure distribution at Q ≈ 10 m³/s and H = 108 m on the original runner design



Pressure distribution at Q ≈ 10 m³/s and H = 108 m on optimised runner design RuOptV37



Turbines in the power house



Visualisation of the different damages found on the original runner after testing a tungsten-carbide coating

The picture shown below visualise the original (left) and optimised (right) runner. Both pictures refer to an operation time of around 2800 hours each. The operational experience proves the improved resistance to erosion.

Apart from minor flaking of the coating, the new runner is still in good condition.



Technical highlights

- Number of units: 3 horizontal Francis turbines
- Rated net head H: 108 m
- Maximum discharge QMax: 10.4 m³/s
- Turbine speed n: 600 rpm
- Turbine power P: 3 x ~10 MW
- Specific speed nq,BEP: ~ 50 rpm
- Runner diameter at outlet DS: Ø 1035 mm
- Number of runner blades zRu: 13 #
- Number of guide vanes zGV: 16 #

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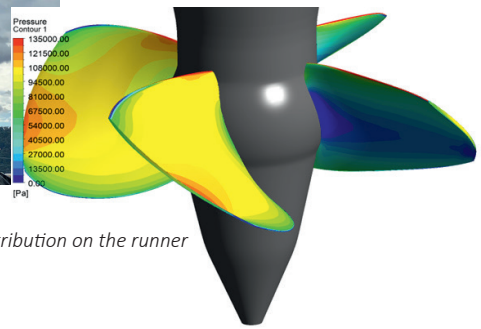
Gratkorn Run-of-River Hydropower Plant

Ten kilometres north of Graz, Austria, the Gratkorn run-of-river hydropower plant began operation in October 2024. Developed by VERBUND and Energie Steiermark, the facility converts the flow of the River Mur into renewable electricity for around 15,000 households.

We performed the CFD-based detailed hydraulic design of the two vertical Kaplan turbines and supported the subsequent model test. Under severe spatial constraints, the team developed a compact spiral casing and jointly optimised runner blades and the draft tube, achieving a peak efficiency of 94%. The model test confirmed the numerical design and turbine requirements.



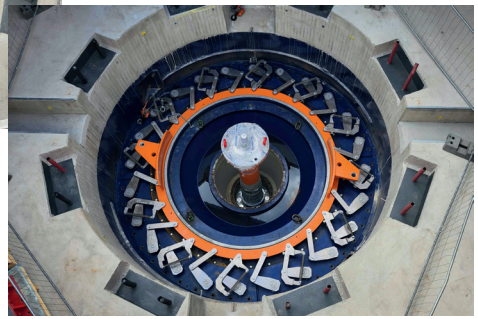
Completed turbine hydraulics ready for installation at the Gratkorn hydropower plant



Pressure distribution on the runner



View of the installed Kaplan turbine



Turbine incl. the installed guide vane apparatus

Technical highlights

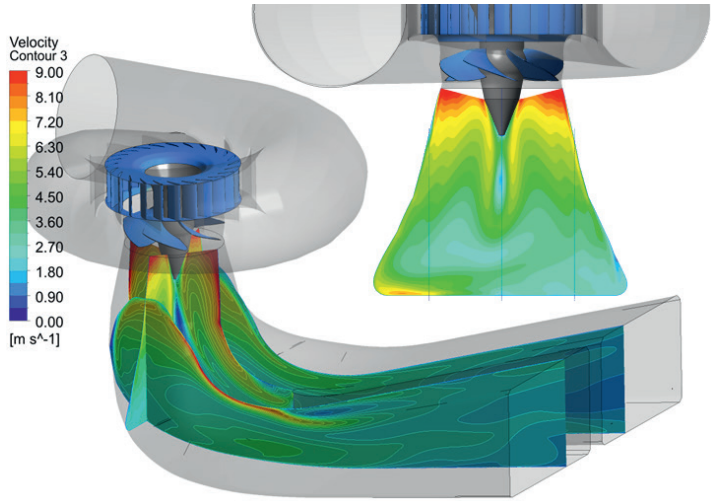
- Two vertical Kaplan turbines
- Maximum flow rate: 205 m³/s (total)
- Net head: 6.62 m (at max. flowrate)
- Maximum output: more than 11 MW
- Peak turbine efficiency: 94%

