DESIGN, MANUFACTURE AND SUPPLY
OF HYDRO GENERATORS

Hundreds of installations and more than 60 years of proven experience
IHB Electric AD is the inheritor of STZ “Vasil Kolarov”, which was founded in 1948. The company is the founder of the electric machines industry in Bulgaria and is currently the largest manufacturer of rotating electric machines in the region. Since 1997 the company, formerly known as Elprom ZEM Co, is a privately held company part of the Industrial Holding Bulgaria, one of the biggest industrial groups in Bulgaria.

TRADITIONS. INNOVATIONS. QUALITY.

Established traditions combined with continuous implementation of innovations allow IHB Electric to guarantee high product quality. We firmly stand behind our slogan by maintaining the deserved reputation over the years and permanent strive for improvement. Our philosophy is based on the personalized approach and cooperation with clients, which we consider to be the foundation for long standing and beneficial relationships. We firmly believe that you will find a professional and loyal partner in IHB Electric.
IHB Electric began production of hydro generators during middle of the last century. More than 300 hydro generators have been designed, built, installed and commissioned in more than 200 HPPs on 5 continents with an installed power summing up to 2500 MW. Thanks to the experience gained over more than 60 years in the sector, combined with our constant strive for product improvement, we are capable of offering a comprehensive range of hydro generators. In conjunction with after sales services, aimed to assure trouble-free and efficient operation throughout the entire lifecycle of a generator, we can maximise HPP investor returns. These services include preventive and corrective servicing and upgrading aimed at improving performance and extending service life as well as the provision of spare parts and proactive support.

**Features of our hydro generators**

- Synchronous generators ranging from 400 kVA up to 100,000 kVA
- Manufactured in different voltages, from 400 V to 20,000 V
- For all machines up to isolation H
- Degree of protection IP-23 to IP-56
- Air and water cooled
- For hydraulic turbines of different types, Pelton, Francis and Kaplan
- Different forms of construction, vertical and horizontal
- International standards IEC, NEMA, IEEE, etc.
GENERATOR DESIGN FEATURES
With our “Tailor made” approach for hydro generators, we have always preferred to design generators based on plant characteristics in order to guarantee maximum performance in terms of efficiency, reliability and maintenance.

Our hydro generator optimization process, based on individual plant specifications, begins with electromagnetic design, defining the active parts of the device. High performance and cost efficiency are achieved through optimal utilization of active materials. Technical data (power output, voltage, speed, etc.) is used to identify the ideal machine configuration based on existing benchmark models, by balancing maximum performance with transport and erection constraints. The generator project is then verified using advanced computer based models, providing for in-depth analysis of its electromagnetical, mechanical and thermal behaviour. Generators are designed to withstand the heaviest duty operating conditions, frequent start-up and shut-down cycles, and accidental operating events such as short circuits.
STATOR FRAME and STATOR CORE
The stator frames are welded construction, made of rolled structural steel for large dimensions. The sufficient mechanical strength is reached by using transverse and longitudinal ribs, which forms channels for the cooling air. In certain cases, following welding operations, tempering or vibration of the housings is applied in order to remove residual mechanical stresses. Machining of the base surface is carried out by vertical and horizontal lathes and drills which are capable of handling stator frames of rotating machines with a capacity of 250 MVA. The stator core is installed on the stator frame by means of guiding beams with T-heads and tightening bolt connections.

Stator core is built up from laminations (steel punching) made of high grade steel with low level of specific losses and high magnetic conductivity, which is in accordance and fully meets the requirements of the International Standard of Electrical Machinery efficiency EN 60034-30. The factory has high quality machines for bilateral varnish coating with a thickness of 0.004 to 0.02 μm, which allows to achieve good filling with steel of the stator package with guaranteed insulation between segments. Technology used to built up the stator frame and core allows to achieve high perfect concentricity and circularity and guarantees excellent magnetic properties. The technology applied reduces the thermo-mechanical stress on the generator structure, which contributes to improved reliability and lifetime.
The heart of the generator is the stator winding (coils or bars) and the quality of stator bar insulation is a decisive factor for machine reliability. Insulation systems we apply are made on technology lines for hydro-vacuum pressing or Global VPI for voltage of up to 20 kV. Resin Rich insulation system is used for production of high voltage stator bars. Consolidation of the tapes is carried out in a deep vacuum process and under hydro vacuum pressing system. Global VPI technology is used for electric machines with medium and small dimensions. Both technologies use special insulation tapes, supplied by leading industry manufacturers. Both system insulation technologies are characterized by low levels of partial discharge and leakage current, high dielectric strength, coefficient of stock $ks = 2 + 3$, $ks = U_{br,v}/U_{test}$, ($U_{test} = 3.5*U_{nom}$) which further improves lifespan and reliability of the generator.
Depending on the power output of the hydro generators the rotor may be implemented with rotor spider which is welded construction, made by rolled structural steel or rotor ring built up by segments. Poles are laminated construction. They are connected to the rotor body. For rotor spider segments manufacturing IHB Electric JSC utilizes a precise laser-cutting machine, resulting in elements with a high degree of accuracy (0.02-0.04 mm). Coils of the rotor poles are made of copper strip with a purity of 99.99%, insulated with high-quality materials and temperature resistance class F and H supplied by world-leading companies in the industry. It is pressed by 2000 tons press, capable of withstanding the worst failure events such as over-speed and short-circuit. Damper coil winding is made of copper or brass.
EXCITATION SYSTEM

