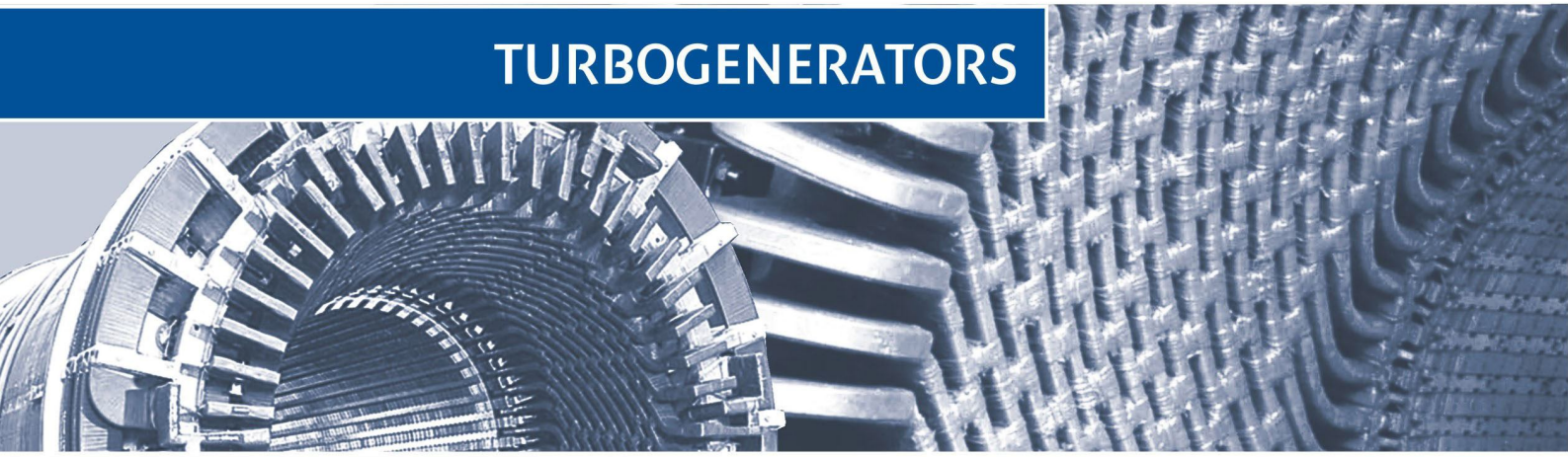
NPO “ELSIB”

TURBOGENERATORS

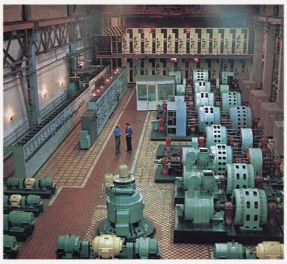


Power of Siberia – strength of Russia

EXPERIENCE AND ACHIEVEMENTS
IN GENERATOR TECHNOLOGY

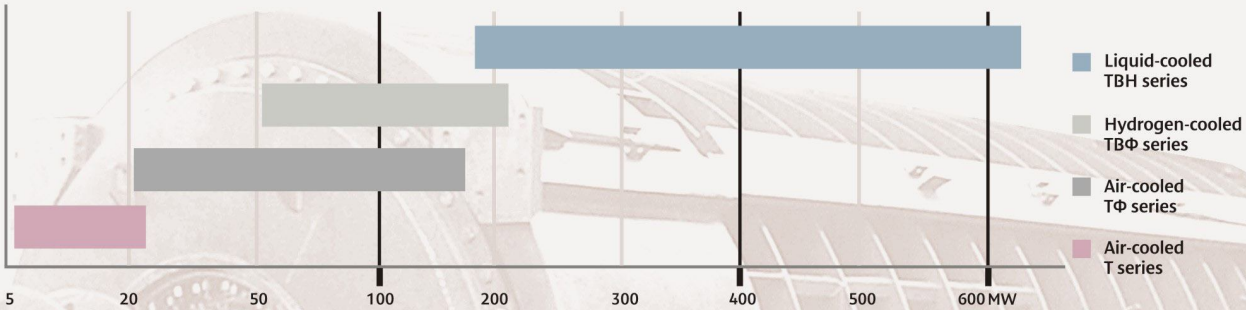
World-class technologies and solutions for the best results






"ELSIB" has over 50 years experience in design of the turbogenerators. Use of progressive world achievements and successful application of unique solutions, constant perfection has led to the creation of own design school. Our generator engineers capable to meet a wide range of challenges in its field and occupying by right an important place among their colleagues.

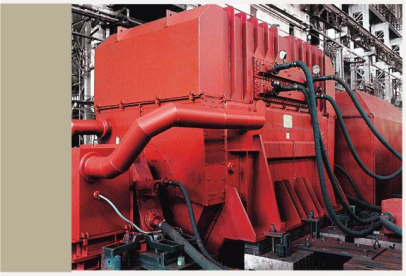
In former Soviet Union, Eastern Europe, China, Mongolia, on Korean peninsula, the Power Generation professionals have estimated at their true worth generators created by the collective of "ELSIB" for their high efficiency, durability and reliability, convenience of repair and maintenance. They, with good reason, can rely on the equipment with the trade mark of our enterprise.



