

Modernization of Russian Energy Sector

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This article addresses the objective of technical retrofitting of the power sector by way of modernization. The primary objectives of technical modernization in the thermal power sector have been listed. It also addresses the strategic objectives of modernization of thermal, gas and coal power plants. The problems connected with equipment service life extension and repair, preservation and development of the national power engineering industry are also discussed.

Key Terms – modernization, technical retrofitting, supercritical steam conditions power generating unit, national high-capacity gas-turbine plant, cogeneration, hydropower industry, equipment service life, overhaul, power-plant industry, technical regulation, scientific school.

1. INTRODUCTION

The new General Scheme of Location of Power Generating Facilities until 2020 (the “General Scheme”) is not feasible without modernization of the electric power industry and bringing it to the new technological level. The Joint meeting of the Scientific and Technical Board of Non-commercial Partnership “Scientific and Technical Council of the Unified Energy System” (NP “STC UES”) and Scientific Council for Problems of Reliability and Safety of Large Power Generating Systems of the Russian Academy of Science (the Joint meeting) under the aegis of the Russian Ministry of Energy held on March 24, 2010 with the following agenda: “Modernization of Russian Power Industry – the Key Objective of the Energy Policy” showed the urgent nature of the problem.

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Technical retrofitting of the power sector by way of its modernization should have a broad interpretation as the alteration of the design of the currently used power generating equipment to meet the present day requirements, and the technical retrofitting and reconstruction of the existing facilities. Modernization should be also understood as the new construction using the innovative technology.

Below are the key issues of the power sector modernization which were under focus at the Joint meeting.

2. NEW PARAMETERS OF THE GENERAL SCHEME

After the adoption of the General Scheme in February 2008 the conditions of the electric power sector development have changed. The country has gone through the economic crisis, the Energy Strategy of Russia for the Period until 2030 and the Federal Law On Energy Saving and Energy Efficiency Improvement were adopted, the forecast gas prices have decreased and the coal prices remain high.

According to the data of the Institute of Research of Natural Monopolies the actual rate of increase in electric power generation will be higher than it was forecasted: 1.8–2 % (18–20 bln kWh) annually, and the power production volume will not exceed 1200 bln kWh in 2020. Given the economy growth in Russia even after the adjustment of the figures it will be necessary to put into operation new capacities from 2 mln kW (2008) to 5–6 mln kW annually during 2012–2020.

3. MODERNIZATION OF THERMAL POWER SECTOR

3.1. *Modernization of the gas-run thermal power sector*

Russian electric power sector using gas as fuel has become outdated, is operating mainly using steam turbines with efficiency not exceeding 32–34 %. In the developed countries over

recent years the combined generation power plants (CCPP) with efficiency reaching 55–60 % have been actively used. While in Russia the CCPP share covers only 1% of the total electricity generation.

Thus, one of the strategic points is the introduction of new ecologically friendly high capacity CCPP of high efficiency. The change-over of gas-run thermal power plants (TPP) to combined generation technology will raise their efficiency up to 52–56 %. Replacement of steam turbines on large power plants with CCPPs will allow either to save 30–40 % of gas or raise the electric power capacity in the country by more than 50 GW.

3.2. *Development of the national high capacity gas turbine*

Gas turbine (GT) is the basic element of a CCPP which determines the efficiency of the whole plant. As to big gas turbines there is only one national turbine in our country – GTU-110 and another one is licensed by Siemens – GTU-160. The gas turbine plants (GTP) manufactured by Russian aircraft engine plants (JSC “Saturn – gas turbines,” NPO “Salyut,” etc.) have become obsolete, and high capacity gas turbines are not produced in our country. While the needs of the national hydro power and nuclear power sector can still be satisfied by the national industry, those of the thermal power sector cannot.

It is an urgent issue to design the efficient national GTP of 300 – 350 MW capacity. The State should take the burden of organization of this work - this is a common practice in the world, since private power business is not willing to invest in large projects with long-term payback period.

The design of the national powerful GTP by our own means will take several years and require significant financing, while it is today that CCPPs need to be put into operation. Thus, cooperation with foreign GTP manufacturers may be needed. A possible form of such cooperation may be acquisition by Russian power machines manufacturer of a license with development of the technological basis on site for the manufacturing of high capacity GTP or establishment of a joint venture in Russia for

the production thereof. The basis for such cooperation may become the Leningrad Metal Plant (LMZ) of JSC “Power Machines” which has already acquired a license from Siemens to manufacture GTU-260. The national machine of this type is recommended to produce in the first place since the technological basis for this purpose has already been built.

