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VOITH

Bulb/Pit/S-Turbines and Generators

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Harnessing the power of water

Generating electricity from the power of water represents large amounts of clean, renewable energy. Seventy-one percent of the earth’s surface is covered by water. So far, the installed world´s hydropower potential is 4 million GWh/year. There remains a huge hydropower potential of 16 million GWh/year.

Cover picture:
Rheinfelden, Germany

1 Meldahl, Ohio River, USA

2 Karkamis, Firat - Euphrates, Turkey

3 Rheinfelden, distributor

Hydropower is a clean, renewable and environmentally friendly energy source – with low carbon dioxide emissions. Hydropower plants have the highest operating efficiency of all renewable energy generation systems. They are largely automated, and operating costs are relatively low. Hydroelectric power plants also play an important role in water resource management, flood control, navigation, irrigation and in creating recreational areas.

Customer focused and innovative

Voith is a leading full-line supplier as well as trusted partner for equipping hydropower plants all over the world. Our portfolio of products and services covers the entire life cycle and all major components of hydropower plants:

- Generators
- Turbines
- Pumps
- Automation systems
- Spare parts
- Steel structural components
- Maintenance and training services
- Digital solutions for intelligent hydropower

A world-class laboratory

Using state-of-the-art technologies and innovative digital solutions, we are committed to developing customized long-term solutions in hydropower in the years to come. At the Voith Hydro Engineering Center, scientists, engineers and measurement technicians access more than 100 years of know-how and can make use of one of the most modern hydraulic laboratories in the world. Combined with the deep domain knowledge that evolved over decades from more than 40 000 units delivered to customers, this environment paves the way to innovations of the existing product portfolio as well as new technologies.

Global experts

As part of our international network, each Voith 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, North and South America, we are close to our customers and active in all major hydropower markets worldwide.

Technical reliability with highest quality standards

Voith has been known for quality right from the start. We strive to continuously meet our own high aspirations in terms of quality: Our global certification is based on well-known international standards (ISO) for quality management environmental protection as well as occupational health and safety. Moreover, we have developed our own methods for quality assurance and work according to them. In this way, future generations will continue to benefit from the quality of our work.

Turbine characteristics

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

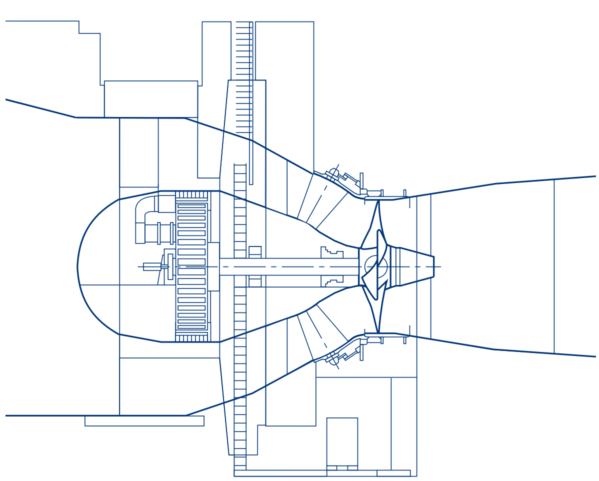
Characteristics

While the bulb turbine is the most common solution for high outputs at large flow rates and low head conditions, Pit-, S-up- and S-downstream turbine are frequently favored for economic solutions in small hydropower applications with outputs up to about 10 MW. Specific project requirements determine, which hydroelectric equipment is favorable on a case by case basis.

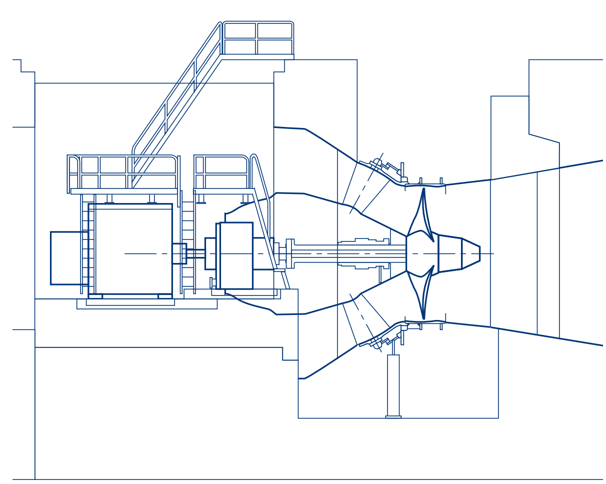
The application of pit and S-turbine units provides unique advantages. Their design provides good accessibility of various components and assures reliability and long service life.