The generators supplied by "ELSIB" may be driven by steam and gas (heavy-duty or aeroderivative) turbines and create the optimum systems for central power plants, factory and city TPPs.

Combining all their experience with developing technologies and materials our engineers provide the evolutionary development of generators for achieving higher effectiveness on technical and operational parameters. The key element of our activity is an experience of working with the customers, that forms the development direction of technologies, products and service.

AIR-COOLED
TURBOGENERATORS




Turbogenerators with air-cooling system of "ELSIB" production are the optimum choice for the power system application that demand flexibility and simplicity of operation and service.

Air-cooled generators is well suited to the cyclic and peak operating mode, allow to achieve the high extent of automatization of the technological processes, reducing the operation costs significantly.

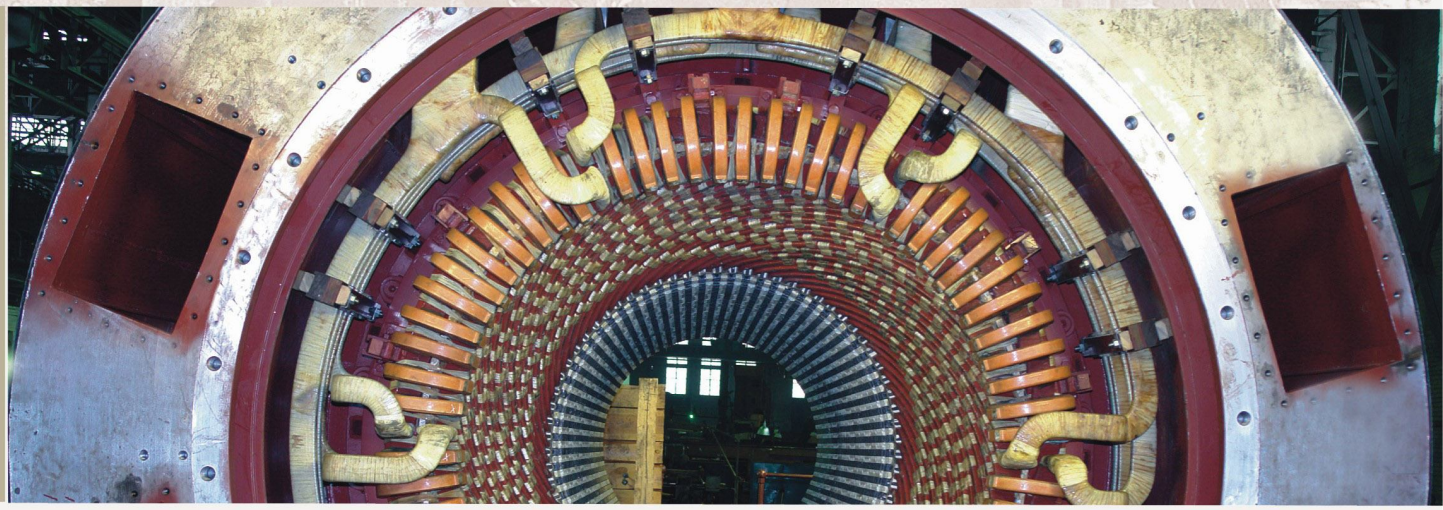
Almost all generators supplied by "ELSIB" with capacity rated from 6 to 20 MW have the indirect cooling system of the rotor winding that provides the higher reliability and durability. The use of the joint insulating impregnation of the stator winding and core provides a higher resource on a capacity, heat loads and minimizes the vibration values. The coil and coil-bar stator windings allow to reduce a length of generator and increase its specific weight characteristics. A proved materials and excellently presented itself insulation system exclude an appearance of the damages at the coronas. The thermal-resistance insulation class is "F". At the rated and maximum modes, it provides the use of "B" class insulation, that allows "ELSIB" generators to operate at the extended modes and at the wider range of the environment. This characteristic is especially important for generators matched to the gas turbines, because capacity of those notably increases at the reduction of the ambient temperature.

Air-cooled generators operate with closed-loop cooling system. The air circulation is provided with the axial fans on the shaft of rotor, and the air-to-water heat exchangers located on each side of generator remove heat from the air.

The generators of power rating from 25 to 160 MW are produced at the one-piece welded case of cylindrical shape. The design of case provides the high rigidity and strength, that allows generators to operate reliably and stably at all operation modes include cycled load, peaking duty, overload modes. This is pledge of the generator durability and reliability providing for its high operational characteristics.

The air circulating inside the generator over the close loop is cooled at the air-to-water heat exchangers built in the stator case horizontally. The heat exchangers of 160 MW generator located on each side of the stator. The simple and effective cooling system is slightly soiled, that significant assists to keep relatively low heat level of the active parts and the high effectiveness of the generator at the whole lifetime.