In the development of the new national high capacity GTP program it is necessary to determine:

- Frame size of the GTP.
- The organization to be in charge of the implementation of the State program for the design and commercial manufacturing of the GTP.
- The consumers and supply schedule of the GTP.
- The volume of the state financing of the R&D related to the design of the GTP.

3.3. *Modernization of coal-run thermal power sector*

The basic component of the coal power generation sector development should be unification of coal power plant equipment. Coals standardization and coal improvement are the preconditions to the changeover to the clean coal technology. The manufacturing of the first power unit of 660 MW capacity for supercritical steam conditions will create conditions for significant raise in efficiency in the course of expanding and technical retrofitting of coal-run electric power plants. The third power unit of Nizhnevartovskaya GRES shall become the demonstration unit of the new technology.

4. COGENERATION DEVELOPMENT

Russian electric power generation sector has been built on the basis of large TPPs, HPP and NPP with large capacity range. The share of large power plants (500 MW and more) is 70 % of total installed capacity, while that of the small distribution generators including renewables is only 1.5 %.

The cogeneration of thermal and electric power is the most efficient method of power generation. The share of cogeneration reaches 80 % in the US and 50–80 % in Europe. In

Russia, however, the cogeneration share is only 31%.

The “capacities concentration and power distribution centralization” principle adopted in the 60-es of the last century should be supplemented by the requirement of optimum combination of large generating facilities and distributed power sources of medium and low capacity that should be as close to the consumers as possible. This will contribute to the efficiency and reliability of power supply to consumers.

An important aspect of heat and electricity supply development is the complementary development of the centralized and decentralized power supply. It is proposed to build decentralized municipal and commercial thermal and electrical gas-turbine plants of low capacity with a payback period of 2 – 3 years.

There are over 30.000 gas-run boiler houses in our country. The majority of them are those that have been built on the basis of coal-run boiler houses, and have very low efficiency of only 50 – 60%. By replacing boiler houses with GTP-HEP it is possible to raise the effectiveness of gas use and thus, either to generate almost free electric power (subject to replacement of old boilers), or the electric power of 65% efficiency at the previous heat capacity with adding only 20 – 30% of gas.

The changeover from the separate electric power, heat and cold generation to predominantly cogeneration on the basis of the latest technology includes:

- Development in cities and municipalities of their electric and heat power generation sources on the basis of highly efficient module-based GTP-HEP.
- Replacement of inefficient boiler houses with GTP-HEP and GTP-HEP in combination with thermal pumps (HP).
- Modernization of the centralized heat supply systems (CHSS) by their gradual changeover to lower heat carrier temperature level in the direct and return lines, optimization of thermal capacities balance in the CHSS.

The existing annual power generating potential in terms of heat consumption by 167 cities with population over 100 thousand is estimated,

according to ZAO “APBE,” in 310 bln kWh while the total capacity is 500 bln kWh.

The high efficiency of GTP-HEP electric power generation secures their quick payback. Dozens of such plants have already been built in Russia. The spare capacity in case of boiler houses changeover to GTP-HEP accounts for 90 mln kW.

Modernization of boiler houses apart from obtaining additional electric power will allow to changeover from the centralized to the distributed (decentralized) power supply system. In this case only the reduction in the thermal power transmission losses will give 10% of electric and heat power. The thermal power generating cost will decrease by 1.5 times.

To equip GTP-HEP with gas-turbine plants the GTP of 1–25 MW unit capacity will be necessary. The necessary gas-turbine plants (of more than 15 types) are available in our country manufactured by aircraft engine enterprises to meet this demand. Dozens of them are already being operated. Over 2000 of the national small GTPs are operating as gas compressor stations. Such companies are currently able to manufacture 100–150 of such GTP annually with a potential to raise the production volume to over 200 annually. The only thing that remains to be done is to improve their emission (emission gas composition).

The main obstacle in the way of cogeneration development is the lack of cooperation between large and municipal power sector administrations. The leading role in solving this problem should be vested in the local generating companies. The Russian Ministry of Energy should assume the coordinator functions in the development of both large and municipal power sectors. It may be expedient to elaborate legislative measures that would inspire the interest in the building of GTP-HEP. One of such measures should be to oblige power generating companies to allow GTP-HEP access to the electric power grid. It is also necessary to:

- Develop the pricing principles in respect of thermal and electrical power generated by cogeneration facilities.

- Provide for the obligation of the network companies to purchase the electric power generated by small generators.

