

Technical Policy in the Power Sector of the Far East

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These article focuses on the current state of the power-generating equipment and on the development of the power sector of the Far East of Russia. The most advanced technical solutions that should be applied by JSC “RAO Energy Systems Vostok” in its production activities have been identified. The required technical performance figures have been identified for thermal-mechanical and electrical equipment. The technologies and equipment that should not be used in the power sector of the Far East have also been listed.

Key words – modernization, technical retrofitting, repairs, thermal-mechanical and electrical equipment, electrical network, equipment operation modes, fuel supply, ecology, small-scale power generation sector, ashes and slag waste, cable lines, heat supply network, energy efficiency, automatic and automated control systems, professional training.

1. INTRODUCTION

Regulations on Technical Policy of JSC “RAO Energy Systems Vostok” for the period until 2020 was developed by agreement between JSC “RAO ES Vostok” and ZAO “Scientific and Technical Firm “Energoprogress” of Corporation “United Electric Power Complex” (UEPC) as a program document to be followed by JSC “RAO ES Vostok” in its operations. The Regulations was approved on April 26, 2010 at the meeting of the Presidium of the Scientific and Technical Board of Non-commercial Partnership “Scientific and Technical Council of the Unified Energy System” (NP “STC UES”).

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2. KEY ISSUES ADDRESSED IN THE TECHNICAL POLICY

2.1. Condition of the Power Equipment in the Far East

The major problems of the power sector in the Far East include: fixed assets wear and tear, increased losses in the electrical network and non-optimum fuel balance of power plants. The economic life of power plants has been used up for 65 %.

The distribution network is overloaded, with their wear and tear exceeds 70 %.

The problem of old transformers with actual operation term of over 25 years is becoming of concern.

The power generating equipment retrofitting process is hindered by a number of factors, including:

- Unattractiveness of the power sector of the Far East to external investors.
- Insufficiency of the Company’s own resources to implement capital intensive projects (new construction and retrofitting).
- High prices for materials, equipment, services and design.
- Vast decentralized power supply areas.

2.2. Thermal-mechanical and electrical equipment

In retrofitting as well as in the construction of new thermal power plants (TPP) only combined-cycle power plant (CCPP) and gas-turbine plant (GTP) gas use technologies should be used. In the GTP-Heat electric plant (HEP) schemes it is recommended to use gas-turbine units with the exhaust gas (combustion products) temperature at the turbine exhaust casing not exceeding 470 °C, and in the CCPP schemes – gas-turbine units with that ensuring electrical efficiency of at least 50 %.

It is necessary to supply coal-run condensing power plants (CPP) with the upgraded units of the steam temperature exceeding 560 °C, and

in case of the low-quality fuel – with circulating fluidized-bed (CFB) boilers.

The technical policy in terms of TPP retrofitting provides for:

- Upgrading of the existing TPP equipment (steam boilers, steam turbines, hot water boilers, accessories, cooling towers, water-treatment equipment).
- Conversion of fuel oil-run CPP and boiler houses to natural gas (given the prospects of the Sakhalin and Kamchatka gas fields development) and further replacement of the HEP steam-power equipment with CCPPs or GTPs with waste heat recovery boilers, of the existing boiler plant equipment – with cogeneration units.
- Conversion of coal-run HEP and boiler houses located in the urban residential areas to natural gas while retaining the possibility to use coal.

In the TPP reconstruction the following should be used:

- Air-cooled turbine generators of up to 300 (MW) capacity.
- Sulphur hexafluoride switches.
- Power transformers with automatic voltage control, of the required dynamic ability, low no load loss and low short-circuit currents, equipped with advanced reliable bushings with solid insulation, improved reliability governors, winding with repressing, diagnostics, with the increased life between overhauls (up to 20 years).
- For the key auxiliary mechanisms of power units it would be expedient to apply controlled electric drives or liquid-clutch drives.
- Operating DC voltage systems c/w low-maintenance stationary batteries and rectifiers with output voltage regulation not worse than 0.5 %.
- Auxiliary DC distribution system with separate supply to protective and control circuits, equipped with automatic earth fault locators.

All power generating facilities in the course of retrofitting shall be equipped with a full-scale automated process control systems (APCS). The key points of the technical policy in terms of construction of new TPPs include:

- Building of coal-run TPPs with the power units operating in the increased steam conditions.

- Development in large cities of the gas-run CCPP-HEP and GTP-HEP of electrical efficiency not lower than 30 %.

In the construction of new coal-run TPPs it is recommended to use the same equipment as used in retrofitting and reconstruction.