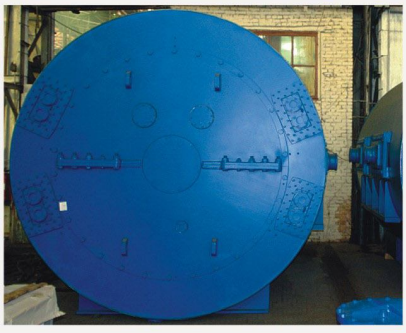
Convenience, simplicity and flexibility



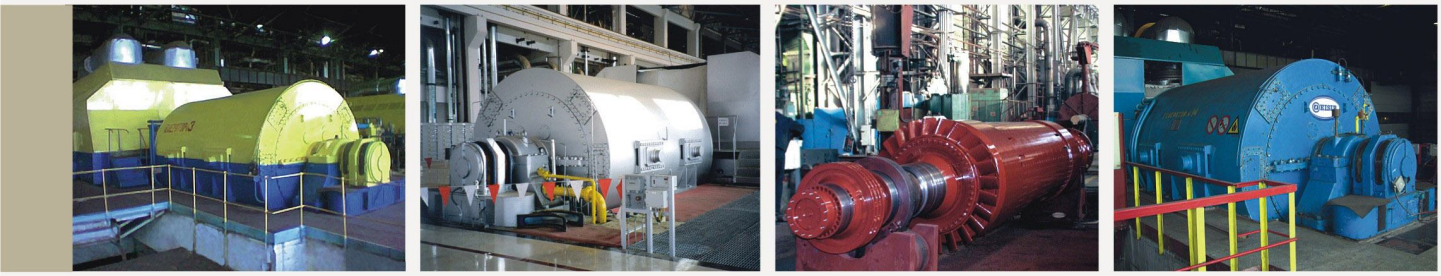
Many design solutions for air-cooled turbogenerator were based on the reliable and proved by the long time service decisions realized before at the hydrogen-cooled generators of the similar class. Due to that, the "ELSIB" air-cooled generators imbibed all the best and proved existing today at the Russian generator technology. Moreover, they possess the unique capability to be transformed into hydrogen-cooled generator with the slight modernization fulfilled on site. At the same time the capacity of generator can be increased to 150 %. This gives the additional opportunities for our customers to plan the power system changes and reconstructions.

The design and manufacturing technology of the generators guarantee the high maintainability of the equipment that at great extent reduces the possible future costs of our customers. Moreover, these generators with the minimum costs can be assembled on the existing foundations of the retired turbogenerators of the same capacity class with air and hydrogen cooling system.

Generator	Full power, MVA	Rated power, MW	Stator voltage, kV	Frequency, Hz	Excitation system	
					Static	Brushless
T-6-2	7,5	6	10,5/6,3	50		+
T-16-2	20	16	10,5/6,3	50		+
ТФ-20-2	25	20	10,5/6,3	50		+
T-25-2	31,25	25	10,5/6,3	50	+	+
ТФ-32-2	40	32	10,5/6,3	50	+	+
ТФ-63-2	78,75	63	10,5/6,3	50	+	
ТФ-80-2	100	80	10,5	50	+	
ТФ-110-2	137,5	110	10,5	50	+	
ТФ-125-2	156,3	125	10,5	50	+	
ТФ-160-2	200	160	15,75	50	+	