With the experience and comprehensive understanding of these turbine types, Voith Hydro can always offer customized, optimized solutions for customers at existing or new sites.

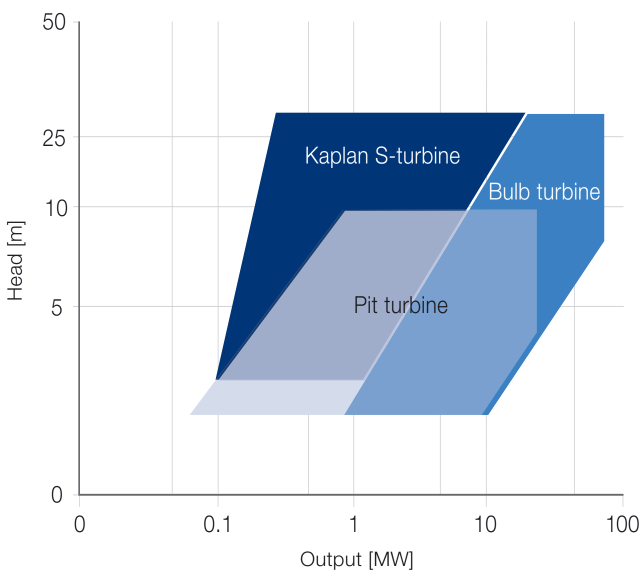
Cross section of a bulb turbine and generator



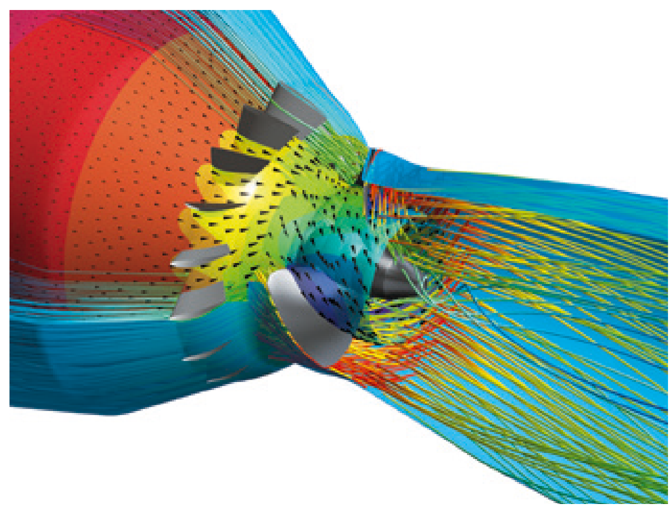
Cross section of a pit turbine, gearbox and generator



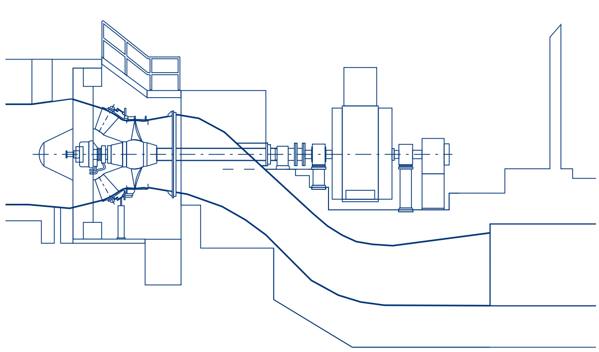
Application range



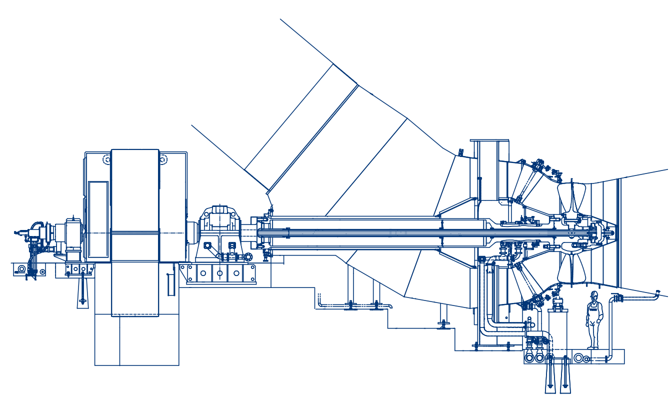
CFD illustration: Pressure and velocity distribution in a bulb tubine



