Bulb/pit/S-turbines and generators
Hydro power is not only environmentally friendly, but also cost-effective. Hydro power plants have the highest operating efficiency of all known generation systems. They are largely automated, and their operating costs are relatively low. Hydroelectric power plants also play an important role in water resource management, flood control, navigation, irrigation and in creating recreation areas.

Voith Hydro is an industry leader in the production of generators, turbines and the associated control systems to put the power of water to work. A range of services, from engineering through manufacturing and project management to commissioning, completes our portfolio as a leading product and service provider.

As part of our international network each Voith Hydro facility operates under the same cutting edge platform and is equipped with consistent best-in-class processes and tools. This network also ensures that we can meet special customized requirements: from individual components to project planning, through project management and plant maintenance. With branches and production facilities for electrical and hydraulic machines and components in Europe, Asia and North and South America we are close to our customers and all major hydro power markets.

Voith Hydro is also a trend-setter in the field of “new renewables”. Wave and ocean current power technology from Voith Hydro are amongst the pioneering initiatives for the commercial development of the power of the oceans in the foreseeable future.

Generating energy from the power of water represents large amounts of clean, renewable energy. 71 percent of the earth’s surface is covered by water. The world’s hydro power potential amounts to 20 billion Mega Watt hours per year and only 30 percent of this has been developed so far.
Our promise to the customer. Precise and creative. Our products and services are designed specifically for our customers’ needs. Always efficient and economical, and, above all, following our values and visions for a sustainable solution.

Competence and capabilities

- Consulting, engineering, erection and commissioning
- System/plant assessments
- HyService – 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 turbines, pump-turbines, standard and custom
- Storage pumps, radial, semi-axial and axial-flow pumps
- Generators and motor-generators for constant and adjustable speed, excitation systems
- Frequency converters, protection systems, switchyards for all voltages, transformers
- Power plant automation, control centers for hydro power plants and cascades, including plant management and diagnostic systems
- Shut-off valves
- Integrated Management System to safeguard excellence and quality

*Engineered reliability.*

Our promise to the customer. Precise and creative. Our products and services are designed specifically for our customers’ needs. Always efficient and economical, and, above all, following our values and visions for a sustainable solution.

Rheinfelden, guide vane ring

Karkamis
For decades, the hydraulic development, design and manufacture of bulb and pit turbines has been significantly influenced by Voith Hydro.

Characteristics

While the bulb turbine is the most common solution for high outputs at low headsites, S- and pit turbines are frequently favored for economic solutions in small hydro applications with outputs up to about 10 MW. Specific project requirements determine, which hydroelectric equipment is favorable on a case by case basis.

The application of pit and S-turbine units provides unique advantages. Their design provides good accessibility of various components and assures reliability and long service life.
Cross section of an S-turbine and generator

CFD illustration: Pressure and velocity distribution in a bulb turbine

Application range

- Kaplan S-turbine
- Bulb turbine
- Pit turbine

Output (MW) vs. Head (m) chart showing the application range of different turbine types.
Advantages of the bulb design

Higher full-load efficiency and higher flow capacities of bulb and pit turbines can offer many advantages over vertical Kaplan turbines. In the overall assessment of a low head project, the application of bulb/pit turbines results in higher annual energy and lower relative construction costs.

Pit-type turbines with a speed increaser located between the runner and generator are used for projects with heads lower than 10 meters. Since 1955 over 180 machines have been installed all over the world with outputs ranging from 50 kW to nearly 50,000 kW and with runner diameters between 800 mm and 8400 mm.

Currently, projects with outputs of up to 75,000 kW are being developed.

3-, 4-, 5-blade bulb turbine runners
Trend of runner diameter

Runner diameter [m]

Year of contract

3 blades
4 blades
5 blades
Most bulb units are arranged with two bearings: a guide bearing near the overhung turbine runner, and a combined guide and thrust bearing supported by the stay column just downstream of the generator. The bearing systems of horizontal machines, whether for bulbs, pit-turbines or S-type machines, are arranged to handle the counter thrust associated with load rejections of such units.