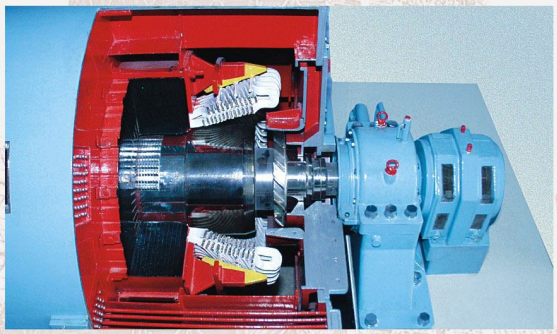


HYDROGEN-COOLED
TURBOGENERATORS



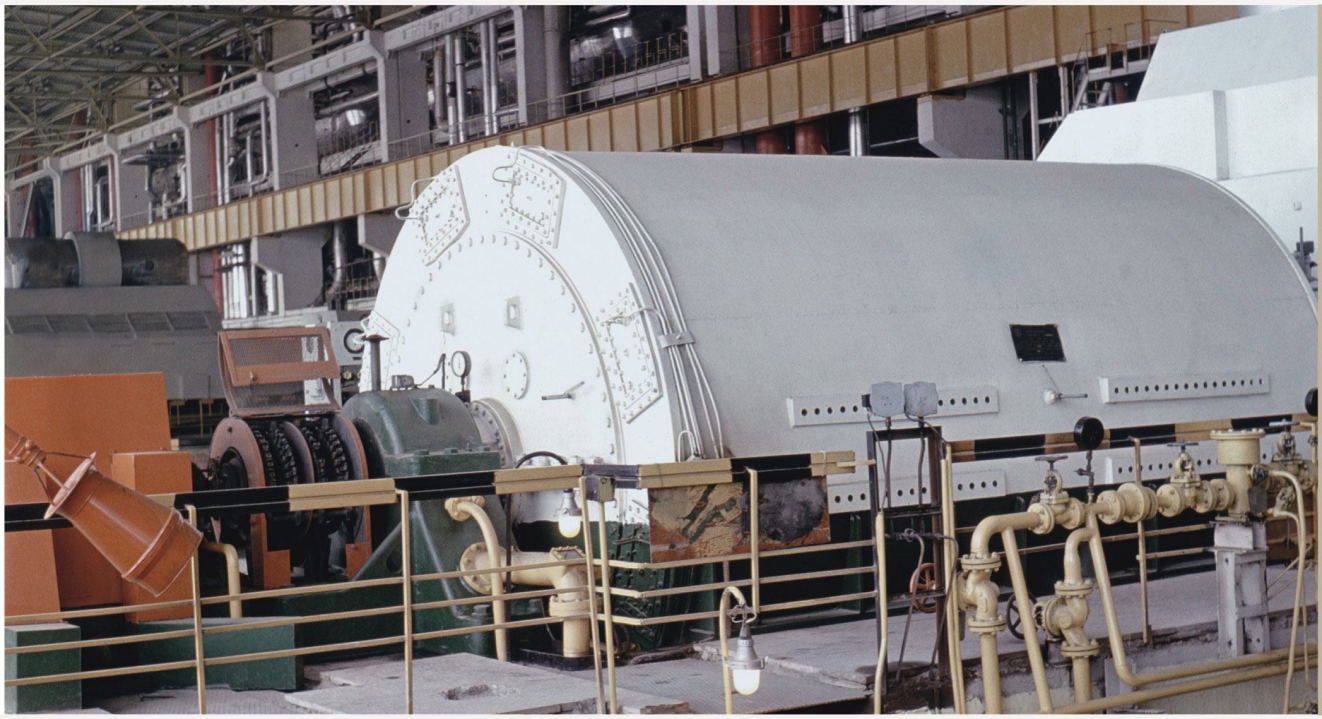
Hydrogen is the superior coolant for the rotating electrical machines due to a combination of three outstanding properties – low density, high specific heat and thermal conductivity. The use of hydrogen allow to create compact, high effective, reliable and durable constructions.

"ELSIB" supplies hydrogen-cooled generators unified "E" series marked "ТВФ". About 30 % of installed electric power of Russian thermal power plants belongs to the similar type generators. Hydrogen-cooled generators have the biggest base life time and showed their reliability and durability with their operation.

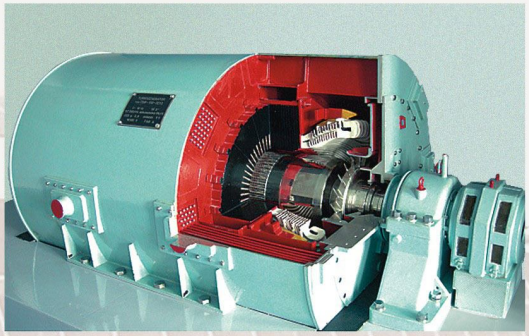


The gas-proof generator one-piece welded case is the rigid sealed design of cylindrical shape. The case and shields is tightly sealed and oil seals installed on the rotor shaft at each end of the stator exclude leakage of hydrogen. Hydrogen is circulated in a closed loop inside the generator case to remove the heat from its active parts and then it is cooled by gas-to-water heat exchangers which are built in a case of the generator horizontally. The circulation of hydrogen inside the turbogenerator is provided by axial fans located on the rotor shaft at each side. The multi-jet cooling system creates an equal, rational distribution of hydrogen along the full length of the generator. The cooling system of the rotor winding is self-ventilated with cooling hydrogen input from a gap area between stator and rotor. The hydrogen-cooled generator's interior is completely sealed from environment, so dust, humidity, salt or other aggressive media have no effect on the machine. This circumstance and the absence of oxygen in its cooling gas significantly increase machine's reliability and durability.