Cross section of an S-turbine and generator



Cross Section for S-Upstream and generator



Advantages of the bulb design

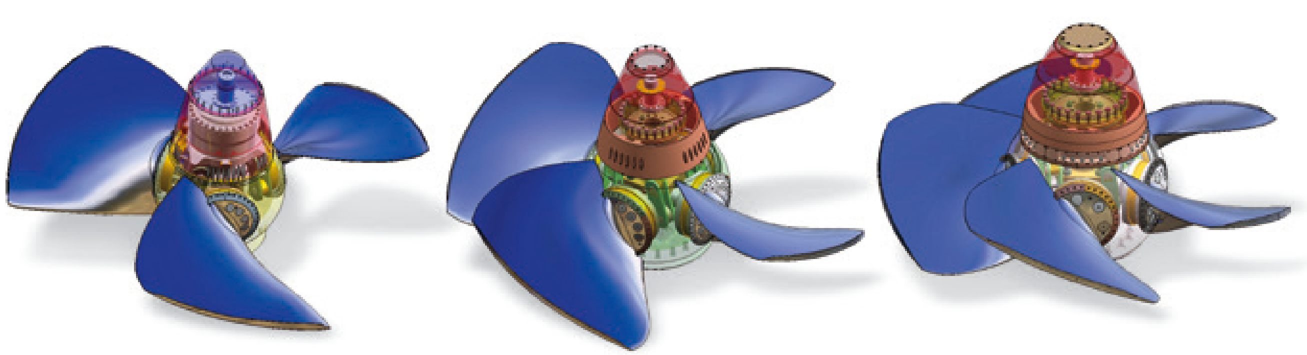
Higher full-load efficiency and higher flow capacities of bulb and pit turbines can offer many advantages over vertical Kaplan turbines.

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.

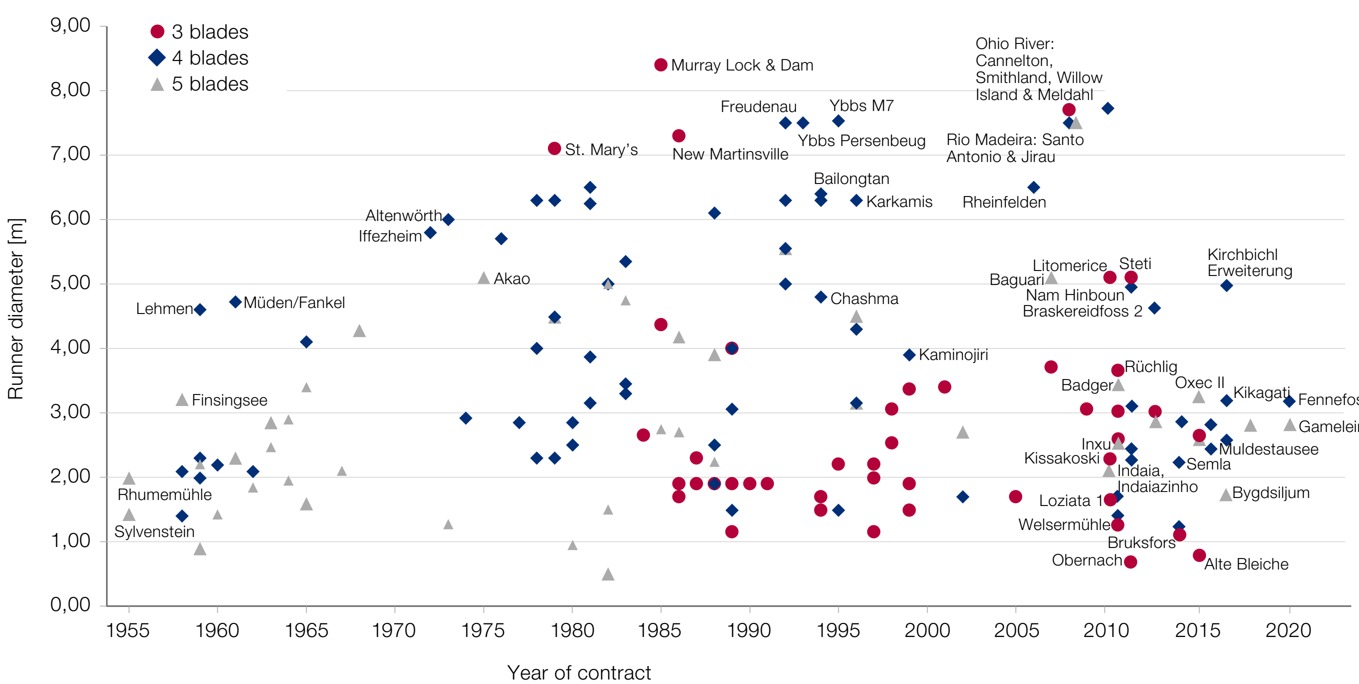
Pit-type turbines with a speed increaser located between the runner and generator are used for projects with heads lower than 10 meters. Since 1955, more than 282 machines with outputs ranging from 19 kW to 76.55 MW and with runner diameters between 500 mm and 8 400 mm have been installed worldwide.