The power supply of the rotor exciter coil, depending on client requirements, may be executed in two versions: with slip rings mounted on the shaft and brushes or supplied by static converter and using the inbuilt-exciter with rotating rectifier. IHB Electric JSC has developed a wide range of exciters with rotating rectifier, characterized by high reliability of operation due to lack of rotating electrical outlet, suitable to be embedded in the body of the generator for external mounting for vertical and horizontal mounting.

BEARINGS

Our hydro generators are equipped with bearings, supplied by reputable manufacturers, guaranteeing reliable operation in heavy duty environment, handling various radial and axial tensions from hydraulic turbines and others. Depending on the design requirements, our machines are being equipped with rolling bearings, sleeve bearings with babbit or teflon contact layer. In the case of vertical hydro generators for very high vertical loads (i.e. for Kaplan Turbines), we can provide proven solutions with hydraulically equalised thrust bearings and, if required, a self-pumping thrust collar. In manufacturing of hydro generators with higher rated power we use slide bearings with oil high-pressure lubrication, while in the process of making generators with lower rated power we incorporate the bearings inside bearing shields. The lubricant systems are designed in order to guarantee long operational life, possibility for effortless maintenance and controlling the condition of the bearings and their cooling.

COOLING SYSTEM

Our generators are designed with a redundant, closed-circuit cooling system, using “air-water” coolers. Based on the type of generator, either axial fans with adjustable angle blades or solutions with radial ventilation or electric fans for bi-directional motor-generators are utilized.
IHB Electric JSC’s primary focus is the provision of products and services of outstanding quality, in order to assure this, the company has underwent ISO 9001, ISO 14001 and OHSAS 18001 certification.

In order to ensure the highest possible quality, all stages of the hydro generator manufacturing process are subject to strenuous control tests, also spanning over the construction of individual components.

These control tests cover: geometrical measurements of individual details and units, performance of welds, condition of insulation applied on separate details and windings.

Special care and attention is given to the insulation of windings, which are subject to systematic production tests - from the selection of materials to production of each individual element to their final assembly.

Furthermore, a set of mandatory tests is carried out, including: high-voltage testing, in accordance with the nominal power of the windings and the requirements of the standards.

One of IHB Electric JSC’s assets is its portfolio of digital measurement and control equipment: 3D laser tracker - allowing for precise control of geometrical measurements - accurate to 0.005 μm/35 m and 0.017 μm/70 m; thermo vision cameras - for control and measurement of temperatures; three-phase combined meter of electrical parameters - all types I, U, cosφ, rated and nominal power, analyzing harmonics, vibrations measurement and balance, including balance in operating mode.
The Chaira Pumped Storage Hydro Power Plant (Chaira PSHPP) was built in Rila mountains. Chaira has generating capacity of 864 MW and a pumping capacity of 788 MW, and is thus the largest pumped-storage plant in southeast Europe. The motor-generators are manufactured in IHB Electric and put into operation in 1999.

- Rated power output - 235 MVA
- Rated voltage \( Un = 19 \text{ kV} \)
- Power factor \( \cos \phi = 0.85 \)
- Frequency \( f = 50 \text{ Hz} \)
- Rated speed \( n = 600 \text{ min}^{-1} \)
HPP Studen Kladenets, Bulgaria - one hydro generator
- Rated power output $S_n = 23$ MVA
- Rated voltage $U_n = 10.5$ kV
- Power factor $\cos \phi = 0.85$
- Frequency $f = 50$ Hz
- Rated speed $n = 300$ min$^{-1}$

HPP Tsankov Kamak - two hydro generators
(Based on the design and manufactured for Andtiz AG)
- Rated power output $S_n = 50$ MVA
- Rated voltage $U_n = 10.5$ kV
- Power factor $\cos \phi = 0.85$
- Frequency $f = 50$ Hz
- Rated speed $n = 428.6$ min$^{-1}$