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Hydraulic optimisation and model test for the refurbishment of a vertical Kaplan turbine in India

Set in a diversion channel in Uttarakhand, northern India, the Dhakrani run-of-river hydropower plant has operated since 1965. After around six decades, its three vertical Kaplan turbines required renewal to overcome wear, limited flow capacity and low efficiency.

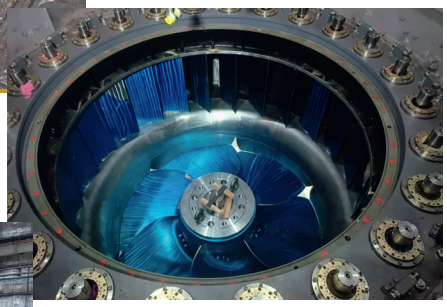
We reverse-engineered the existing water passages through on-site scanning and reference drawings, then developed a new runner and guide vane system using CFD. The design was validated through an IEC 60193 model test at Graz University of Technology and confirmed in the field acceptance test of Unit 1.



Impression of the CFD simulation



Turbine dismantling



Pre-assembly of the prototype runner



Installation of the new turbine at the plant

Technical Highlights

- 3 vertical Kaplan units
- Rated net head: 19.6 m
- Runner diameter: 3.4 m
- 6 runner blades / 24 guide vanes
- Turbine speed: 187.5 rpm
- Guaranteed weighted-average efficiency: 93.0%
- Two units commissioned by end-2025; Unit 3 scheduled for mid-2026.

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Design optimisation of a diagonal turbine for a small-scale hydropower plant

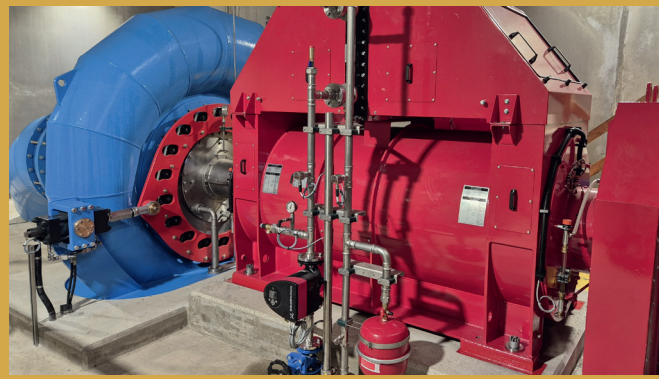
In the second half of 2025, one of our customers commissioned a new diagonal turbine for a small hydropower plant in Salzburg (Austria), which was successfully delivered and put into operation.

As the basis for a customised design optimisation, we used a reference design that we had originally developed from scratch for the same customer back in 2020.

