

**VOITH**

# Small Hydro





- 1 Tambobach, Austria
- 2 Kissakoski, Finland
- 3 Bahcelik, Turkey
- 4 Alpach, Switzerland

# Harnessing the power of water

Small hydropower plants make use of rivers especially in remote areas – and improve the livelihood of many people all over the globe. Clean, efficient and reliable - Small Hydropower solutions of Voith can make a difference.

Hydropower plants with an output of up to 30 megawatts can change the world: In certain remote and mountainous regions hydropower plants bring electricity to thousands of people who never could imagine a life with power supply. Rural societies running small-scale industries can immensely benefit from well-interlinked hydropower plant networks. This kind of power generation has accelerated the development of local economies and decreased greenhouse gases at the same time.

Voith's Small Hydropower plants are sophisticated and reliable solutions for sustainable power supply.

Many customers need comprehensive consultancy when planning a small-scale hydropower plant. Voith Hydro is the right partner close at hand: our experienced experts are located worldwide and we accompany each project from the first day of planning to covering a reliable full-fledged lifetime service in the aftermath of the first day of operation.

This kind of service comes across as natural as possible, because Voith Hydro can prove business experience in the field of Small Hydropower since 1870.

Additionally, Voith built or equipped 25% of all Small Hydropower plants worldwide with an output up to 30 MW per unit - an outstanding performance from which our customers benefit.

Due to our research and development activities, we gather progressive knowledge about hydropower. And we are able to manage the knowledge transfer and create standardized solutions.

Make the most of your Small Hydro resources through Voith.

## Voith's technical scope of supply

- Consulting, engineering, erection and commissioning
- System/plant assessments
- Service – global, fast and effective for modernization and rehabilitation of existing hydroelectric power plants
- Complete equipment, installation and services for hydroelectric power plants
- Francis, Pelton, Kaplan, Bulb/Pit/S-turbines, pump-turbines, standard and customized products
- Storage pumps, radial, semi-axial and axial-flow pumps
- Generators and motor-generators for constant and variable speed
- Excitation systems
- Frequency converters, protection systems, switchyards for all voltages, transformers
- Power plant automation, control centers for hydropower plants and cascades, including plant management and diagnostic systems
- Shut-off valves, hydraulic steel structures
- Water-to-wire (W2W)
- Voith Hydro Safety Policy: Guidelines for a safe and reliable power plant operation

# Voith Hydro - your reliable partner

Excellent competence and strong support for our customers: individual solutions with standardized components are our accomplishments. Voith offers the following services and products:

- A standardized platform concept as basis for customized solutions
- Cost effectiveness
- Short delivery times
- Integrated solutions with minimized interfaces
- Minimized civil construction cost
- High performance
- Reliability and top quality control
- Environmentally friendly solutions
- Workshop assembly and reduced erection time
- Rapid commissioning of overall systems, training of operating and maintenance staff, after sales service

We combine the following requirements:

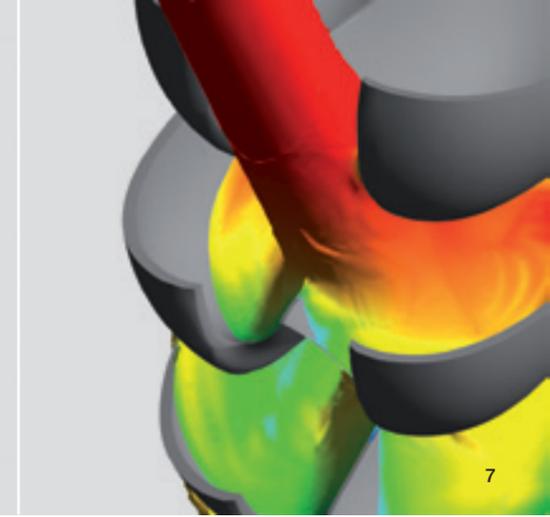
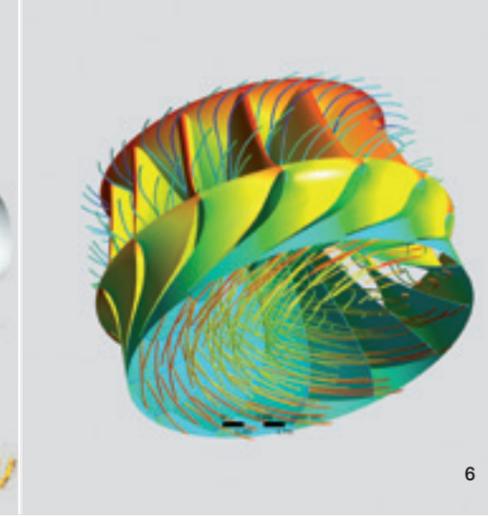
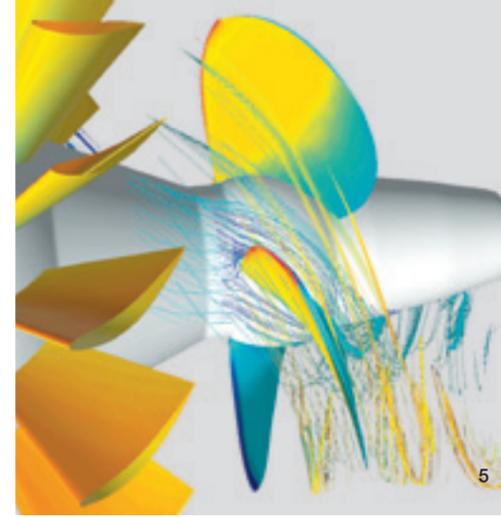
- Safety and high availability
- Long life and adaptability
- Proven solutions and concepts
- Standard and flexibility