In the construction of new natural gas-run TPPs it is recommended to use highly maneuverable CCPPs using the 2 GTPs + 1 CCPP scheme with load control range of 25–100 %. The TPP power units operating under the initial steam pressure of 8.8 MPa and less should be removed from service upon expiration of the individual service life (subject to availability of the replacement capacity).

It is recommended to use:

- Combined air-water cooling turbine generators.
- Turbine generators with diagnostic equipment systems.
- Asynchronized turbine generators.

2.3. *Electrical Network*

Construction and installation work in the building, upgrading or reconstruction of overhead power (OHP) lines should be performed using the following:

- Mechanization of laying cuttings work by using high-capacity machines and equipment, differentiated as to the type of cutting work, size of trees, relief and soil conditions.
- Advanced cutting work technologies and methods of trees and shrubs cutting.
- Integrated and close utilization of row wood.
- Decrease of amount of earthwork by using thermopiles and anchors in the permanently frozen soil, rod-shaped inserts in rocky ground.
- High performance drilling equipment for hole making in hard rocks and rocky ground.
- Wire routing under tension avoiding putting the wire on the ground which allows to avoid mechanical damage to the wire and, accordingly, to decrease corona and radio interference power loss.

The recommended types of foundations in the conditions of Extreme North and permanent frost are:

- Piled ferroconcrete and metal foundations (reinforced-concrete pile foundation with metal pile caps, screw piles, open section piles).
- In-situ reinforced concrete (embedded, slightly embedded and surface) foundations.
- Composite piles.
- Bored piles with pile base cooling and soil surface heat insulation.
- Profiled ferroconcrete piles.
- Bored cast-in-place piles with permanent casing.
- Pipe-concrete piles with metallic packing.

For 220 kV OHP lines it is recommended to use single-circuit and multi-circuit multisided steel towers as intermediate supports, and lattice steel towers as angle-tension supports. When reasonable, it is admissible to use multisided steel towers as angle-tension supports.

As anticorrosion protection of tower metal structures hot dip (HD) galvanizing or thermodiffusion zinc coating methods should be preferred.

For 35–110 kV OHP lines it is recommended to use single-circuit and multi-circuit multisided steel towers. When reasonable, 110 kV towers may be used instead of the 35 kV intermediate steel supports.

For 6–10 kV OHP lines it is recommended to use, in the first place, ferroconcrete supports and, when reasonable – wooden towers treated with special preservatives ensuring the service life of at least 40 years, with ferroconcrete attachments.

For 0.4 kV OHP lines it is recommended to use wooden towers treated with special preservatives ensuring the service life of at least 40 years, with ferroconcrete attachments. Furthermore, in the suspending of self-supported insulating conductors hooks should not be used, since they entail the decay of supports from inside while wooden towers treated with preservatives have preservative penetration depth ranging between 0.6–1 cm only.

The main cause of faults of 6–10 kV OHP lines is damage to the towers erected on waterlogged

or saline soils (due to concrete corrosion), as well as towers fall down due to arching (the ordinary towers have bodies of fixed length which does not allow to bury them deeper than 2–3 m). The incident rate of OHP lines on wooden towers is much greater than that of other towers.

It is possible to substantially increase the reliability of OHP line towers by using steel supports and steel screw pile foundations. Although screw piles may be more expensive than ferroconcrete piles, in the regions with complex building conditions the main price component is not the cost of materials, but transportation and erection costs. Furthermore, the use of screw piles allows the erection of towers right after screwing which significantly reduces the construction time. It also allows to lay foundations close to the infrastructure facilities.

To increase the stiffness of the existing 110 kV OHP lines in the permanently frozen soil conditions it is recommended to stabilize the footings of metal towers by bordering of footing with the designated sand-gravel mix. The use of such technology allows to maintain the stiffness of the constructions which normally gradually weakens due to the ever frozen soil melting.

2.4. *Fuel Supply to Power Plants*

The major share in the fuel consumption structure of the power plants in the Far East is held by coal – 72 % (2008), natural gas – 21 % and oil fuel (fuel oil, diesel oil) – 7 %. TPPs mainly use local coal.

Coal will continue to be the main fuel for TPPs until 2020.

According to forecasts, the natural gas prices will be increasing and the correlation of gas/coal price will increase from 1.55 in 2009 to 2.43 in 2020 (as to the coal from Neryungry) and from 0.66 to 1.36 (as to the coal from Primorsky Krai).

The main fuel supply costs saving measures include:

- Formation of the own resource base satisfying the demand of TPP in coal products on the level of at least 50 % of total consumption.

- Centralization of fuel, goods, work and services procurement activity in terms of fuel supply and cargo transportation management.
- Introduction of industrial fuel supply system and establishment of an independent unified fuel quality testing center.
- Introduction of coal-blending complexes at power plants. By mixing several coal blends and obtaining of solid homogenous coal blends it will be possible to ensure the substitutability of coal fuel at TPPs.
- Formation of the standard quality power plant coal market.