The highest efficiency and reliability

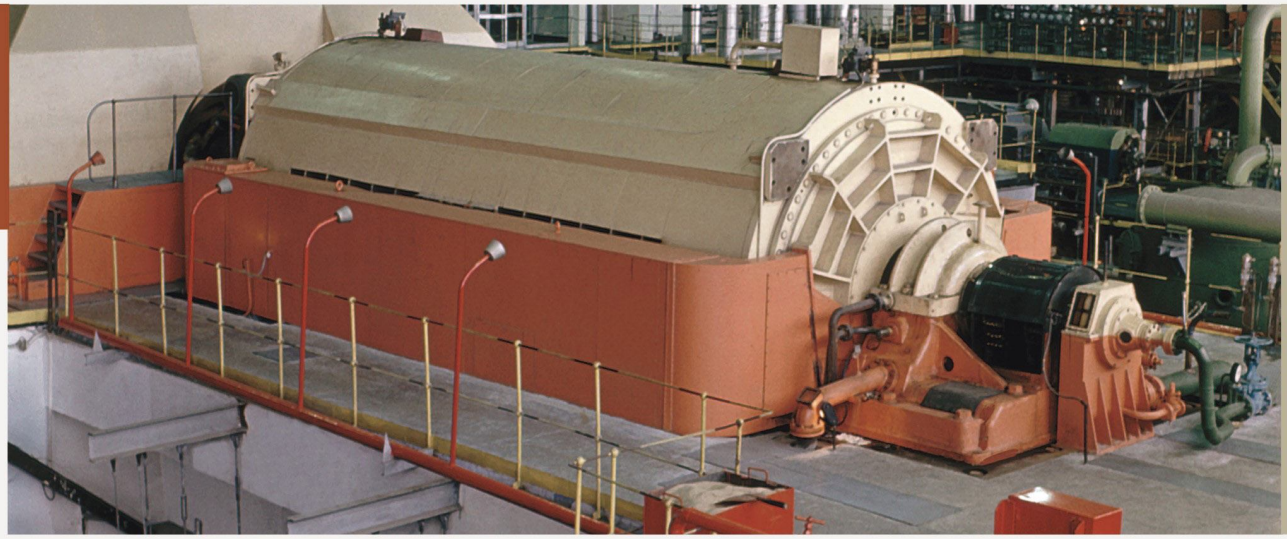


The development of hydrogen-cooled generators supplied by "ELSIB" evolves simultaneously with the development of the materials and technologies. Thus, the customer gets the equipment qulified the most modern requirements.



Generator	Full power, MVA	Rated power, MW	Stator voltage, кV	Frequency, Hz	Excitation system
ТВФ-63-2	78,75	63	10,5/6,3	50	Static
ТВФ-63-3600	78,75	63	11	60	Static
ТВФ-110-2	137,5	110	10,5	50	Static
ТВФ-125-2	147,06	125	13,8	50	Static

LIQUID-COOLED
TURBOGENERATORS

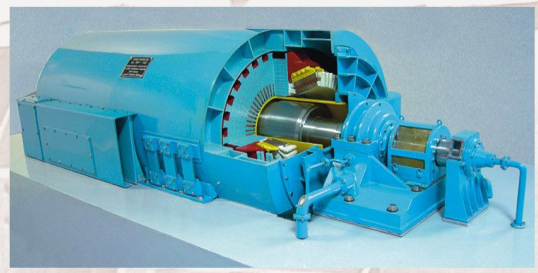


The liquid-cooled turbogenerators are well suited to central large power plants with power blocks of large output capacity. The requirements for a reliability and stable operation in the power grid of these generators are especially high.

The liquid-cooled generators of TBH type supplied by "ELSIB" are unique equipment without analogues in the world generator technology. The construction peculiarity is a filling of the stator volume with the heat resistance dielectric liquid that is also the cooling medium and a stator insulation system component (like in oil transformer).

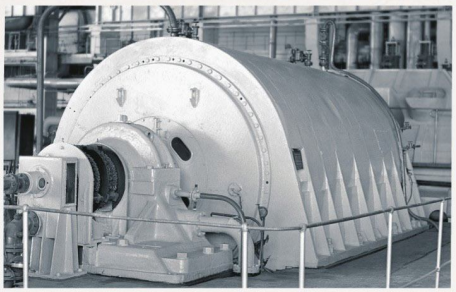
The dielectric liquid is circulated in a closed loop to remove the heat from the active elements of stator and cools at the water heat exchangers located out the case of the generator. The stator volume filled with the liquid is limited by the end shields, stator case, and from the side of a gap between stator and rotor – by the special dielectric cylinder.

The insulation system of stator winding has the significantly more high dielectric strength than other known types of the insulation used at the large turbogenerators. This allows to create the generators with the optimum stator voltage in respect to the main parameters of the machine.



The generator rotor is cooled by water supplied and drained through a water-fed device located at the central part of rotor shaft. The supply of cooling water to the rotor winding is provided with the radial units of the water-fed device.

Solution for the maximum loads



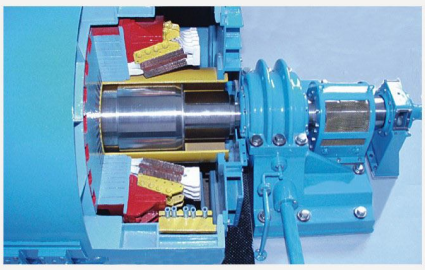
The cooling and insulation systems of TBH generator give it the high reliability and provide a lot of the advantages and unique operational properties. The sufficient resources on the dielectric strength, heat loads, stability to the mechanic influences at vibration and deformation of the stator winding bars and other the design features allow to our customers to achieve the significant saving of the means and be fully sure in the reliable operation of these machines. This happens mainly due to the followings:

- longer overhaul life up to 10 years,
- higher mantainability,
- protection of stator from humidity and dust,
- higher overload capabilities and extended operation capabilities at extreme modes (underexcitation, asynchronous modes, asymmetrical loads),
- high efficiency that is of up to 99 %,
- capability of early detection of the stator core and winding status by gas chromatography.

In comparison with the other generators of large capacity the TBH generators have simple design and production workability that provide the high reliability and durability at the relatively low costs.

For design the TBH generators the hydraulic and thermal phenomena at ducts of core and stator and rotor windings on the models, samples and test platforms were investigated. The researches done with the special platforms and natural generators defined the design of the end conical packets of stator core, wedge area of rotor and other assemblies.