Currently, units with outputs of up to 75 MW are in operation.

3-, 4-, 5-blade bulb turbine runners



Trend of runner diameter



Generator characteristics of bulb

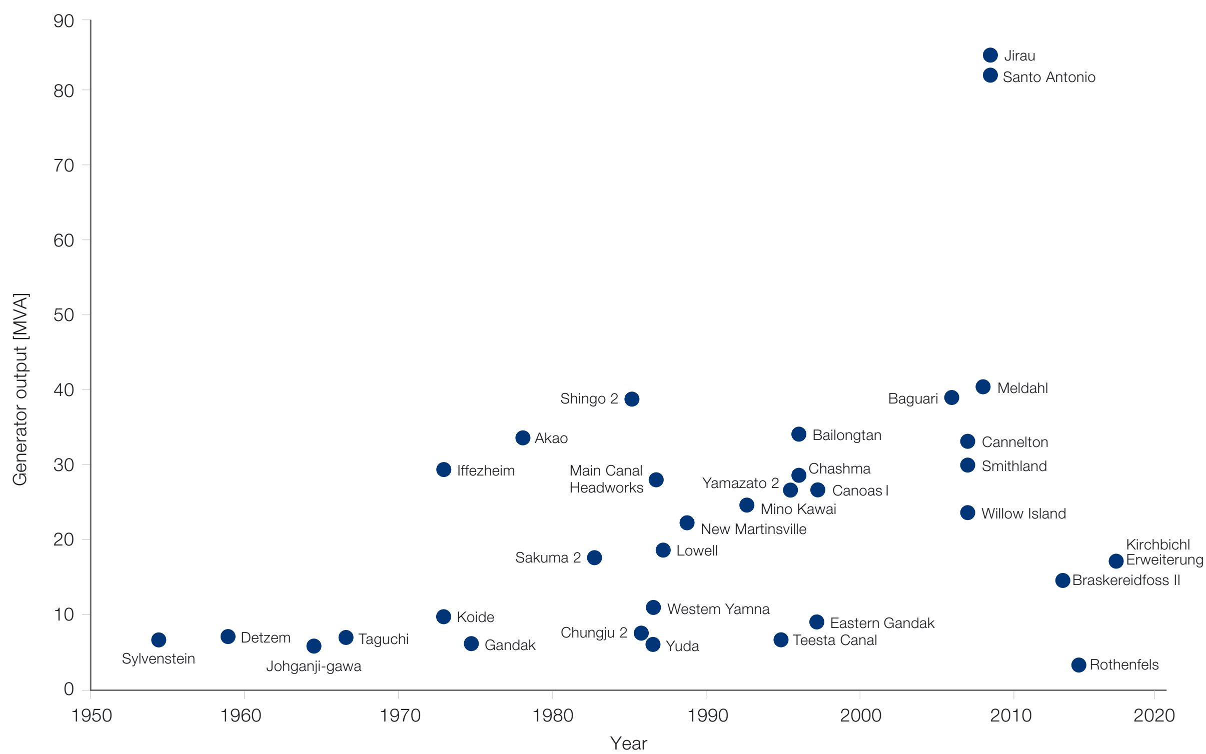
Since the mid-1950s, Voith has supplied bulb generators with new designs approaching high outputs in excess of 80 MVA.

As bulb units grew in size, generator voltage also grew from the initial 3.3 kV and 6.6 kV to 11.0 kV and 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.

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.