2.5. *Small Generators*

The power isolated regions comprise 75 % of the overall area of operation of JSC “RAO ES Vostok.” These include the major part of the Sakhalin and Kamchatka Regions and the Republic of Yakutia. The power supply to the isolated regions can be characterized as follows:

- Consumers with the loads not exceeding 3 MW are spread out on a large territory.
- The lack of the power supply network facilities, which construction is not expedient.
- Poor transportation infrastructure.

The main power supply source for decentralized power supply will continue to be diesel power plants (DPP) and boiler houses. The technical policy related to the use of DPPs implies the use of:

- Modular power generating complexes (DPPs in block containers in ready-to-operate condition, designated for particular climate conditions).
- Electronic engine fuel feed system.
- Unification of the main equipment for DPPs by type and prime engine dimensions.
- Package units diesel engine design.
- Building of DPPs with cogeneration diesels.

An important aspect of the technical policy in the decentralized power sector is the building of mini-HEPs on the basis of the existing DPPs using the local coal fuel. Diesel engines, gas shaft engines, gas turbines and steam turbines of low capacity are used as drivers for mini-HEP generators. Waste-heat boilers (in case of

use of diesel engine), cooling water and oil heat exchangers, hot-water boilers and steam boilers are used as thermal generators. Mini-HEPs shall be supplied on turn-key basis or built by way of upgrading of the existing boiler houses by adding power generating units thereto.

Should gaseous or liquid fuel be available to a DPP, boiler house or mini-HEP it is not recommended to use low capacity steam-power units or heat-water boilers run by that kind of fuel.

Gas piston units (GPU) represent the new generation of natural gas-run internal combustion engines. The key advantages of a GPU are as follows:

- High efficiency which is low-sensitive to load and ambient temperatures variation.
- High motor capacity.
- Possibility of operating under low gas pressure.
- Short term supply and building.

In the prospect it is recommended to use gas piston engines run by natural gas or coal gasification or pyrolysis products, biogas. In selecting the type of the power unit (a GTP or a GPU) it is necessary to take account, among other things, of the possibility of service maintenance.

Wind and wind-diesel power is considered prospective for remote areas. It is expedient to use wind-diesel power units using the local fuel concurrently with wind-driven power units (WDPU) and wind power plants (WPP).

It is also suggested to establish autonomous multifunctional power technology complexes (MPTC) driven simultaneously by wind and diesel generation. This will allow to decrease the dependence on diesel fuel. Initially, as a basis for MPTC it is proposed to design a multi-fuel diesel generator unit of 1000 kW capacity which will operate in a complex with a WPP.

The use of high power capacity accumulator batteries (HPCAB) is also considered a prospective approach.

DPPs in complex with a GTPs will ensure the effective and stable operation of the gas turbine and diesel generator while reducing fuel consumption and hazardous emissions.

Wind power is considered the most promising among renewable energy (solar energy, biomass, minor hydropower). Given the unregulated nature of wind power generation, wind electrical units taking the place of the traditional power generating units are not, however, able to be a substitute in terms of power generating capacity. Accordingly, it is expedient to use WPP concurrently with traditional power generating units which capacity shall correspond to the maximum consumers' load. The autonomously operating DPP shall become the stand-by units for WPP.

2.6. *Environment Protection*

The specifics of the human impact on the airspace of the Far East include the long-lasting heating season and the significant proportion of the coal-run generating facilities. The main air pollutants which emissions are regulated by state include gaseous sulfur oxide, nitrogen oxide and particulate pollutants (ash). The greatest share of hazardous emissions into atmosphere belongs to thermal power plants and boiler houses.

The key objective in the environment protection sphere is gradual substitution of the equipment with poor ecological characteristics with the modern and more ecologically friendly equipment. The point of the technological measures to reduce the nitrogen oxide emissions to atmosphere by coal-run TPPs is to impact on the combustion process by way of changing the design and operation modes of burners and furnace units so as to create conditions in which the nitrogen oxide generation is reduced to a minimum.

For fume gases dedusting it is expedient to use rather inexpensive already mastered and effective electric and fabric filters. The difficulties connected with the use of electric filters may be eliminated by optimization of their design and dimensions, improvement of supply systems using pre-ionization and alternating, intermittent or on-and-off power supply units and filter operation automation. In many cases the decrease of the incoming gases temperature can be expedient.

The cleaning of fume gases of nitrogen oxide is recommended to be done by chemical methods.

