Generators
Harnessing the power of water

Generating energy from the power of water represents large amounts of clean, renewable energy. Seventy-one percent of the earth’s surface is covered by water. The world’s hydropower potential amounts to an estimated 20 million Gwh/a, and only 25 percent of this has been developed so far.

Hydropower is not only environmentally friendly, but also cost-effective. Hydropower 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 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 electric 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 nearly 150 years’ experience in the field of hydropower and high annual spending for research and development, Voith is well equipped to continue delivering excellence in hydropower in the years to come.
Technical reliability
This is our promise to our customers. Our products and services are designed specifically for our customers’ needs. Always efficient and economical and, above all, following our values and visions for sustainable hydropower solutions.

Competences 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 hydropower plants and cascades, including plant management and diagnostic systems
- Shut-off valves
- Integrated management system to safeguard excellence and quality
Characteristics

For well over a century, Voith has supplied the world’s largest and most powerful hydroelectric units with respect to both performance and size. As we push the envelope in hydropower technology, Voith focuses on customized solutions for utilities.

Power demand increases with the expansion of the economy and improved living standards. Following this trend, the capacity of generating units has also increased, growing from 6.25 MVA at Necaxa in 1903 up to 840 MVA at Three Gorges in 1997 and now to more than 855.6 MVA at the Xi Luo Du and even 944.5 MVA at the Wu Dong De power station. These are the most powerful generators designed and manufactured by Voith today.

To improve optimum project economics, higher unit capacity machines are often used in order to reduce the number of units at each plant. For compact machines, direct water cooling is very effective. Within the renewable energies, pumped storage plants play a new role with the use of variable speed technology to directly support grid control.

Frades II is a milestone in hydropower: thanks to their variable speed based of DFIM (Doubly Fed Induction Machine), the pumped storage units designed and supplied by Voith can adapt their number of revolutions continuously and take or provide power from and to the grid.

Above this, the asynchronous motor generators can also be utilized for frequency stabilization of the grid. The highly sensitive control systems react to grid variations within milliseconds, can tap the kinetic energy of the flywheel masses of the motor generators, and provide immediately energy to the grid, or respectively absorb energy from it. Facing variations in the grid, the motor generators react extremely fast and in the case of faults can compensate voltage drop accordingly – and thus enhance security of power supply.

With a maximum continuous output of 433 MVA and a speed range from 350 rpm to 381.2 rpm, those are the most powerful variable speed motor generators in Europe built so far.

Another milestone in hydropower is the powerhouse at Limberg I in Austria. The built-in synchronous full inverter machine provides a maximum continuous output of 81.5 MVA and a speed range from 400 rpm to 750 rpm.
History of generators and motor generators

Rating (MVA*):

Projects
1. Necaxa, Mexico
2. Herdecke, Germany
3. Suiho, China
4. Vianden, Luxembourg
5. Furnas, Brazil
6. El Chocon, Argentina
7. Rottau/Malta, Austria
8. Wehr, Germany
9. Santo Antonio, Brazil
10. Jirau, Brazil
11. Riel (SC**), Canada
12. Raccoon Mountain, USA
13. Paulo Afonso IV, Brazil
14. Helms, USA
15. Bath County, USA
16. Samrangjin, South Korea
17. Bath County MOD, USA
18. Frades II (DFIM***), Portugal
19. Chang Long Shan, China
20. Belo Monte, Brazil
21. Guri II, Venezuela
22. Itaipu, Brazil/Paraguay
23. Three Gorges, China
24. Xi Luo Du, China
25. Wu Dong De, China

* Mega volt ampere
** Synchronous Condenser
*** Doubly Fed Induction Machine

Water-cooled
Air-cooled
Hydrogen

Na
Design criteria

Voith is setting milestones with its generator technology. Customers benefit from our deep understanding of sophisticated engineering and conceptual competence in project execution.

And at the same time, our engineers incorporate the cause and effects of the related components of the entire plant. We master the interplay of thinking outside the box and traditional engineering in order to provide a highly reliable generator that offers the state-of-the-art technology.