Generator	Full power, MVA	Rated power, MW	Stator voltage, kV	Frequency, Hz	Excitation system
TBH-160-2	200	160	15,75/18	50	Static
TBH-220-2	258,8	220	15,75	50	Static
TBH-320-2	376,5	320	20	50	Static
TBH-500-2	588,2	500	20/36,75	50	Static
TBH-500-2	617,6	525	20/36,75	50	Static



CONTROL AND EXCITATION SYSTEMS OF GENERATORS



The ranging of power systems on a modern level requires today the high degree of automation and constant control of the technological processes and equipment. To solve these tasks "ELSIB" supplies the generators in the complete set with the systems of technological control and diagnosis, microprocessor excitation systems.

The automated control and diagnosis systems provide the constant control of the generators and auxiliary equipment status, the diagnosis of the metering sensors and issue of the information on the status of the system and deviations. The functionality and ranging of this system allow to integrate it into the Automated Systems of Control of Technological Process of a whole power block easily with the issue of the controlling influences at the realization of the technological protections of the equipment, fulfillment of the technological processes at the automatic mode. Moreover, this system is able to do the mathematical calculations for a determination of the equipment resource characteristics, fulfillment of the diagnostic algorithms. Therefore, a customer, at any time, can get all the necessary information for a providing of the equipment operation without any emergencies and arrangement of its timely maintenance commanding his means to the best advantage.

The excitation systems produced by "ELSIB" meet the last requirements and use the advanced algorithm of the excitation control for the generators in the distributed power system. The excitation systems have the reservation of both controlling regulators and power converting channels, possess the maximum functionality and a set of the necessary protections providing all the modes of the generator operation, its turning on and turning off to the power system without any emergencies. The integration capability of the excitation systems into the automated control system for power block meets the requirements of our clients at full capacity.

SERVICE AND ENGINEERING

Individual approach
of high qualified specialists



Following to the requirements of our clients and approach chosen at its activity, "ELSIB" maintains its products during a whole life cycle including the service after the equipment delivery.

The enterprise carries out the followings:

- contract supervisionand commission works,
- supply of the spare parts, complete units and accessories for regulation repairs, restoring repairs of the stators and rotors at the factory, for a modernization of the turbogenerators at the power plant facilities to increase their life times, capacity an reliability,
- supply of special materials and components,
- technical consulting and instructions at the mounting and setting up, liquidation of the defects, modernization.

The modernization of generators is conducted to increase a capacity at a range 5–15 % and a lifetime simultaneously. Also, we are ready to fulfill the other works to improve the technical status and the generator parameters:

- replacement of the stator winding to the new bars with thermosetting insulation of "F" class,
- replacement of the seals of the shaft of end type to the modern ring seals,
- fitting of the brush contact aggregate with the thermal control system to diagnose its status,
- improvement of the design of rotor bandage assembly for two pole generators with the installment of a corrosion-proof slip rings (including of titanium alloy ones) and a transition to a single set design of the slip ring,
- improvement of the oil-catch systems at the seals of the shaft from the side of high pressure (stator),
- improvementof sound insulation at the area of brush and contact aggregate using an erection of noise-protected housing.

The engineering services offered by "ELSIB" include:

- complex technical inspection of the equipment status after its long exploitation or long storage with the recommendations on a restoration of its working ability and further service,
- vibration inspection of the equipment including the setting up of the vibration state of the bearings, stator and rotor, liquidation of low frequency vibration of the shaft and bearings,
- thermal tests of the equipment or its separated parts,
- designing services: analysis of the technical requirements, making of the technical task, choice of the equipment, calculation of the operation modes.

The engineering for a solution of the particular tasks and satisfaction of the special requirements of the power engineering specialists at the repair and supply of the new equipment is a part of our complex approach to a satisfaction of the needs of our cients.

SUPPLIES OF
"ELSIB"'S TURBOGENERATORS SINCE 1990

Over 50 years "ELSIB" has produced more than 800 turbogenerators of different types. The total rated capacity of all these machines is about 68,800 MW.