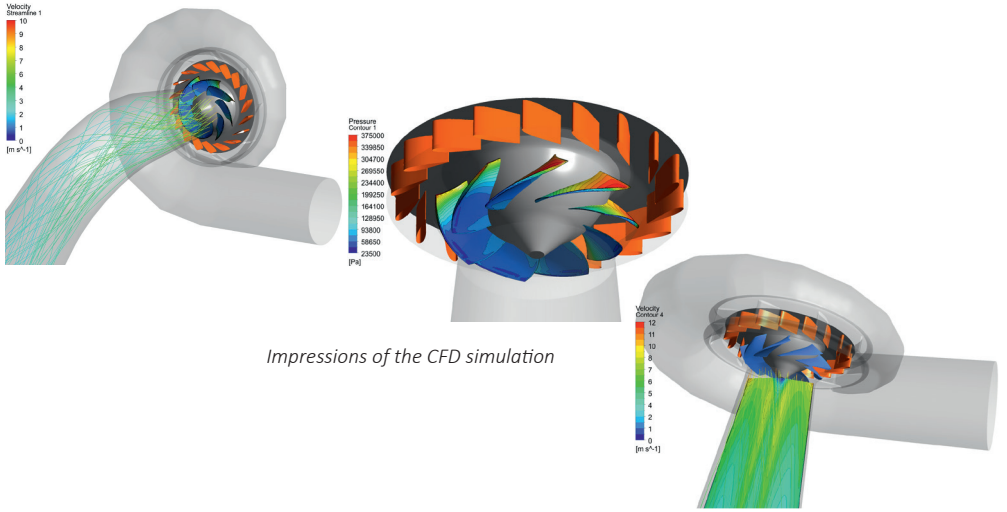
With a reference diameter of DRef = 0.85 m, the turbine is still relatively large. However, due to the comparatively high head for a small diagonal turbine and the required installation configuration above the tailwater level, the turbine had to meet very demanding requirements in terms of cavitation safety.

New diagonal turbine ready for assembly





Powerhouse of the hydropower plant



Impressions of the CFD simulation

The key plant data can be summarised as follows:

- Rated net head H: 38.75 m
- Design flow rate QMax: 3 m³/s (excluding a reserve of 3–5%)
- Turbine speed n: 600 rpm
- Reference diameter DRef: 0.85 m
- Suction head at design flow rate HS: 2.35 m (machine axis above tailwater level)

Compared to the reference hydraulic design, the number of guide vanes, zLe = 18, and the number of runner blades, zLa = 8, remained unchanged.

In addition, we had the opportunity to support the project with a water hammer analysis. Since the end of 2025, the plant has been successfully in operation.

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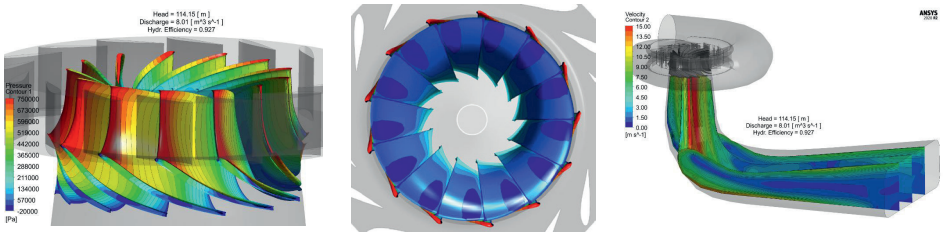
Successful CFD optimisation of a Francis turbine as part of a power plant refurbishment

Canales Hydropower Plant is located in Spain at an altitude of approximately 800 m. After more than 35 years of service, its Francis turbine had developed cavitation damage and showed limited performance across the plant's wide operating head range.

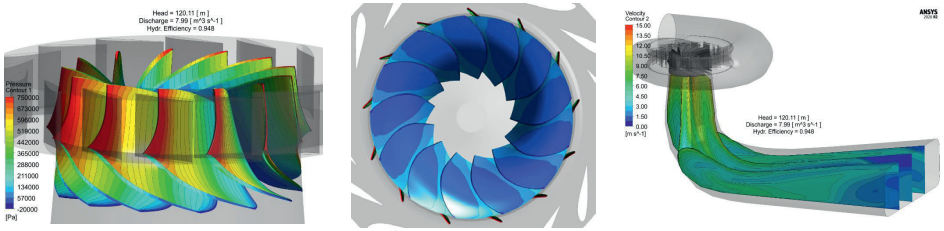
As part of the refurbishment, we carried out a CFD-based study to assess the existing flow conditions, cavitation behaviour and hydraulic performance. The results informed the optimisation and replacement of the runner; the redesigned turbine has since been manufactured and is now operating successfully.