### Everything from a single source.

Economic efficiency is assured by innovative, standardized concepts. The excellent price-performance ratio comes as a result of the latest engineering and application of modular principles.

This offers additional advantages:

- Clearly defined scope of delivery
- High availability
- Smooth operation
- Low operating costs
- Short payback periods



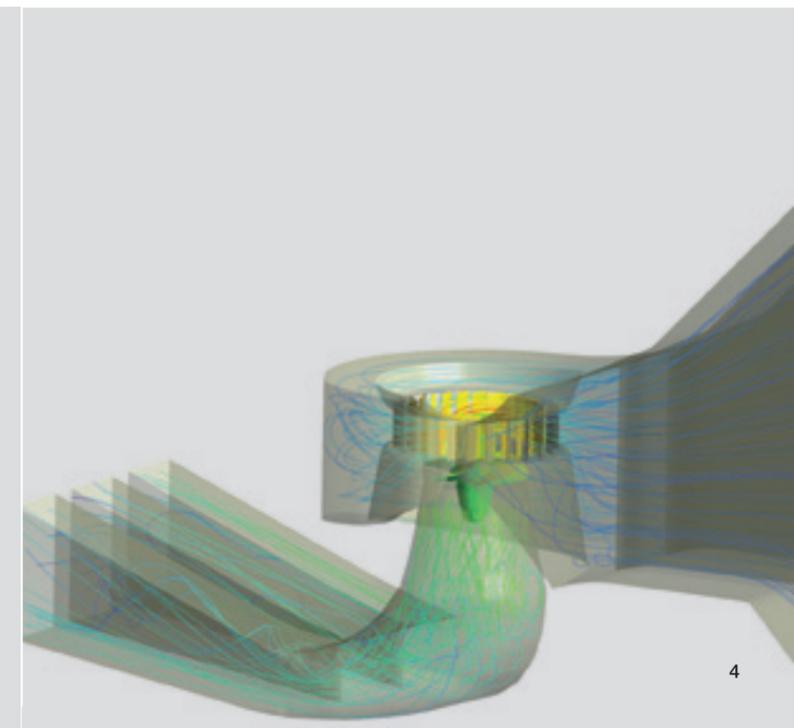
## Research and development

The center of know-how: The roots of Small Hydropower

Voith Research and Development is located in Heidenheim's historic "Brunnenmühle". It can look back at more than 100 years in hydropower technology development. It is the central management and distribution center of knowledge within the global network of

Voith coordinating highly productive hydraulic test labs. Intensive project specific developments like hydraulic model tests in Large Hydro is the basis for our Small Hydro standard design concepts.

- 1 Glafkos, Greece
- 2 Kayabükü, Turkey
- 3 Simulation of turbulent sub-structures downstream of a Francis turbine
- 4 Flow through a Kaplan turbine with semi-spiral inlet
- 5 Kaplan simulation
- 6 Francis simulation
- 7 Pelton simulation



## Our Small Hydro turbine competence

### Pelton turbines

High head Pelton turbines with excellent partial load operation ability can be:

- Horizontal and vertical shaft
- 1 to 6 nozzles
- Overhung 2-bearings, 3- or 4-bearings arrangement of turbine generator unit
- Inner and outer regulated nozzles
- Up to 1000 m head and 30 MW
- Standardized solutions possible up to 700 m head and 10 MW

### Francis turbines

For medium heads our program meets the full range of specific speed, all technical and economical requirements:

