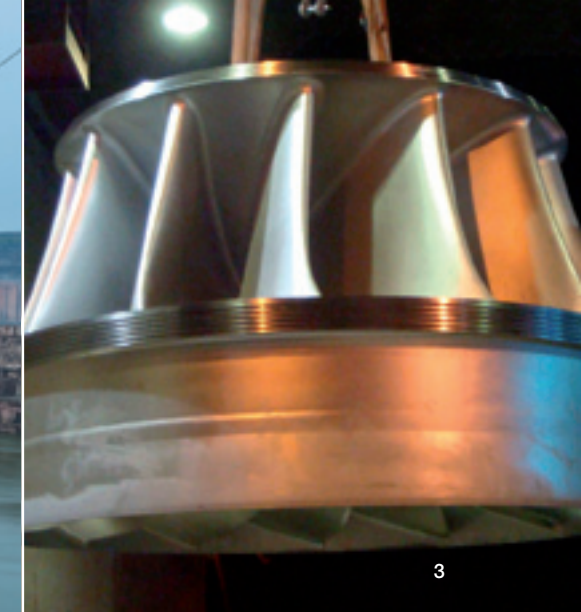


**VOITH**

## Francis turbines







Cover picture Francis Runner, Workshop, Brazil

# Harnessing the power of water with engineered reliability

Generating electricity 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 hydropower potential amounts to 20 billion Megawatt hours per year and only 25 percent of this has been developed so far.

Hydropower is not only environmentally friendly, but also cost-effective. Hydro-power plants have the highest operating efficiency of all renewable 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 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 one of the world's leading hydropower product and service provider.

As part of our international network each Voith facility 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.

With more than 140 years experience in the field of hydropower and major achievements in research and development, Voith is well equipped to continue delivering excellence in hydropower in the years to come.

## Engineered reliability

Is our promise to our customers. Voith's products and services are designed specifically for our customers' needs. We always work efficiently and economically and, above all, following our values and visions for sustainable hydro power solutions.

## 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/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 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



# Characteristics

From the beginning, Francis turbine development has always been synonymous with Voith.

With decades of continuous optimization based on the latest hydro-dynamic research, well over half the turbines manufactured by Voith are of the Francis type.

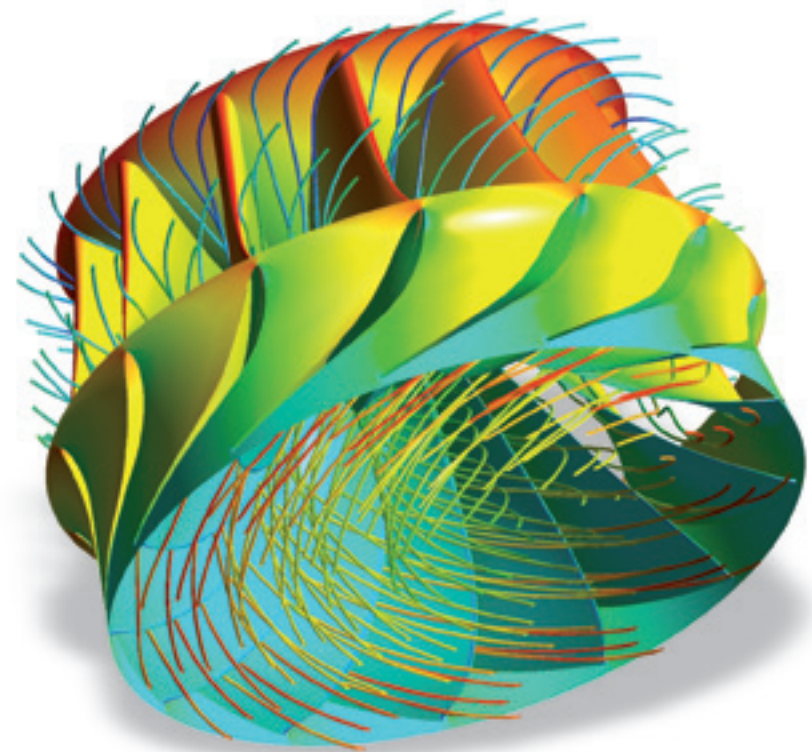
Our Francis turbines, including the world's largest and most powerful, are in service around the globe. What better testimony to our more than 140 years of hydro turbine experience?

Numerical development methods linked to computer-aided manufacturing processes guarantee optimum hydraulic performance and reliability.