We keep in mind what customers are looking for: efficiency, easy handling, absolute reliability. Two of the world’s most powerful synchronous generators are part of the Xi Luo Du power plant in China with a maximum output of 855.6 MVA at 125 rpm and the Wu Dong De power plant with a maximum output of 944.5 MVA at 90.9 rpm.
The following design criteria influence the generator’s main dimensions:

- In order to ensure a long and reliable operation, it is essential that operational temperatures are aligned with the allowable limits of the materials, especially those of the winding with respect to the applied insulation system.
- The required moment of inertia must be provided within the given stator bore dimensions:
  - to enhance the grid stability and improve the LVRT (Low Voltage Ride Through) characteristic
  - to increase the time until the power unit achieves the runaway speed
  - to reduce the water hammer pressure
  - to guarantee turbine regulation at shutdown
- At runaway speed the mechanical stress incurred by the rotating parts shall be designed within the maximum allowable stresses of the specific material and load universe for static as well as dynamic integrity.
- A safety margin is provided between the first critical speed and the unit’s runaway speed. A shorter and lighter rotor helps to achieve this margin.
- For air-cooled machines, a shorter core length and a larger diameter might be suitable for uniform cooling along the entire core length and windings.

Voith has vast references in water-cooled machines and has designed the world’s largest and most powerful air-cooled hydropower generators, including Guri II (Venezuela) rated at 805 MVA and the 672 MVA units at Grand Coulee II (USA), as well as the world’s largest and most powerful directly water-cooled units at Itaipu (Brazil/Paraguay) rated at 823.6 MVA and the 840 MVA units at Three Gorges (China). These records have been broken with the totally air-cooled generators for the Xi Luo Du power station (China) with a rated output of 855.6 MVA and for the Wu Dong De power plant (China) with a rated output of 944.5 MVA.

All Voith generators are designed and manufactured with the latest state-of-the-art technology including the use of Vacuum Pressure Impregnation (VPI) for the stator bars and coils. Rated voltages up to 25 kV are part of our standard production.
Keep your energy flowing
HyService and modernization

Over decades, generators have been running reliably. To ensure continuous and first-class operation in the future, extensive service and maintenance will be indispensable to prevent or solve your problems effectively.
Voith offers comprehensive and tailor-made first-class service and modernization solutions. Reliable service management incorporates the idea of thinking forward. Our HyService teams at Voith offer repairs, spare parts, preventive maintenance, inspections and assessments. Our focus is clear: Voith is your partner to extend the lifetime of your hydropower plant at any point of its life cycle. And we want to keep it running smoothly. As an experienced service partner, we support you in any part of the plant’s operation. Reliable. Experienced. Available all around the world.

Consider our modernization project of the pumped storage plant Wehr in southern Germany. By completely renewing the motor generators, Voith increased the efficiency and especially the reliability of the machines. This included the refurbishment of the stator and rotor using modern state-of-the-art calculation methods, materials and design features. During the Bath County modernization that started in 2005, we delivered six new state-of-the-art stator windings and later six completely new rotors; each motor generator now has a rated output of 530 MVA instead of the original 389 MVA.

This helped, among other modernization measures, to re-establish Bath County as the pumped storage power plant with the highest power output in the world. For a successful modernization such as these examples, you have to consider the complete design of the plant and at the same time investigate the different options for service, refurbishment and renewal of every single part of your generators. We at Voith develop new, high-quality parts and refurbish existing parts to deliver what you really need. For instance, our engineers think of individual solutions to deliver the outstanding Micalastic insulation from our modern factories in Mississauga (Canada), São Paulo (Brazil) or Shanghai (China).

Get in touch with us! Contact: HyService@Voith.com
Synchronous generators

References

1867 Werner von Siemens invents the direct current dynamo.

1881 Start of design and manufacturing of direct current dynamos at Siemens factory in Berlin.

1895 Kuråsfossen, Norway
First alternating current generator for a hydropower station.

1903 Necaxa, Mexico
World’s first 100 MVA generators.

1938 Fengman, China
World’s first 100 MVA generators.

1941 Grand Coulee I, USA
World’s first 100 MVA generators.

1969 El Choco, Argentina
First generator with a stator bore diameter of 16 m.

1976 Guri II, Venezuela
Most powerful air-cooled generators with 805 MVA.

1978 Itaipu, Brazil / Paraguay
Complete mechanical design for the world’s most powerful hydroelectric plant (13 300 MW). Maximum output of each unit: 823.6 MVA.

1982 Xingo, Brazil
Design and supply of six generators with 555 MVA and rated speed 109.1 rpm.

1992 Grand Coulee III, USA
New water-cooled stators for the largest hydroelectric generators in the world to date, rated 826 MVA per unit with an outside diameter of 23 m.

1997 Three Gorges, China
Design and supply of generators and electrical equipment for the largest hydroelectric power plant in the world with an ultimate total capacity of more than 22 500 MW.