- Horizontal and vertical shaft
- Overhung 2-bearings 3- or 4-bearings arrangement of turbine generator unit
- Spiral Francis type
- Open flume Francis type
- Up to 250 m head and 30 MW
- Standardized solutions possible up to 250 m head and 18 MW

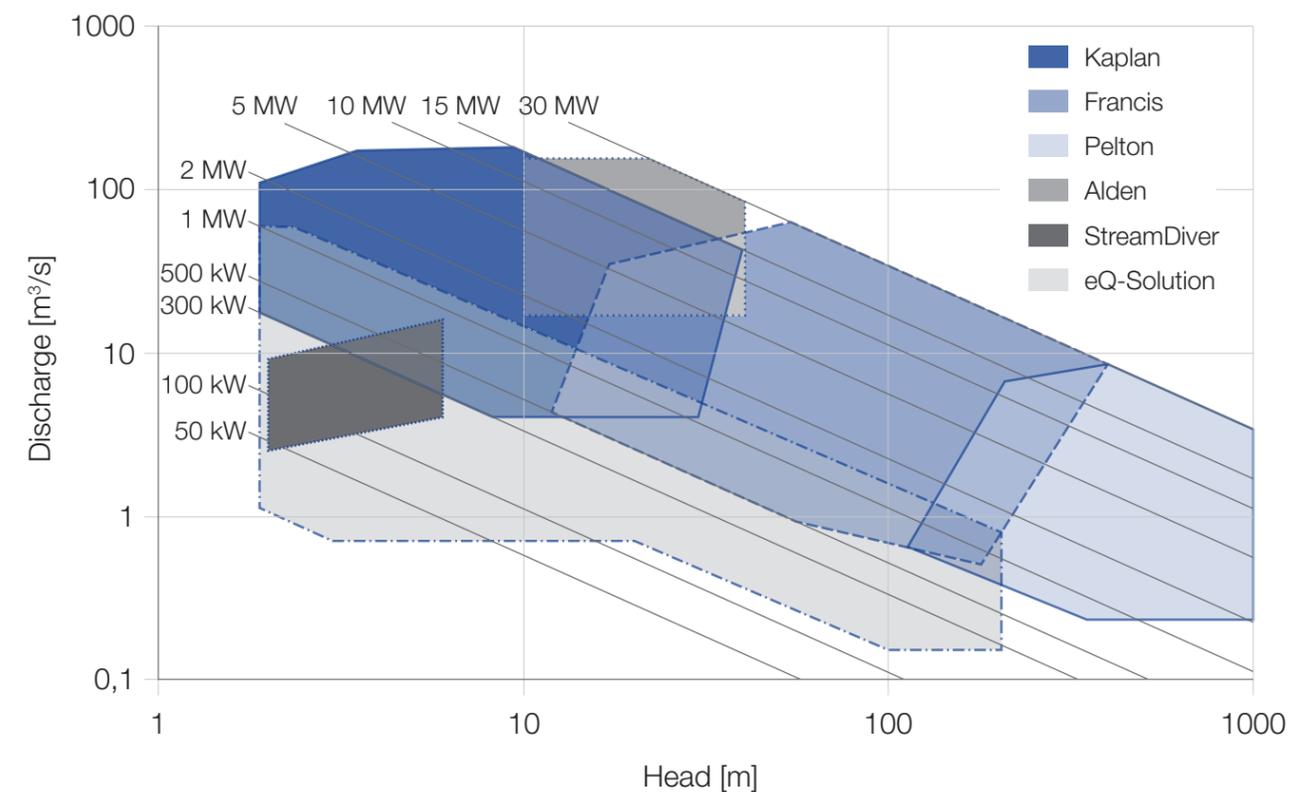
### Pelton turbine



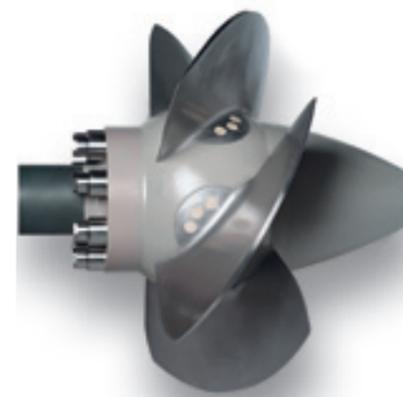
### Francis turbine



### Range of application



### Kaplan turbine



### Kaplan turbines

Full range of Kaplan turbine types for lower heads and larger flows can be provided:

- 3 to 7 blade runners of any diameter
- Vertical full or semi spiral arrangements, syphon types
- Pit turbines, S-turbines
- bulb turbines
- tubular axial turbines
- Double and single regulated turbines
- Up to 50 m head and 30 MW
- Standardized solutions possible up to 35 m head and 10 MW



1 Water lubricated bearing  
2 Runner finishing  
3 Shop quality control

1 Generator assembly  
2 Bearing assembly  
3 StreamDiver installation

## StreamDiver™

Innovative turbine technology is setting new economical and ecological standards.