Pressure distribution on the runner blades and velocity distribution in the draft tube at BEP before and after optimisation:

Old design



New design



Cavitation damage on the suction side at the runner outlet of the original runner





Cavitation damage to the leading edges of the original runner

Manufacturing and assembling of the new, optimised turbine





Installed new components on site

Technical Highlights

- Design net head: 114.2 m (operating range: 86-138 m)
- Design discharge: 8.68 m3/s
- Maximum mechanical output: 9 MW
- Nominal speed: 750 rpm
- Runner outlet diameter: 980 mm
- 13 runner blades and 16 guide vanes

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Extensive power plant modernisation project with the hydraulic development of a 5-bladed Kaplan turbine

Commissioned in 1959, Matala Hydropower Plant is located in Angola, West Africa. Its three Kaplan turbine units continue to support a stable and sustainable electricity supply.

Within a major modernisation programme, our team developed and optimised a new five-bladed Kaplan runner for the existing plant. The complete water passage was recreated as a 3D model, and CFD analyses, informed by IEC 60193 model-test experience, were used to evaluate runner variants, define the final blade geometry and establish the optimal guide-vane/runner-blade settings.

Technical Highlights

- Plant capacity: approx. 40 MW
- Turbine configuration: 3 Kaplan turbines; 5-bladed runner
- Nominal head: 19.5 m
- Nominal maximum discharge: 81.25 m³/s
- Runner diameter: 3.3 m
- Verified peak efficiency: at least 94%



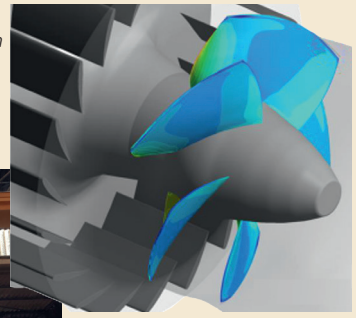
Hydropower plant powerhouse

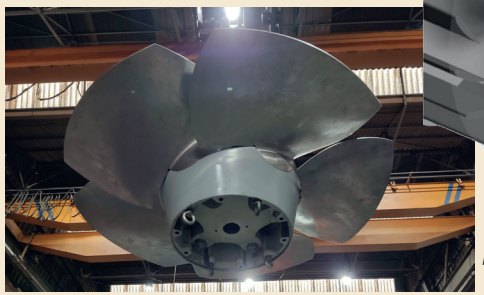




Damaged runner blade and runner shroud

CFD-simulation of new runner blade design





New Kaplan runner ready for assembly

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Hydropower Plant Stegenwald
Draft design of the machine concept and hydraulic development