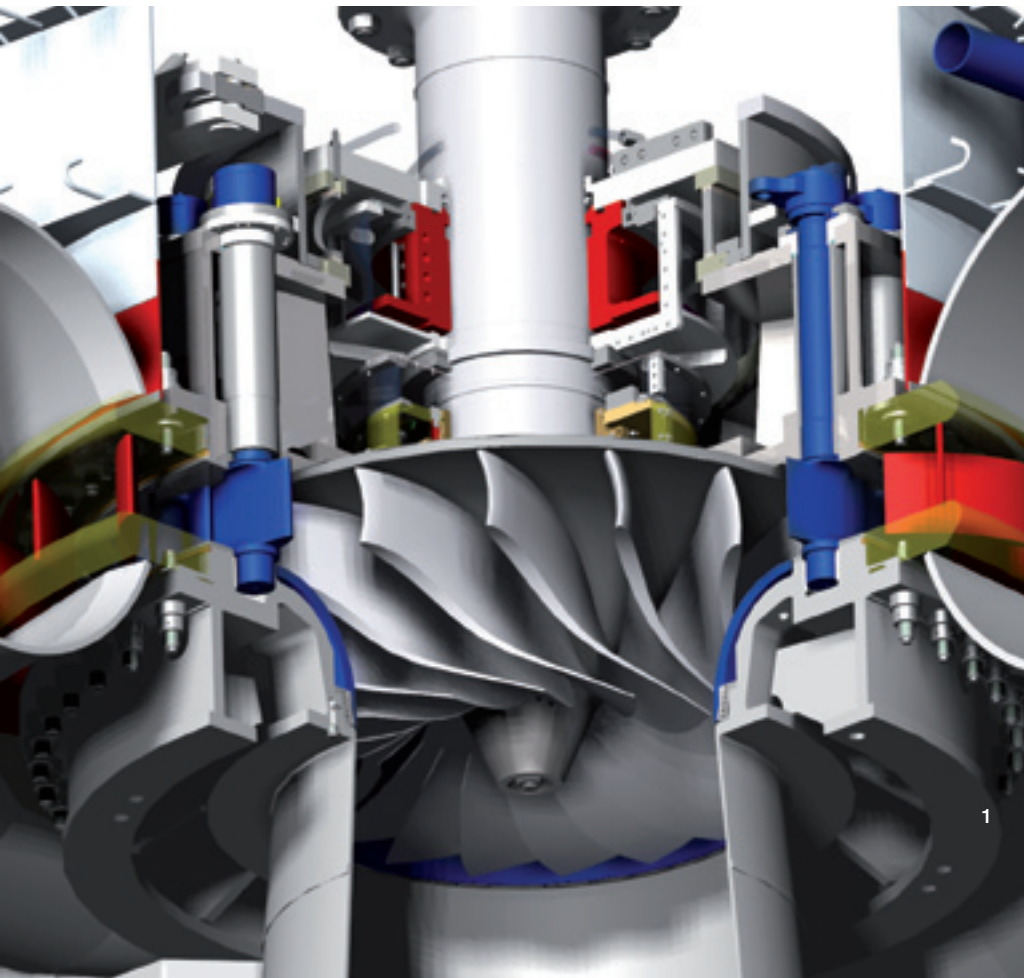
Francis turbines are used primarily for medium heads and large flows applications. Their special hydraulic characteristics result in relatively high-speed compact units, right up to the largest capacities.

Voith also supplies cost-effective Francis units in standardized designs and packages for small hydro plants.