All over the world there are run-of-river schemes with low heads whose high energetic potential could so far not be utilized. The StreamDiver™ ideally combines the demands on economy and ecology needed by these plants. The innovative technical concept of the StreamDiver™ ensures minimum maintenance and service work. As it can be directly installed into an existing or new weir system, its installation can even render conventional power station structures unnecessary. Construction technology and peripheral equipment can thus be reduced to a minimum.

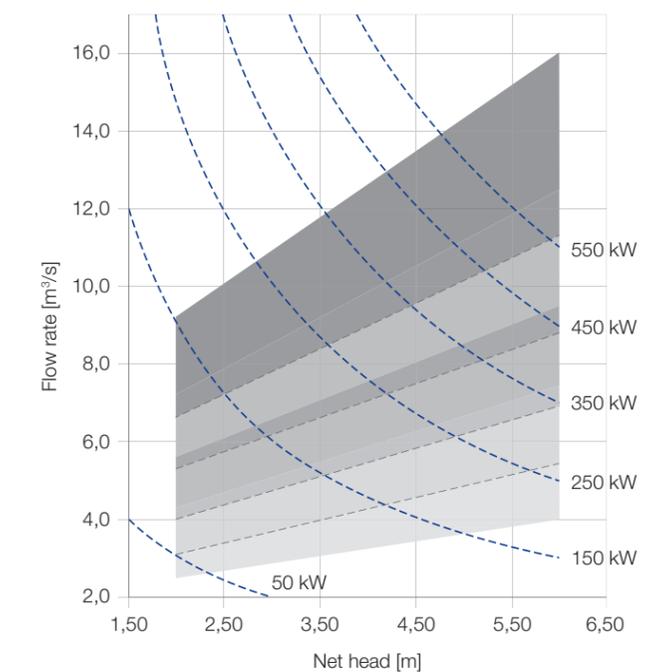
The StreamDiver™ is a compact turbine with an output of up to 800 kW per unit, which can be used for modular extensions as a minimum-flow turbine or as an alternative to existing Small Hydro plants. Apart from economical aspects, the development of the StreamDiver™ focusses strongly on ecological considerations. The bearings of this new development are water-lubricated. As a result, the compact turbine can be operated without any oil or grease.

### Advantages of the StreamDiver

- Particularly economical solution due to minimum operating
- Ideally suited for low heads
- Easy integration in existing weir systems or transverse structures
- Ecologically advantageous due to water-lubricated bearings and therefore oil and grease-free operation
- Low structural requirements and universal applicability



### Application areas of StreamDiver™ modules



## eQ Solutions

Standardized turbine solutions for economical applications in the lower output range.

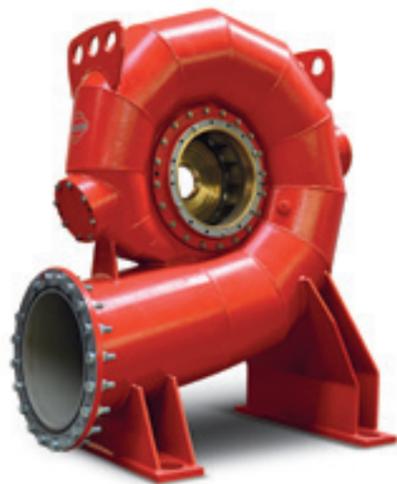
eQ-Solutions stand for compact Francis, Pelton and Kaplan turbine solutions in the output range of up to 1 200 kW. Standardized solutions are supplied in proven quality with a view to material selection, production and operating safety for man and machine – with a strong focus on essential functions and equipment. Due to their technically mature design, the construction of these turbines can be deliberately kept uncomplicated and compact.

This concept opens up totally new application opportunities. The applied turbine hydraulics are identical with those used for larger plants. For this reason, we can guarantee outstanding performance data and high investment security. All components and production stages are of course subject to our strict quality control.

Wherever possible, the turbines, generators and auxiliary units are pre-assembled in our works. This results in short delivery times and low on-site assembly requirements.

eQ-Solutions: developed for economical applications in the lower output segment. And produced in the quality, for which we have been renowned for decades.