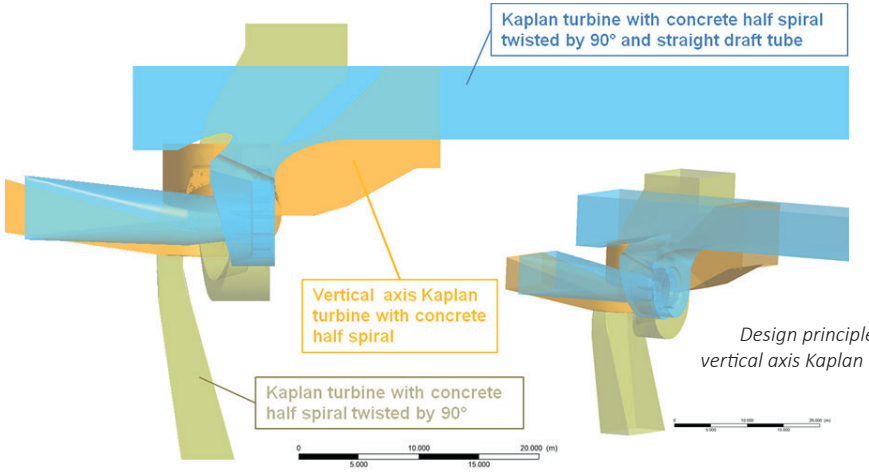


View of the hydropower plant

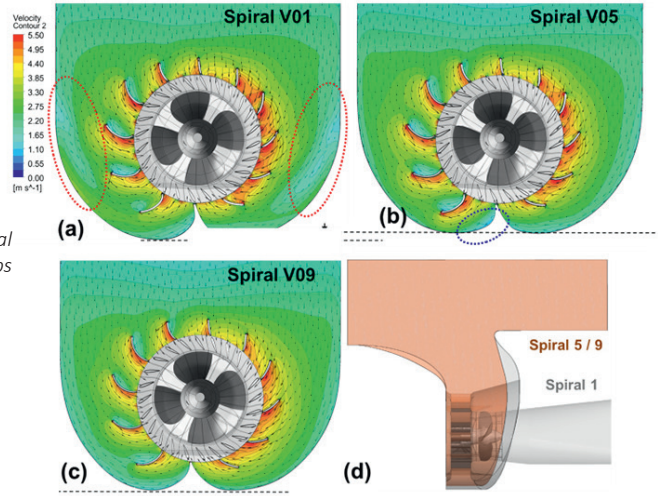
On a previously unused reach of Austria's 225-kilometre Salzach River in the province of Salzburg, HPP Stegenwald adds a compact low-head facility to a hydropower cascade expanded since the mid-1970s. Its unconventional layout was developed to limit the footprint in a sensitive river landscape while maintaining flood-handling capacity.

Our work comprised CFD-based hydraulic design and optimisation of the 90°-rotated concrete half-spiral, runner and straight draft tube. Full-plant simulations, supported by physical-model findings and particle tracking, refined flow uniformity, cavitation behaviour and gravel transport for safe operation.

The Stegenwald hydropower plant was successfully commissioned in September 2025, marking the completion of the project and the start of reliable commercial operation.



Design principle of the vertical axis Kaplan turbine



Modification of the spiral in several steps

Technical Highlights

- 2 horizontal-axis Kaplan units
- Installed capacity: 14.3 MW (2 × 7.64 MW)
- Design net head: 8.25 m
- Maximum discharge: 203 m³/s (total)
- Annual generation: >73 GWh
- Runner diameter: 3.6 m

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ACADEMY

pump.ing
Vocational Training for Pump Experts

Practitioners' Conference
"Pumps in process engineering"

Practitioners' Conference
"Hydropower"



Expert exchange during the practitioners' conferences

pump.ing.
Vocational Training for Pump Experts

pump.ing. is an extra-occupational distance learning study programme for pump-specific expertise regarding pump technology, operational issues and systems. The study course is divided into the chapters “Pump basics”, “Pump unit”, “Pumps in systems” and “Fields of application (optional subjects)”.

Via the teaching and learning platform TU Graz TeachCenter all students have access to the study material and are totally free with regard to their self-study time management. In addition, they have to participate in eight attendance events at various locations in Austria and Germany. The duration of the course is about 15 months.



Attendance event



pump.ing
theory and practice in the laboratory

The acquired knowledge on the optimum design and operation of pumps and systems and the ability to conduct energy counselling are documented by the certificates “Certified energy consultant for pumps and systems” and “Pump Engineer” or respectively “Pump technician”.

The study course for pump engineers starts every year in July. In 2026 already the 22th study course has been launched. The first study course was launched in 2005 with around 30 lecturers – all of them leading pump experts with well-founded and relevant industrial experience. More than 700 pump experts from the top industry representatives have since been exclusively trained as pump engineers and pump technicians. Especially in the last years the pump engineer course achieved record numbers of up to 50 participants.

Practical training by renowned pump specialists

pump.ing. is highly appreciated by the industry. The practical relevance and the high standard of the teaching content probably contribute to this. Ambitious goals and challenges – also of international significance – are a welcome incentive for us, and of course we aim at keeping the programme at the latest state of the art.

pump ing
PUMP-ENGINEER

Managing Director pump.ing.:
Prof. Dr.-Ing. Paul Uwe THAMSEN

Management:
Christina OPPELZ MSc

Tel.: +43 660 1045 818
info@pump-engineer.org
www.pump-engineer.org

Our Two Practitioners' Conferences

Practitioners' conferences are an integral part of Jaberg & Parnter's calendar of events. The appeal of the concept developed by Prof. Jaberg nearly three decades ago remains as strong as ever, with each conference attracting up to 150 participants to Graz.