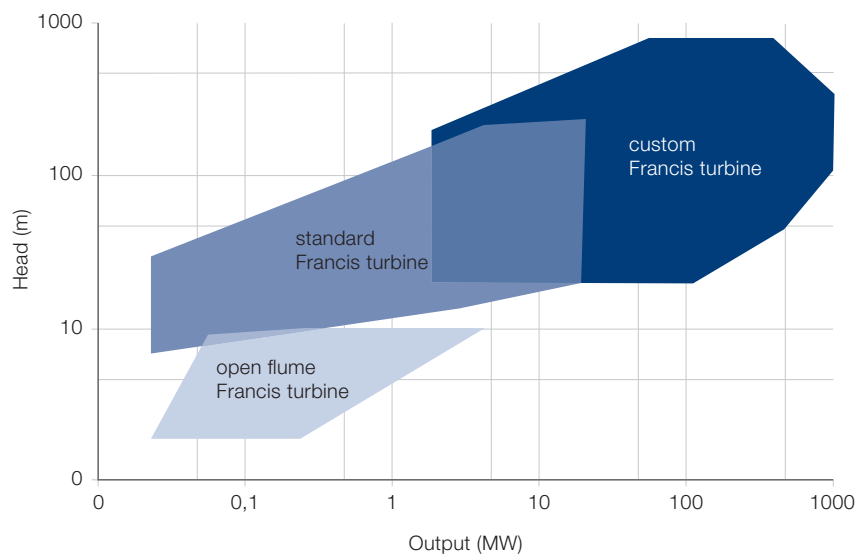
Francis turbine 3D model



- 1 Francis turbine 3D model
- 2 Xi Luo Du, China



Application range







- 1 Xingo, Brazil
- 2 Xi Luo Du, China
- 3 Eastmain, Canada
- 4 Revelstoke, Canada

- 1870** Hydro turbine production began.
- 1873** First Francis turbine with a modern distributor.
- 1903** Niagara Falls, Canada:  
Double spiral turbines with  $P = 5.2$  MW and  $H = 79.5$  m.  
Most powerful turbines of their time.
- 1912** Niagara Falls, Canada:  
Double spiral turbines with  $P = 12$  MW and  $H = 54.9$  m.  
Most powerful turbines of their time.
- 1974** Grand Coulee III, USA:  
 $P = 820$  MW and  $H = 87$  m.  
Most powerful and largest Francis turbines in the world with 9.7 m runner diameter.

- 1974** Rovina-Piastra, Italy:  
 $P = 133$  MW at the high head of  $H = 554$  m.
- 1978** Itaipu, Brazil/Paraguay:  
 $P = 800$  MW and  $H = 118.4$  m.  
Overall design and joint supply of turbines and generators for the world's most powerful hydro plant to date at 13,300 MW.
- 1982** Xingo, Brazil:  
 $6 \times 535$  MW; Francis turbines with an operating head of 111.7 m and a runner diameter of 7.2 m.
- 1991** Norris Dam, USA:  
First aerating Francis turbine runner increases dissolved oxygen content for enhanced aquatic life.
- 1997** Three Gorges, China:  
Participation in the supply of turbines, generators and electrical equipment for the world's largest hydroelectric power plant with a total capacity of more than 18,000 MW.

- 1997** Ghazi Barotha, Pakistan:  
 $5 \times 295$  MW; vertical Francis turbines with an operating head of 69 m and a runner diameter of 6.4 m.
- 2003** Omkareshwar, India:  
 $8 \times 66.3$  MW; large low head Francis turbines with operating head in the range of about 30 m.
- 2005** Xiaowan, China:  
 $6 \times 714$  MW; Francis turbines including 8.7 m outside diameter ring gates.
- 2006** Revelstoke, Canada:  
 $1 \times 512$  MW; Francis turbine with an operating head of 127.1 m and a runner diameter of 7.1 m.
- 2007** Jin Ping II, China:  
 $8 \times 610$  MW; high head Francis turbines equipped with ring gates; first application of the splitter blade design for a large runner (runner diameter about 6.5 m).

- 2007** Eastmain 1 A, Canada:  
 $3 \times 260$  MW; Francis turbines with an operating head of 63 m and a runner diameter of 6.6 m.
- 2007** Nuo Zha Du, China:  
 $3 \times 650$  MW; Francis turbines with an operating head of 187 m and a runner diameter of 7.3 m.
- 2008** Xi Luo Du, China:  
 $3 \times 784$  MW; Francis turbines with an operating head of 197 m and a runner diameter of 7.7 m.
- 2008** Li Yuan, China:  
 $4 \times 612$  MW, Francis turbines with an operating head of 106 m and a runner diameter of 8.2 m.
- 2009** San Esteban II, Spain:  
 $1 \times 177.3$  MW, Francis turbine with an operating head of 95 m and a runner diameter of 4.6 m.
- 2010** Waneta, Canada:  
 $2 \times 167$  MW Francis turbines with an operating head of 61 m and a runner diameter of 5.5 m.
- 2011** Bratskaya, Russia:  
Refurbishment and runner replacement for  $6 \times 255$  MW Francis turbines, operating head of 100 m, runner diameter of 5.6 m.

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**VOITH**  
Engineered Reliability