### Francis eQ Solutions turbine



### Advantages of eQ - solutions

- Standardized series
- Concentration on essential functions
- Proven high quality, production and safety standards
- Shorter delivery times
- Low assembly requirements
- Guaranteed performance values due to the application of proven turbine hydraulics

## Small Hydro Automation System

As the world's leading manufacturer of hydroelectric power plants, we offer tailor-made automation systems to meet the requirements of hydroelectric power generation. The system not only sets new standards in terms of functionality, quality and reliability, but also represents outstanding value.

Our expertise gained in more than 20,000 hydropower plants, and our long-standing experience in the automation of hydroelectric power stations is a guarantee for perfect operation.

### Integrated, optimized overall system:

- Integration of automation systems, electrical and mechanical equipment for a well-functioning plant.
- Combination of digital automation technology with mechanical/hydraulic control elements, protection and excitation systems, low-voltage distribution boards and other auxiliary for a complete, fully optimized system.
- Combination of top plant engineering know-how with experience in modern digital systems.
- Complementation of standard control technology by addition of optimization and plant management modules that are tailored to the specific hydropower needs.



### The Voith Control Family

Mechanical equipment	Electrical equipment	Unit automation & plant control
governing systems – electrohydraulic converters, moving coil valves – control valves – emergency shut-down valves – shut-off valves – relay valves	digital protection systems	HMI
pressure oil supply system	digital excitation system voltage regulator reactive power control	automation efficient excellent
mech./hydr. control equipment for butterfly and spherical valves	LV. switchgears LV. distributions	digital turbine governor
instrumentation	power supply batteries UPS units	joint control
	synchronizers	river control
	security system	continuous monitoring

# Small Hydro Generator

Our contribution to making Small Hydro attractive is to ensure that your return on energy production is optimized. We are experts for generators, intergrating them perfectly into your powerhouse.

Generators in hydropower applications are an integrated part of the drive train with interfaces to various power house components – the understanding of the complete power house system is hence essential in developing a Small Hydro generator product line. This product line offers several advantages which conventional industrial generators cannot provide adequately.

Our engineers developed specific Small Hydro Generators for horizontal and vertical applications in order to increase lifetime by having moderate costs of operation. The Hydro specific design ensures grid stability, has high mechanical damping for stable operation and components designed for long life pans. With customers in Europe, America and Asia we offer proven solutions with no hidden expenses throughout the generator's

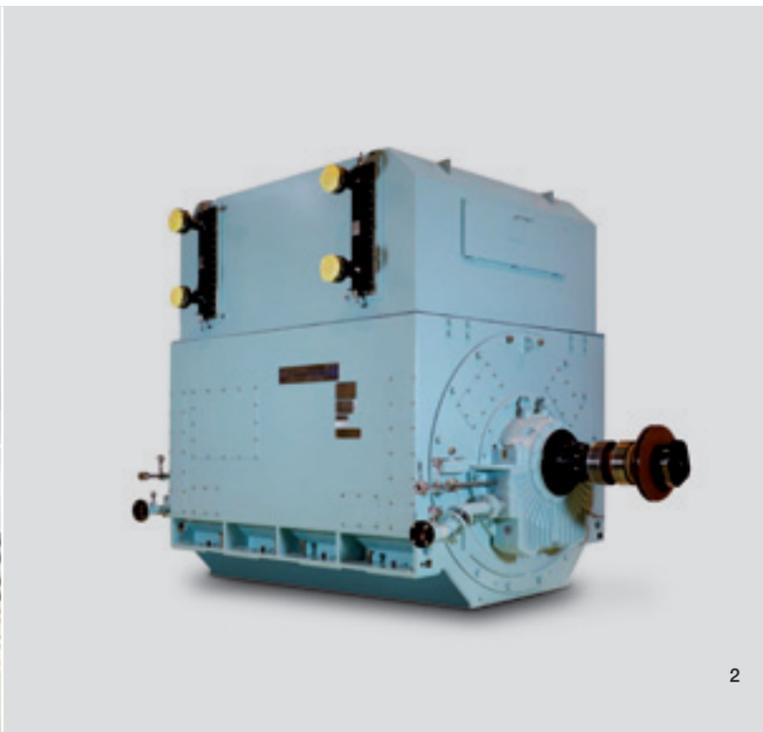
lifetime. As a result, the world of Voith is about quality and safety: we offer generators for small hydropower plants up to 33 MVA with a range from 690 V to 13,8 kV (frequency: 50 to 60 Hz) and full IEC tests including heat and speed test. And we promise reliable product support.