It is recommended to use the following two nitrogen-elimination technologies: nitrogen oxide selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR). SNCR technology should be applied in technical upgrading of coal-run power plants with slag-tap boilers. At all times nitrogen oxide cleaning shall be preceded by application of the NO_x reduction technological measures.

By mastering the above technologies it will be possible to have an economically expedient sulfur-bearing fuel combustion products cleaning method reducing 95–97 % of SO₂. Natural lime-stone is commonly used as sorbent in this case, and commercial gypsum is the by-product of the cleaning.

TPPs should apply technological solutions allowing to keep the main contaminants within the maximum permissible concentration (MPC) and decrease the number of polluted flows, in particular, by chemical washing of equipment, oily water, waste water of hydraulic ash-removal systems and water treatment units. As to water treatment the progress should be achieved by adoption of ecologically friendly ultrafiltration and reverse osmosis technologies which allow to solve the TPPs saline runoff problem without using reagents and significantly reduce the TPPs waste water problem in general.

Gas turbine units supplied to TPPs should be equipped with low-toxic combustion chambers. The heat insulation of the combined-cycle power plant equipment located indoor shall be designed so that the heat insulation surface temperature is not to exceed 45 °C, and in case of the equipment located outdoors – not to exceed 55 °C.

3. PROFESSIONAL TRAINING

Technical specialists are in urgent demand in the Far East: enterprises lack personnel of the middle age. Power plant, substation and electrical network repair and maintenance services are undermanned.

It is recommended, first of all, to conduct a by-sector certification of standard workplaces and positions in terms of whether higher or secondary vocational education is necessary. It can be assumed confidently that the industry

will need more lower and mid-level specialists trained by vocational schools (colleges) and less specialists with higher education degree. Higher education institutions should train specialists predominantly for scientific and design organizations, such as analytics, innovation engineers and managers, prospective higher-level managers. The shortest practicable term necessary to train a specialist with a higher education degree is 8–10 years since the commencement of the training.

To secure the placement of the graduates from higher and secondary education institutions with power generation companies of the Far East it is recommended to use a special contract-based training program providing for the entering into of three-party (education institution – employer – student) contracts to secure the employment of graduates and provision of social benefits thereto.

Training of specialists in particular areas may be organized at the Yakutsk State University (Yakutsk), the Pacific State University (Khabarovsk), the State Technical University (Komsomolsk-on-Amur), the Far East State Technical University (Vladivostok), the Amur State University (Blagoveschensk), the Yuzhno-Sakhalinsk Institute of Economics, Law and Informatics (Yuzhno-Sakhalinsk). In the future such training may also be organized at the Asian-Pacific Polytechnic University which is being established on the basis of the abovementioned institutions.

The establishment of the further training and re-training system will not take as much time. There are only two options here: further training and re-training. Further training can be organized at the Personnel Training Center (Khabarovsk), the non-commercial education institutions located in Blagoveschensk, the Settlement of Artyomovsky, Primorsky Krai, Yakutsk and Yuzhno-Sakhalinsk, as well as at the training facilities in Petropavlovsk-Kamchatsky, Magadan, the Settlement of Luchegorsk. Development of the training and methodological materials for further training in the above institutions will not take longer than a year.

The establishment of the Corporate University on the basis of the above listed education institutions will further the implementation of the uniform policy in the sphere of education and uniform training standards of further training, improve the quality of the training.

Professional re-training is the most efficient way of training specialists in particular areas of expertise in the field of new equipment and technology. According to the Russian Educational Standard there are three forms of professional re-training: professional re-training, master's degree program and postgraduate program.

Professional re-training, master's degree program and postgraduate program can be organized at the above mentioned education institutions which train higher education specialists in particular areas.

It is also important to continue to improve the personnel training by companies themselves and by their structural subdivisions, i.e. at the workplace in off-work hours. Such form or training is suitable both for engineering specialists and for industrial workers. Theoretical courses should be read by lecturers from both higher education institutions and colleges, and by experienced skilled specialists and managers.

It is also expedient to develop such a well-established form of training as personal guidance. An important form of teaching personnel new techniques and technologies is organization in companies of various courses, seminars, trainings, at which technical staff gets acquainted with new equipment, materials and technologies.

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5. CONCLUSION

Regulations on Technical Policy of JSC “RAO Energy Systems Vostok” for the Period until 2020 is a program document to be followed by JSC “RAO PS Vostok” in its operations. The Regulations identifies the most advanced technical solutions and the required technical standards for the equipment to be applied by JSC “RAO PS Vostok” in its operations.

Based on the Regulations a set of methodological and normative technical documents will be developed which will identify the technical requirements to the reconstruction and upgrading of the existing and to the building of new power generating facilities in the Far East.

6. BIOGRAPHICAL DATA



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