1998 Lajeado, Brazil
Design and supply of five generators with 190 MVA and rated speed 100 rpm.

1999 Baspa II, India
Design and supply of two generators with 122.1 MVA and rated speed 375 rpm.

1999 Cana Brava, Brazil
Design and supply of three generators with 163.4 MVA and rated speed 90 rpm.

2002 Irape, Brazil
Design and supply of three generators with 127 MVA and rated speed 300 rpm.

2002 Peixe Angical, Brazil
Design and supply of three generators with 175 MVA and rated speed 85.7 rpm.

2003 Omkareshwar, India
Design and supply of eight generators with 80 MVA and rated speed 107.1 rpm.

2005 Yeywa, Myanmar
Design and supply of four generators with 230 MVA and rated speed 142.8 rpm.

2005 Gilgel Gibe II, Ethiopia
Design and supply of four generators with 125 MVA and rated speed 333 rpm.

2005 El Platanal, Peru
Design and supply of two generators with 120 MVA and rated speed 450 rpm.

2006 Holtwood, USA
Design and supply of two generators with 64.1 MVA and rated speed 85.7 rpm.

2006 Mazar, Ecuador
Design and supply of two generators with 100 MVA and rated speed 257.1 rpm.
2006 Revelstoke, Canada
Design and supply of one generator with 532 MVA and rated speed 112.5 rpm.

2007 Eastmain 1A, Canada
Design and supply of three generators with 285 MVA and rated speed 100 rpm.

2007 Karcham Wangto, India
Design and supply of four generators with 340 MVA and rated speed 214.3 rpm.

2007 Svartisen, Norway
Design and supply of one generator with 320 MVA and rated speed 375 rpm.

2008 Long Kai Kou, China
Design and supply of five generators with 400 MVA and rated speed 83.3 rpm.

2008 Xi Luo Du, China
Design and supply of three totally air-cooled 855.6 MVA generators. Voith’s most powerful generator at the time.

2008 Akkøy II, Turkey
Design and supply of air-cooled generators with rated speed of 750 rpm and a rated output of 135 MVA.

2009 San Esteban II, Spain
Design and supply of one generator with 210 MVA and rated speed 166.7 rpm.

2010 Waneta, Canada
Design and supply of two generators with 186.1 MVA and rated speed 112.5 rpm.

2010 Embrets foss IV, Norway
Design and supply of one generator with 56 MVA and rated speed 93.8 rpm.

2010 Ferreira Gomez, Brazil
Design and supply of three generators with 94 MVA and rated speed 90 rpm.

2011 Budarhals, Iceland
Design and supply of two generators with 45 MVA and rated speed 166.7 rpm.

2011 Teles Pires, Brazil
Design and supply of five generators with 404.45 MVA and rated speed 75 rpm.

2011 Belo Monte, Brazil
Design and supply of four generators with 679 MVA and rated speed 90 rpm.

2012 Las Lajas, Brazil
Design and supply of two generators with 146 MVA and rated speed 300 rpm.

2012 Alfalfal II, Chile
Design and supply of two generators with 145.2 MVA and rated speed 600 rpm.

2013 Cambambe II, Angola
Design and supply of four generators with 195.5 MVA and rated speed 187.5 rpm.

2013 Great Millenium, Ethiopia
Design and supply of four generators with 417 MVA and rated speed 125 rpm.

2014 Tarbela IV, Pakistan
Design and supply of three generators with 522 MVA and rated speed 107.14 rpm.

2014 Keeyask, Canada
Design and supply of seven generators with 117 MVA and rated speed 69.23 rpm.

2019 Wu Dong De, China
Design and supply of six generators with 944.5 MVA and rated speed 90.9 rpm.
Motor generators

References

1962 Erzhausen, Germany
Design and supply of two motor generators with 62.5 MVA and rated speed 428.6 rpm.

1964 Roenkhausen, Germany
First reversible motor generator unit in a German pumped storage station.

1970 Racoon Mountain, USA
Most powerful reversible pumped storage motor generators in the world at the time, with four 425 MVA units and directly water-cooled stator and rotor.

1971 Wehr, Germany
Design and supply of four motor generators with 300 MVA and rated speed 600 rpm.
World most powerful machines with 600 rpm.
2008 modernization: New stator
2010 modernization: New rotor

1972 Rodund II, Austria
Europe’s most powerful reversible motor generator at the time with 310 MVA and water-cooled stator and rotor.

1973 Malta Hauptstufe, Austria
Design and supply of four motor generators with 220 MVA and rated speed 500 rpm.

1976 Bath County, USA
Largest pumped storage reversible motor generators in the world at the time, with six 447 MVA air-cooled units.