1 22.95 MVA generator

2 9,6 MVA generator



1



2

## Your requirements

### Maximized Annual Energy Production

Voith generators offer high availability and great efficiency even at part load. They are robust and require low maintenance. To maximize your Annual Energy Production, Voith has designed generators for continuous reliable operation.

### Long generator lifetime

Voith has extensive experience in manufacturing generators and we pull from this long history to provide excellent solutions for Small Hydro. Our design concept considers fail synchronizations, short circuits and overspeed. Thus, Voith promises high level of safety and guarantees long lifespan.

### Stable generator operation at grid

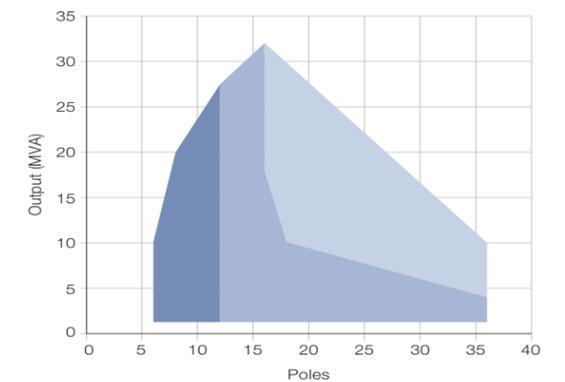
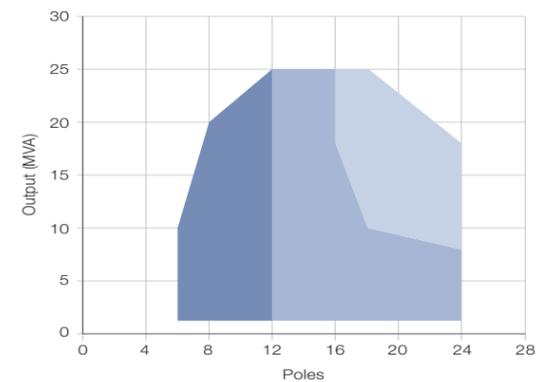
Our product line demonstrates an excellent grid connection behavior. Moreover, our generators have the capability to go through grid faults in transient conditions. All requirements of the latest grid codes have been considered during design and testing phases.

### Minimized Total Lifecycle Cost

Voith's generators are engineered utilizing an efficient modular design concept thus reducing the upfront investment required by a Small Hydro developer. All designs consider the most extreme operating conditions possible which ensure minimum Total Lifecycle Costs for the equipment.

No. of poles	RpM	
	50 Hz	60 Hz
6	1000	1200
8	750	900
10	600	720
12	500	600
14	429	514
16	375	450
18	333	400
20	300	360
22	273	327
24	250	300
26	231	277
28	214	257
30	200	240
32	188	225
34	176	212
36	167	200

## Generator standard application range\*



\* Others are available on demand

# Environmental Solutions

Voith sets standards in protecting the nature: Small Hydro solutions incorporate technological accomplishment our company has invented to keep the environment clean. Oil-free turbines or fish-friendly runner concepts help to adapt Small Hydropower plants to local habitats.

It is simple and sophisticated at the same time: Voith developed solutions for Small Hydropower plants that work environmentally friendly and highly efficient. As a full line supplier, we contribute to the preservation of the environment by offering ecological standard solutions.

For instance, our aerating runner concept enriches the water with oxygen, and the fish-friendly runners facilitate fish wandering downstream.

Moreover, we assist managing fish-passages and channels. With regard to keeping water clean, our water lubricated components substitute oil coated engine parts, such as our oil-free turbine.

## Alden Turbine

One of the latest improvements to fish passage technology comes through development of an innovative runner concept by Alden Research Laboratory. The Alden Turbine features a slower rotational speed and only three blades to reduce fish mortality due to blade strike. Voith Hydro has optimized the final design and tested it at their hydraulic laboratory in York, Pennsylvania (USA).

The blade shapes are specifically designed to minimize shear, pressure change rates and minimum pressures within the water passage. Full-scale fish survival range are expected to range from 98 to 100%.

Other benefits are optimized, wicket gates and stay vanes as well as redesigned hydraulic profile of the turbine components and the rotational speed. The turbine also features better water passage geometries to meet specified fish passage criteria.

## Minimum Gap Runner

To minimize the effects of gap flows on fish survival, Voith Hydro developed the Minimum Gap Runner (MGR) technology as part of the Department of Energy's Advanced Hydropower Turbine System (AHTS) program.