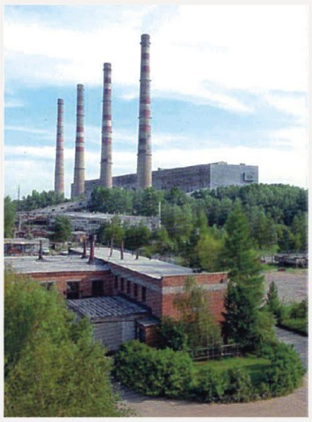


Hydrogen-cooled generator since 1990

Year	Type	Plant	Country	Power MW	Turbine
1990	ТВФ-63-2Е	Mosenergo TPP-22	Russia	63	Steam
1990	ТВФ-63-2Е	TPP-1 Pavlodar	Kazakhstan	63	Steam
1990	ТВФ-63-2Е	Yakutsk PP	Russia	63	Gas
1990	ТВФ-63-2Е	Svetlogorsk TPP	Byelorussia	63	Steam
1990	ТВФ-63-2Е	Krasnoyarsk TPP-1	Russia	63	Steam
1990	ТВФ-63-2Е	Svetlogorsk TPP	Byelorussia	63	Steam
1990	ТВФ-63-3600	East-Phenyang TPP	Korea	50	Steam
1990	ТВФ-63-2У3	Toliatti TPP	Russia	63	Steam
1990	ТВФ-110-2Е	Nesvetai PP	Russia	110	Steam
1990	ТВФ-110-2Е	Yoshkar-Ola TPP	Russia	110	Steam
1990	ТВФ-110-2Е	Yuzhno-Sakhalin TPP-1	Russia	110	Steam
1990	ТВФ-110-2Е	TPP P.O. Box P-6245	Russia	110	Steam
1990	ТВФ-110-2Е	Karaganda TPP-3	Kazakhstan	110	Steam
1991	ТВФ-63-2Е	Omsk TPP-3	Russia	63	Steam
1991	ТВФ-63-2Е	Mosenergo TPP-16	Russia	63	Steam
1991	ТВФ-63-2Е	Mosenergo TPP-20	Russia	63	Steam
1991	ТВФ-63-2Е	Mosenergo TPP-16	Russia	63	Steam
1991	ТВФ-63-3600	BEast-Phenyang TPP	Korea	50	Steam
1991	ТВФ-110-2Е	Yuzhno-Kuzbass PP	Russia	110	Steam
1991	ТВФ-110-2Е	Mosenergo TPP-21	Russia	110	Steam
1991	ТВФ-110-2Е	Dzerzhinsk TPP	Russia	110	Steam
1992	ТВФ-63-2Е	West-Siberian TPP	Russia	63	Steam
1992	ТВФ-63-2Е	Svetlogorsk TPP	Byelorussia	63	Steam
1992	ТВФ-63-2Е	West-Siberian TPP	Russia	63	Steam
1992	ТВФ-65-2Е	TPP Chi Lu	China	63	Steam
1992	ТВФ-110-2Е	Vladimir TPP	Russia	110	Steam
1992	ТВФ-110-2Е	Neftezavodsk TPP	Turkmenia	110	Steam
1992	ТВФ-110-2Е	Mosenergo TPP-12	Russia	110	Steam

Year	Type	Plant	Country	Power, MW	Turbine
1992	ТВФ-110-2Е	Tom-Usinsk PP	Russia	110	Steam
1992	ТВФ-110-2Е	Mosenergo TPP-16	Russia	110	Steam
1992	ТВФ-110-2Е	Toliatti TPP	Russia	110	Steam
1992	ТВФ-110-2Е	Mosenergo TPP-11	Russia	110	Steam
1993	ТВФ-63-2Е	Novokemerovo TPP	Russia	63	Steam
1993	ТВФ-65-2	TPP Chi Lu	China	65	Steam
1993	ТВФ-63-2Е	TPP of Karaganda Metal Works	Kazakhstan	63	Steam
1993	ТВФ-65-2	TPP Chi Lu	China	65	Steam
1993	ТВФ-110-2Е	Yuzhno-Kuzbass PP	Russia	110	Steam
1994	ТВФ-65-2Е	TPP Nan Ding	China	65	Steam
1994	ТВФ-65-2Е	TPP Nan Ding	China	65	Steam
1994	ТВФ-110-2Е	Smolensk TPP-2	Russia	110	Steam
1994	ТВФ-110-2Е	Kurgan TPP	Russia	110	Steam
1994	ТВФ-110-2Е	Novokemerovo TPP	Russia	110	Steam
1995	ТВФ-63-2Е	Mosenergo TPP-12	Russia	63	Steam
1995	ТВФ-63-2Е	Kursk TPP-1	Russia	63	Steam
1995	ТВФ-110-2Е	Raichikhinsk PP	Russia	110	Steam
1995	ТВФ-110-2Е	TPP Liao Yang	China	110	Steam
1996	ТВФ-110-2Е	Mosenergo TPP-23	Russia	110	Steam
1996	ТВФ-110-2Е	Nizhnekamsk TPP	Russia	110	Steam
1996	ТВФ-110-2Е	TPP Liao Yang	China	110	Steam
1997	ТВФ-110-2Е	Novocheboksary TPP	Russia	110	Steam
1997	ТВФ-1102Е	Mosenergo TPP-20	Russia	110	Steam
1997	ТВФ-63-2Е	Barabinsk TPP	Russia	63	Steam
1997	ТВФ-63-2Е	Irkutsk TPP-11	Russia	63	Steam
1998	ТВФ-110-2ЕУ3	Mosenergo TPP-20	Russia	110	Steam
1998	ТВФ-110-2Е	TPP Liao Yang	China	110	Steam
2000	ТВФ-110-2Е	Mosenergo TPP-11	Russia	110	Steam
2000	ТВФ-63-2Е	Yakutsk PP	Russia	63	Gas
2000	ТВФ-125-2ЕПУ3	TPP Khada Vang	China	125	Steam
2000	ТВФ-110-2ЕУ3	TPP Kostolac	Yugoslavia	110	Steam
2000	ТВФ-110-2ЕУ3	TPP Bachao	China	110	Steam
2001	ТВФ-110-2ЕУ3	TPP Bachao	China	110	Steam
2001	ТВФ-125-2ЕПУ3	TPP Khada Vang	China	125	Steam
2001	ТВФВ-125-2ПУ3	TPP Qiling	China	125	Steam
2002	ТВФ-63-2Е	Yakutsk PP	Russia	63	Gas
2002	ТВФВ-125-2ПУ3	TPP Qiling	China	125	Steam
2003	ТВФ-110-2ЕУ3	Mosenergo TPP-22	Russia	110	Steam
2004	ТВФ-110-2ЕУ3	Novosibirsk TPP-3	Russia	110	Steam
2005	ТВФ-110-2ЕУ3	Mosenergo TPP-21	Russia	110	Steam
2006	ТВФ-110-2ЕУ3	Yaroslavl TPP-2	Russia	110	Steam
2006	ТВФ-110-2ЕУ3	TPP JSC “Achinsk glinozyomny kombinat”	Russia	110	Steam
2006	ТВФ-125-2У3	TPP Tiang Phu	China	125	Steam
2006	ТВФ-125-2У3	TPP Tiang Phu	China	125	Steam