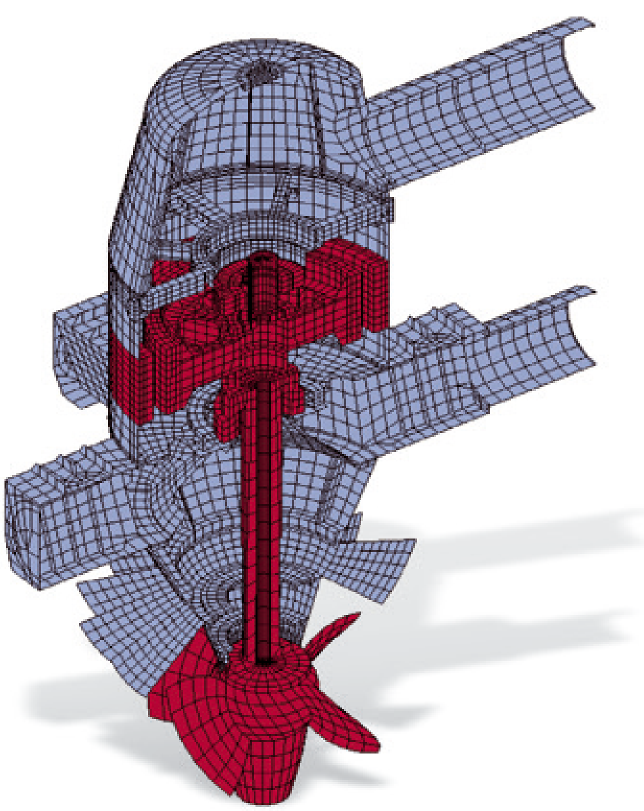
Trend of bulb generator output



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 hydropower generators for the world's largest hydroelectric facilities, and fifty years of experience in the design, manufacture and installation of bulb generators, Voith can provide fully optimized bulb, pit and S-type units for any installation.

3D section of a vertical bulb unit



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1855 **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

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 with a runner diameter of 7.5 m.

1994 **Chashma, Pakistan:**
Largest bulb power station in Pakistan, 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, 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:**
Vertical bulb turbine/generator at 14 MW/14.3 MVA and runner diameter of 3.9 m.

2002 **Kisköre, Hungary:**
Modernization of four bulb turbines with runner diameters of 4.3 m, rated head of 6.27 m.

2004 **Lower Olt, Romania:**
Modernization of 5 x four reversible axial pump turbines bulb type, 14.5 MW each and a runner diameter of 4.5 m.

2005 **Toyomi, Japan:**
Largest vertical bulb turbine/generator in the world at 32 MW with a runner diameter of 4.4 m.

2006 **Rheinfelden, Germany:**
Four 25 MW bulb turbine units with 6.5 m runner diameter.

1 Shingo, Japan
2 Rheinfelden, Germany
3 Baguari, Brazil
4 Ohio River/Cannelton, USA

2007 Baguari, Brazil:
Four 36 MW/39 MVA bulb turbine/generator units with 5.1 m runner diameter.

2008 Ohio River, USA:
Four power stations with eleven bulb turbine/generator units and a capacity of 321 MW/357 MVA in total, runner diameter of 7.7 m.

2009 Rio Madeira, Brazil:
Santo Antonio with 13 bulb turbines with 75.55 MW/82.25 MVA each and Jirau with ten bulb turbines with 76.5 MW/83.33 MVA each. Runner diameters of 7.5 m.

2010 Litomerice, Czechia:
Two 3.5 MW Pit-type turbines with a runner diameter of 3.7 m.

2011 Rüchlig, Switzerland:
Four 2.4 MW bulb turbines with a runner diameter of 3.7 m.

2012 Nam Hinboun, Laos:
Two bulb turbine/generator units of a rated output of 15.4 MW/16.3 MVA.

2012 Santo Antonio do Jari, Brazil:
S-Upstream turbine with an output of 3.5 MW and a runner diameter of 2.4 m.

2013 Braskereidfoss 2, Norway:
Bulb turbine/generator unit of a rated output of 15.7 MW.

2015 Oxec II, Guatemala:
Three S-Upstream turbine with an output of 19.5 MW. Runner diameter of 4.6 m and rated head of 31 m.

2016 Muldenstausee, Germany:
Two 1.4 MW Pit-type turbines with a runner diameter of 2.4 m.

2017 Kirchbichl Erweiterung, Austria:
Bulb turbine/generator units of a rated output of 17.4 MW/20 MVA.

2018 Tamboril, Brazil:
Two S-Upstream turbine with an output of 8.2 MW and a runner diameter of 2.9 m.

2019 Trysilfossen, Norway:
S-Turbine with an output of 1.5 MW and a runner diameter of 1.7 m.

2020 Fennefoss, Norway:
Two 4.9 MW Pit-type turbines with a runner diameter of 3.6 m.

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