The MGR blades are contoured to a fully spherical hub and periphery so that the design gap remains constant across the pitch range. In addition to the stated goal of improving fish survival, the minimal gap also has positive impacts on turbine efficiencies.

Over the past decade, MGR technology has been implemented at several large axial flow units in the field, including Grant County (Washington) Public Utility District's Wanapum Dam, the US Army Corps of Engineers' Bonneville Dam, and American Municipal Power's Ohio River projects. Fish survival rates through MGR units have been documented to be in excess of 95%.

## Oil-free hubs

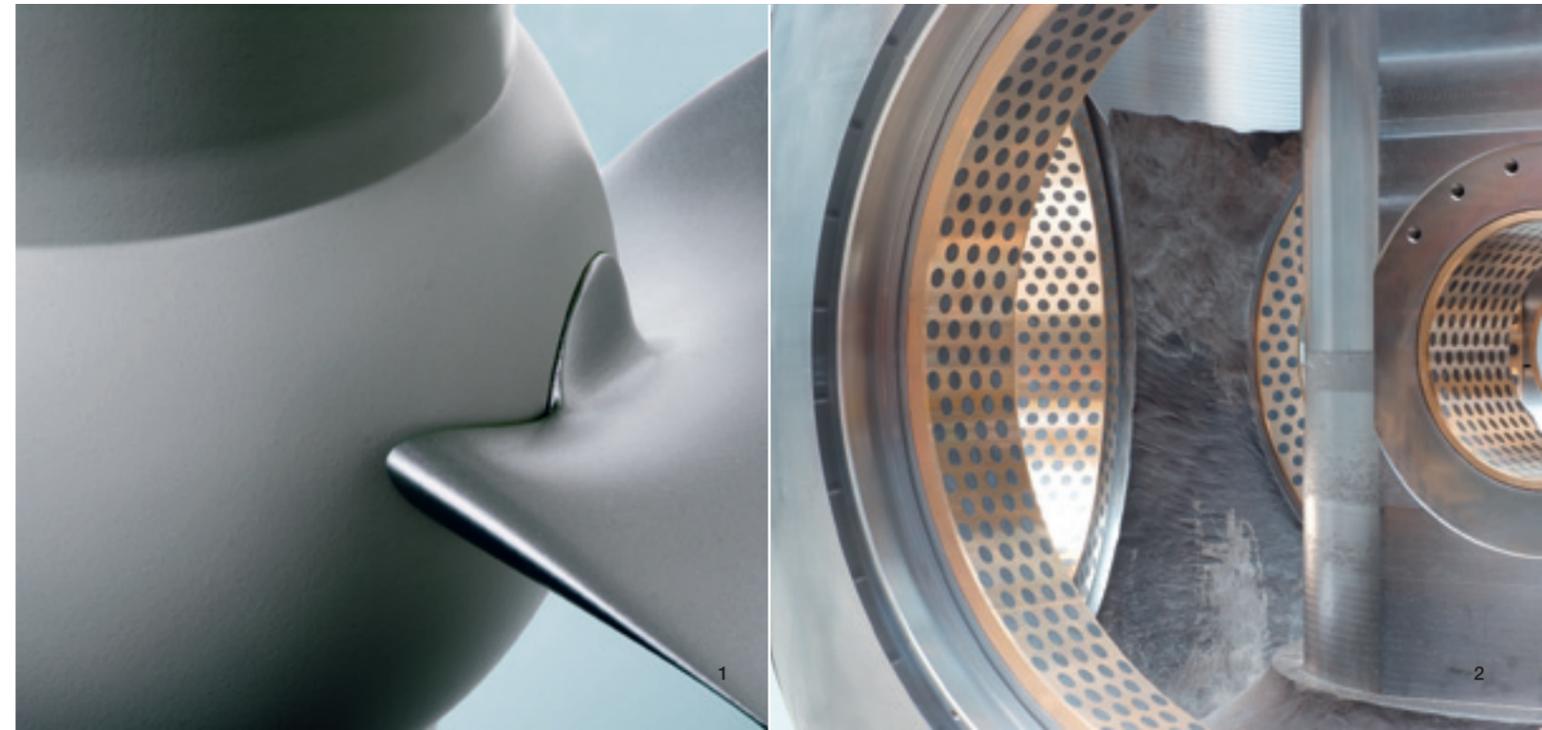
Adjustable blade runner hubs are typically filled with oil. This oil lubricates runner blade trunnion bearings and sliding parts of the operating mechanism in the hub. In order to eliminate this risk, Voith Hydro has been developing and installing oil-free solutions since 1985.