SUPPLIES OF
"ELSIB"'S TURBOGENERATORS SINCE 1990



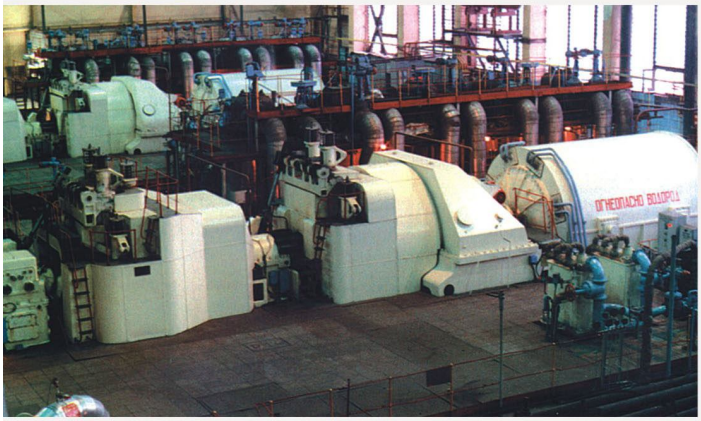
Air-cooled generator since 1990

Year	Type	Plant	Country	Power, MW	Turbine
1996	ТФ-50-2	Mosenergo TPP-16	Russia	50	Steam
1998	ТФ-63-2У3	TPP-11 Irkutsk	Russia	63	Steam
1999	ТФ-100-2У3	TPP Bishkek	Kyrgizstan	110	Steam
2003	ТФ-110-2У3	Yuzhno-Kuzbass PP	Russia	110	Steam
2003	ТФ-32-2У3	TPP Barabinsk	Russia	32	Steam
2004	ТФ-63(Г)-2У3	Mosenergo TPP-28	Russia	63	Gas
2004	ТФ-63-2У3	TPP «Alyuminiy Kazakhstana»	Kazakhstan	63	Steam
2005	ТФ-125-2У3	TPP-2 «Astana-Energia»	Kazakhstan	125	Steam
2005	ТФ-63-2У3	TPP-2 Novosibirsk	Russia	63	Steam
2005	Т-16-2У3	TPP Labitnangi	Russia	16	Gas
2005	ТФ-110-2У3	TPP FGUP «SHK»	Russia	110	Steam
2007	ТФ-80-2У3	Mosenergo TPP-22	Russia	80	Steam
2007	ТФ-80-2У3	TPP-3 Minsk	Byelorussia	80	Steam

Liquid-cooled generator since 1990

Year	Type	Plant	Country	Power, MW	Turbine
1992	ТВВ-500-2Е*	Ekibastuz PP-2	Kazakhstan	500	Steam
1994	ТВМ-160-2	TPP Sigu	China	160	Steam
1995	ТВМ-160-2	TPP Sigu	China	160	Steam
1995	ТВМ-160-2	TPP Cheng Du	China	160	Steam
1995	ТВМ-160-2	TPP Cheng Du	China	160	Steam
1995	ТВМ-160-2	TPP Loyan	China	160	Steam
1996	ТВМ-160-2	TPP Loyan	China	160	Steam
2007	ТВМ-500-2	TPP Refta	Russia	500	Steam

* – with water cooling of rotor and with hydrogen cooling of stator according to the documents of JSC "Electrosila".



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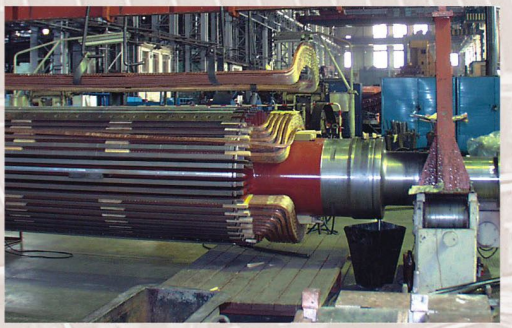

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