As bulb units grew in size, generator voltage also grew from initially 3.3 and 6.6 kV to 11.0 kV or even 13.8 kV on higher capacity units. Cooling systems evolved from originally separate heat exchangers to maintenance-free closed loop systems, providing heat dissipation directly into the river water passing the bulb unit. For very high capacities and high speed units pressurized air can also be used to improve heat dissipation.

Since the mid 1950s Voith Hydro has supplied bulb generators, with new designs approaching high outputs in excess of 80 MVA.

### Generator characteristics of bulb

Generator output (MVA) 

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Jirau, Santo Antonio, Meldahl, Cannelton, Smithland, Willow Island.
Three-bearing systems are provided for certain high capacity machines, optimized for specific project requirements. The challenge in modern bulb unit designs is to achieve maximum reliability and availability, with minimum maintenance of the main units and associated auxiliaries.

With its broad experience in hydro generators for the world’s largest hydroelectric facilities, and fifty years of experience in the design, manufacture and installation of bulb generators, Voith Hydro can provide fully optimized bulb, pit and S-type units for any installation.
References and milestones

1955  Sylvenstein, Germany:  
First compact design bulb turbine.

1961  Fankel/Lehmen/Müden, Germany:  
Four pit machines each with runner diameters between 4.6 m and 4.7 m for the Mosel River.

1973  Altenwörth, Austria:  
Most powerful bulb turbines at the time at 44 MW output, runner diameter 6 m.

1978  St. Mary’s, Ontario, Canada:  
18 MW 3-bladed bulb turbines, runner diameter 7.1 m.

1978  Ma Ji Tang, Hunan, China:  
First modern bulb turbine units in China at 18 MW and runner diameter 6.3 m.

1982  Shingo 2, Japan:  
Largest bulb turbine/generator unit in Japan at the time at 40.6 MW/40.9 MVA, 5 blades and 5 m runner diameter.

1985  Murray Lock and Dam, AR, USA:  
Largest pit turbine/generator units in the world with runner diameters of 8.4 m, rated at 20.5 MW/22.8 MVA with two-stage epicyclic speed increases.

1993  Ybbs-Persenbeug, Austria:  
Large bulb unit at 48 MW and runner diameter of 7.5 m.

1994  Chashma, Pakistan:  
Largest bulb power station in Pakistan equipped with eight bulb turbine/generator units each rated at 23.7 MW/21.6 MVA and 6.3 m runner diameter.

1994  Bailongtan, China:  
Largest bulb power station in China at the time equipped with six bulb turbine/generator units each rated at 33 MW/33.7 MVA with 6.4 m runner diameter.

1995  Karkamis, Turkey:  
Largest bulb power station in Turkey, with six 35.5 MW bulb turbines with 6.3 m runner diameter.
1999  Kaminojiri 2, Japan:
Largest vertical bulb turbine/generator in the world at 14 MW/14.3 MVA and runner diameter of 3.9 m.

2002  Kisköre, Hungary:
The hydraulic turbines of this power station were modernized with new runners and guide vanes. The four units have runner diameters of 4.3 m and operate at 10 m of rated head.

2004  Lower Olt, Romania:
This large project has five power houses and each is equipped with four reversible axial pump-turbines. These bulb type machines have been completely modernized. They generate 14.5 MW and have a runner diameter of 4.5 m.

2006  Rheinfelden, Germany:
This contract is for four new 25 MW bulb turbine units with 6.5 m runner diameter. The new Rheinfelden hydro power plant is the largest investment in renewable energies in Germany.

2007  Baguari, Brazil:
Four new 36 MW/39 MVA bulb turbine/generator units with 5.1 m runner diameter. The units are designed for heads up to 20 m.

2008  Ohio River, USA:
This contract includes four power stations: Cannelton, Meldahl, Smithland and Willow Island. Combined, these projects have an expected capacity of 321 MW/357 MVA with eleven bulb turbine/generator units altogether. The large turbines with 7.7 m runner diameter will operate at very low speed.

2008/ Rio Madeira, Brazil:
2009  Two projects: Santo Antonio with 13 units each generating 75,55 MW/82,25 MVA and Jirau with ten units operating at 76,5 MW/83,33 MVA each. Both have runner diameters of 7.5 m.