Oil has been replaced by self-lubricating materials and assures not only the prevention of accidental releases of grease substances into the environment but also allows for easy maintenance, lower friction and good bearing performance without the necessity of increasing servo size.

Alden Turbine



1 Minimum Gap Runner  
2 Oil-Free Hubs





1 Baños-V, Peru

2 Aishihik, Canada

3 Queixada, Brazil

4 Bardonetto, Italy

## Small Hydro References

A brief selection out of our long-term experience

- |  |   |  |   |
|--|---|--|---|
| <p><b>1890</b> Königsbronn, Germany<br/>1 x 0.025 MW Francis turbine</p> <p><b>1903</b> Niagara Falls, USA<br/>4 x 5.2 MW horizontal Francis turbine</p> <p><b>1994</b> Dobra I, Spain<br/>Modernization: Supply of 7,05 MW horizontal Pelton turbine</p> <p><b>1994</b> Zamuñon, Spain<br/>Supply of new horizontal Pelton turbine with a total output of 1,67 MW</p> <p><b>2003</b> Striven, Scotland<br/>2 x 4.0 MW horizontal Francis turbine (incl. Generators)<br/>Head: 126 m, Runner diameter: 0.96 m</p> <p><b>2006</b> Baba, Ecuador<br/>2 x 21.5 MW vertical Kaplan turbine (incl. Generator, AUT &amp; BoPE, BoPM)<br/>Head: 26.95 m, Runner Diameter: 3.6 m</p> | <p><b>2006</b> Subhash, India<br/>5 x 1,8 MW horizontal Francis turbine (incl. Generator, AUT BopE/BoPM)</p> <p><b>2008</b> Malagone, Brazil<br/>2 x 9.9 MW horizontal Francis Spiral turbine (incl. AUT, BoPE)<br/>Head: 48 m, Runner Diameter: 1.52 m</p> <p><b>2008</b> Esslingen, Germany<br/>2 x 0.66 MW Kaplan turbine (incl. Generator)</p> <p><b>2008</b> Kayabükü, Turkey<br/>3 x 5.0 MW horizontal Francis turbine</p> <p><b>2009</b> Aishihik, Canada<br/>1 x 7 MW horizontal Francis turbine with generator</p> <p><b>2009</b> Bardonetto, Italy<br/>Modernization: Supply of 2 horizontal Francis runner with a total output of 9.1 MW</p> | <p><b>2010</b> Niksar, Turkey<br/>2 x 20 MW Francis Turbine (incl. Generator, AUT, BoP/E)<br/>Head: approx. 60 m</p> <p><b>2010</b> Baños-V, Peru<br/>2 x 4.6 MW Horizontal Pelton turbine.<br/>Head: 350 m</p> <p><b>2010</b> Queixada, Brazil<br/>4 x 7.77 MW horizontal Francis Spiral turbine (incl. Generator, AUT, BoPM, BoPE)<br/>Head: 37.8 m, Runner Diameter: 1.63 m</p> <p><b>2010</b> Indaiá Grande, Brazil<br/>3 x 6.9 MW Kaplan S-turbine (incl. Generator, AUT, BoPE, BoPM)<br/>Head: 26.7 m, Runner Diameter: 2.09 m</p> <p><b>2010</b> Cubujuqui, Costa Rica<br/>2 x 11.44 MW horizontal Francis Spiral turbine (+ Butterfly Valve - Inlet Valve) (incl. Generator, AUT, BoPE, BoPM)<br/>Head: 112 m, Runner Diameter: 1.25 m</p> | <p><b>2010</b> Tambobach, Austria<br/>1 x 1.9 MW vertical Pelton turbine (incl. Generator and AUT)</p> <p><b>2011</b> Badger, USA<br/>Supply new turbine and generator with a total output of 7.26 MW</p> <p><b>2011</b> Ruechlig, Switzerland<br/>4 x 2,5 MW Kaplan Pit turbine (incl. Generator, AUT, BoP/M)</p> <p><b>2012</b> Hadley Falls, USA<br/>Modernization: Supply of new Kaplan runner and generator stator rewind (+2.5 MW)</p> <p><b>2013</b> Eidisverkid, Faroe Island<br/>1 x 7,5 MW new turbine as extension in comm. 2013; 2 x MOD (upgrade) from 6,7 MW to 7,5 MW comm. 2013</p> <p><b>2013</b> El Guineo, Mexico<br/>2 x 8.4 MW horizontal Francis Spiral turbine; complete E&amp;M scope<br/>Head: 40 m, Runner Diameter: 1.53 m</p> |
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