1976 Chongpyong, Korea
Design and supply of two reversible motor generators with 220 MVA and rated speed 450 rpm.

1979 Leitzach I, Germany
Design and supply of one reversible motor generator with 60 MVA and rated speed 333.3 rpm.

1983 Palmiet, South Africa
Design and supply of two reversible motor generators with 250 MVA and rated speed 300 rpm.

1985 Herdecke, Germany
Design and supply of one reversible motor generator with 190 MVA and rated speed 250 rpm.

1992 Bhira 1, India
Design and supply of one reversible motor generator with 176.5 MVA and rated speed 500 rpm.

1994 Guangzhou II, China
Design and supply of four reversible motor generators with 380 MVA and rated speed 500 rpm. World most powerful machines with 500 rpm.

2000 Venda Nova II, Portugal
Design and supply of two reversible motor generators with 106 MVA and rated speed 600 rpm.

2004 Zhanghewan, China
Design and supply of four reversible motor generators with 278 MVA and rated speed 333.3 rpm.

2002 Taian, China
Design and supply of four reversible motor generators with 278 MVA and rated speed 300 rpm.

2005 Bath County Modernization, USA
New air-cooled winding for the six world’s most powerful reversible motor generators with 530 MVA rated capacity.

2006 Waldeck 1, Germany
Design and supply of one reversible motor generators with 81 MVA and rated speed 500 rpm.

2008 Ingula, South Africa
Design and supply of four reversible motor generators with 373.2 MVA and rated speed 428.6 rpm.
2010 Frades II, Portugal
Design and supply of Europe’s largest and most powerful variable speed reversible motor generators (DFIM) with 433 MVA and speed range from 350 rpm up to 381 rpm.

2010 Rodund II new, Austria
Design and supply of totally air-cooled reversible motor generator with 345 MVA and rated speed 375 rpm.

2012 Hong Ping, China
Design and supply of four reversible motor generators with 333 MVA and rated speed 500 rpm.

2014 Lam Ta Khong, Thailand
Design and supply of two motor generators with 282 MVA and rated speed 428.6 rpm.

2017 Chang Long Shan, China
Design and supply of two motor generators with 389.9 MVA and rated speed 600 rpm.

2018 Xia Men, China
Design and supply of four motor generators with 389.9 MVA and rated speed 428.6 rpm.

2018 Limberg I, Austria
Design and supply of two motor generators with full inverter with 81.5 MVA and speed range from 400 rpm up to 750 rpm.
Bulb generators

References

1973 Iffezheim, Germany
Design and supply of four generators with 29 MVA and rated speed 100 rpm.

1988 Oberaudorf-Ebbs, Austria
Design and supply of two generators with 35 MVA and rated speed 93.8 rpm.

1993 Bai Long Tan, China
Design and supply of six generators with 33.68 MVA.

1994 Chasma, Pakistan
Design and supply of eight generators with 26 MVA and rated speed 85.7 rpm.

2007 Baguari, Brazil
Design and supply of two generators with 39 MVA and rated speed 128.6 rpm.

2008 Santo Antonio, Brazil
Design and supply of the world’s most powerful bulb generators at the time with a rated output of 82.25 MVA.

2008 Willow Island, USA
Design and supply of two generators with 23.72 MVA and rated speed 58.1 rpm.

2008 Smithland, USA
Design and supply of three generators with 29.9 MVA and rated speed 60 rpm.

2008 Cannelton, USA
Design and supply of three generators with 33.08 MVA and rated speed 62.1 rpm.

2009 Jirau, Brazil
Design and supply of four of the world’s most powerful bulb generators at the time with 83.33 MVA and rated speed 94.7 rpm.

2009 Meldahl, USA
Design and supply of three generators with 40.3 MVA and rated speed 64.3 rpm.

2012 Nam Hinboun, Laos
Design and supply of two generators with 16.3 MVA and rated speed 107.1 rpm.

2017 Kirchbichl, Austria
Design and supply of one generator with 20 MVA and rated speed 100 rpm.
Synchronous condensers

References

2015  **Riel, Canada**  
Design and supply of four units with 250 MVar and rated speed 1200 rpm.

2017  **Janaúba 3, Brazil**  
Design and supply of two units with 150 MVar and rated speed 900 rpm.

2017  **Terminal Rio, Brazil**  
Design and supply of two units with 150 MVar and rated speed 900 rpm.

2017  **Ariquemes, Brazil**  
Design and supply of one unit with 150 MVar and rated speed 900 rpm.

2017  **Ji-Paraná, Brazil**  
Design and supply of one unit with 150 MVar and rated speed 900 rpm.

2017  **Tapajós, Brazil**  
Design and supply of one unit with 150 MVar and rated speed 900 rpm.

2017  **Rurópolis, Brazil**  
Design and supply of one unit with 110 MVar and rated speed 900 rpm.