In spring 2027, the "Pumps in Process Engineering" Practitioners' Conference will mark its 30th anniversary — a milestone celebrating three decades of technical expertise, innovation, and industry collaboration.

In September 2027, the Practitioners' Conference "Hydropower" will follow, celebrating its 10th anniversary and a decade of shaping the future of hydropower technology.

Its mission statement remains "by practitioners for practitioners" and means that renowned lecturers from the industry will take part in the programme – manufacturers and planners as well as operators. The fact that lectures have to be rejected every year because the agenda is overflowing proves the importance of the conference in the German-speaking world as a forum for exchange between experts in the field of hydraulic fluid machinery.



Practioner conference Graz 2025 - Pumps in process engineering

What distinguishes practitioners' conferences from similar events? First of all, the speakers come from the front row of companies, the presentations are given by leading engineers, and the focus is on technical topics. The generous time frame allows to go into depth during the lectures and do not just remain on the surface of challenging points.

Another advantage is that the conference is held in German. And this will not change, despite a growing number of visitors and speakers from non-German speaking countries: An open dialogue is important to us, and the lively discussions after the lectures confirm that this path is well accepted.



Knowledge exchange and discussion

Presentation and open dialogue between speakers and attendees



Every year, representatives of operators find the time to report on their experiences and problems. After all, the experts in attendance have often contributed valuable insights that helped resolve a wide range of operational challenges.

Since 2020, the practitioners' conferences have also been offered online.

Another distinguished highlight is the conference setting itself: a journey to Graz is rewarding in every respect. Seasoned attendees rarely depart without a bottle of pumpkin seed oil, and the refined evening gatherings in Graz's historic venues offer generous space to cultivate ideas that emerged throughout the day and to foster new professional connections.



Practioners' Conference Graz 2024 - Pumps in process engineering



Late afternoon guided tour through Graz's old town



Laboratory Tour

Practitioners' Conference "Pumps in process engineering"

The conference "Pumps in process engineering" organised by practitioners provides an unique platform for practitioners to share experiences, new developments and ideas for coping with the everyday challenges of pumps and pump systems.

The Practitioners' Conference Pump especially addresses operators as well as planners and manufacturers of pumps and pump systems.

Practitioners' Conference Graz
"Pumps in process engineering"
Graz, Austria
More information and registration:
www.praktiker-konferenz.com





Practioners' Conference Hydropower Graz 2025



Presentation



Practioners' Conference Hydropower at the Graz University of Technology

Practitioners' Conference "Hydropower"

This German-language conference provides the ideal platform to build up networks as well as for the exchange of experience and knowledge by practitioners for practitioners – manufacturers, operators, planners and researchers – focussing on hydro power plants and core technical / economic topics such as turbine efficiency, pressure surge, turbine in- and outtake, pump storage, control units, surge chamber, penstock, service life, refurbishment etc. covering the range from small to large hydro power.

Practitioners' Conference
Hydropower | Turbines | Systems
Graz, Austria
More information and registration:
www.wasserkraft-graz.at



CONFERENCE PARTICIPATIONS

We regularly give presentations at renowned conferences.

Here you will find an extract.

- **Anwenderforum Kleinwasserkraftwerke**
- **CMFF Budapest**
- **EGEC Geothermal District Heating and Cooling Days Vienna**
- **Hydro 2024 Graz**
- **Hydro 2025 Thessaloniki**
- **Praktikerkonferenz „Pumpen in der Verfahrenstechnik“**
- **Praktikerkonferenz „Wasserkraft“**











Prof. Dr.
Jaberg und Partner GmbH
Technologie und Strategie

Kerscheckstraße 41
8076 Vasoldsberg, Austria

T +43 316 873 7571

info@jabergundpartner.com
www.jabergundpartner.com