HPP Bugoye, Uganda - two hydro generators
- Rated power output $S_n = 8.4$ MVA
- Rated voltage $U_n = 6.6$ kV
- Power factor $\cos \phi = 0.85$
- Frequency $f = 50$ Hz
- Rated speed $n = 600$ min$^{-1}$

HPP Konal, India - two hydro generators
- Rated power output $S_n = 6.111$ MVA
- Rated voltage $U_n = 6.3$ kV
- Power factor $\cos \phi = 0.85$
- Frequency $f = 50$ Hz
- Rated speed $n = 600$ min$^{-1}$

HPP Upper Clowhom, Canada - one hydro generator
- Rated power output $S_n = 12.25$ MVA
- Rated voltage $U_n = 13.8$ kV
- Power factor $\cos \phi = 0.90$
- Frequency $f = 60$ Hz
- Rated speed $n = 300$ min$^{-1}$
MODERNIZATION AND RENEWAL OF HYDRO GENERATORS

With efficiency and output increase

The continuous research and development and the performed electric and dynamic tests in our test laboratories result in providing a complete overall technical solution adapted to the latest trends in the production of hydro generators. IHB Electric JSC, thanks to its proprietary technology, offers rehabilitation of hydro generators increasing efficiency and energy parameters. This is achieved by applying an insulation, capable of withstanding 40kV under factory test conditions. IHB Electric JSC has applied this patented process during the rehabilitation of more than 25 hydro generators with rated power between 4.5 MVA and 235 MVA, rated voltage between 6.3 kV and 19.5 kV, delivering increases in energy efficiency of up to 14.2%.

Refurbishment and modernization of existing generators

IHB Electric carries out renewal and modernization of generators up to 235 MVA, 20 kV which are designed to:
  - Increase plant availability and reliability
  - Reduce risk of failures
  - Optimize value and operating life

Redesign of active elements upon request and repowering of generators increasing efficiency and output with up to 14.2%.

Other services available:
  - Maintenance services
  - Field services
  - Spare part services
    - Sheet stamping
    - Manufacture of rotor coils & stator windings
HPP Kardjali, Bulgaria
IHB Electric scope of work includes new stator core and stator winding, rehabilitation of pole coils for units 1, 2, 3, 4.

<table>
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<tr>
<th>Parameter</th>
<th>Before rehabilitation</th>
<th>After rehabilitation</th>
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<tbody>
<tr>
<td>Rated power output ( S_n )</td>
<td>31,25 MVA</td>
<td>36 MVA</td>
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<td>0,85</td>
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<tr>
<td>Frequency ( f )</td>
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<td>50 Hz</td>
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<td>Rated speed ( n )</td>
<td>250 min(^{-1})</td>
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<td>Nominal current ( I_n )</td>
<td>1720 A</td>
<td>2016 A</td>
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HPP Aleko, Bulgaria
IHB Electric scope of work includes new stator core and stator winding, rehabilitation of pole coils for units 1, 2, 3.

<table>
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<tr>
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<tbody>
<tr>
<td>Rated power output ( S_n )</td>
<td>27 MVA</td>
<td>31 MVA</td>
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<td>Rated voltage ( U_n )</td>
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<td>10,5 kV</td>
</tr>
<tr>
<td>Power factor ( \cos \phi )</td>
<td>0,8</td>
<td>0,8</td>
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<tr>
<td>Frequency ( f )</td>
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<td>50 Hz</td>
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<tr>
<td>Rated speed ( n )</td>
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<td>Nominal current ( I_n )</td>
<td>1480 A</td>
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HPP Orpheus, Bulgaria
IHB Electric scope of work includes new stator core and stator winding, rehabilitation of pole coils for units 1, 3.

<table>
<thead>
<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>Rated power output ( S_n )</td>
<td>50 MVA</td>
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<tr>
<td>Rated speed ( n )</td>
<td>300 min(^{-1})</td>
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<tr>
<td>Rated voltage ( U_n )</td>
<td>10,5 ( \pm )5% kV</td>
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HPP Teshel, Bulgaria
IHB Electric scope of work includes new stator core and stator winding, for units 1, 2.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Rated power output ( S_n )</td>
<td>35,3 MVA</td>
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<td>Rated voltage ( U_n )</td>
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<tr>
<td>Frequency ( f )</td>
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</tr>
<tr>
<td>Rated speed ( n )</td>
<td>428,6 min(^{-1})</td>
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WHEN WATER AND TECHNOLOGY COMBINE