5. MODERNIZATION OF HYDROPOWER SECTOR

Modernization of hydropower sector includes the development and introduction of:

- Effective hydraulic turbine equipment that meets the present-day ecological requirements.
- High capacity energy storage units to equalize the power plants load diagrams based on renewables.
- Intellectual diagnostic systems to ensure the reliability and safety of hydraulic structures and equipment.
- New technologies and materials for construction of high-head dams.
- New technological solutions for pumped storage power plants (PSPP), including the options of subsurface laying of their basic components.

6. MODERNIZATION OF NUCLEAR POWER SECTOR

The innovations in the nuclear sector include:

- Design of commercial nuclear power units of the new generation (standard design АЭC-2006 and commercial power unit prototype design БН-П14).
- Development of the new technological basis for the nuclear power sector based on the closed fuel cycle with fast breeding reactor units.
- Dismantling of 9 power units of 12–1000 MW unit capacity at 4 NPPs of total capacity of 3.75 GW.
- Putting into operation of 14 power units of 800–1150 MW unit capacity at 8 NPPs of total capacity of 15.35 GW.

Modernization of the existing NPP units includes:

- Extension of service life of 15 power units of 13.5 GW total capacity by 15–25 years.
- Raising the power generating capacity of NPPs.
- Increase of the Installed Capacity Utilization Factor (ICUF) of the existing power plants.

7. MODERNIZATION OF THE UEN OF RUSSIA

During the last decade the electrical grid fixed assets have significantly aged due to the lack of investments into new grid construction and technical retrofitting. The increase of the share of the electrical grid equipment with nearly expired service life exceeds the rates of the scheduled withdrawal from service and upgrading.

Modernization of the electrical grid includes:

- Grid infrastructure reconstruction for new power plants with focus on the distribution generation, accelerated development of distribution grids.
- Introduction of smart grids in the Unified National Electrical Network (UNEN) and distribution grids.

It is necessary to introduce DC and AC interconnection lines to transmit the electric power and capacity from the excessively supplied regions to the power deficit regions. An important task here is to reduce the inherent limitations in terms of power delivery and consolidate the power generating potential of Siberia and the Ural region.

Modernization of the centralized emergency shut down system (ESD) is to raise the reliability of the power systems parallel operation, reduce the inherent limitations, raise the network transmission capacity and optimize the generating and network equipment overhaul schedule.

Modernization of the Unified Energy Network (UEN) of Russia is not feasible without pursuing of the common sector development policy. To elaborate the development plans general designer should provide all UEN participants with the technical specification to ensure the reliability and sustainability of the systems. However, UEN of Russia has currently no general designer, which functions previously were performed by the Institute “Energosetproekt.”

To raise the reliability and efficiency of the UEN of Russia operation and to carry out the common technical policy of the UEN of Russia development it appears expedient to bring back the status of the UNEN general designer and to vest the relevant functions with JSC Institute

“Energosetproekt.”

8. EXTENSION OF EQUIPMENT SERVICE LIFE AND EQUIPMENT REPAIRS

Currently there are no large repair services companies in the electric power sector that are able to perform along with repairs the modernization of the electric plants and network equipment, while the repairs itself has become a non-core activity. Manufacturers have been barred from performing maintenance of their own equipment which leads to impairment in quality of repair, supply of infringing articles and decrease in reliability. Annually, the facilities of nearly 10 mln kW capacity lack proper maintenance and repair. Specialized maintenance enterprises of the industry (Mosenergoremont, Rostovenergoremont, Uralenergoremont, Sibenergoremont, Dalenergoremont, etc.) each of which used to have over 7 thousand employees and to service 10–20 regions have been closed.

There is a lack of common principles and standards of the equipment current condition assessment. The current approach to assessment of equipment service life allows generating capacity owners to withdraw large volumes of equipment from service. A legal framework should be urgently developed to limit the unjustified withdrawal of equipment from operation.

Development of the state-of-the-industry repair and maintenance infrastructure is an important component of modernization. An important segment of this area is reactivation of large maintenance companies that should be able to perform full-blown overhauls and interim repairs as well as modernization of power plant equipment, substations and power transmission lines (PTL), warranty and post-warranty maintenance under contracts with equipment manufacturers.

It is also necessary to develop the industry criteria and methods of equipment wear rate assessment and to elaborate on measures related to withdrawal from service and life extension, modernization or substitution with the more efficient new equipment.

To ensure the proper conditions for equipment operation it appears expedient to establish a

state energy supervision body, taking advantage of the experience of the State Inspection for Power Plant and Grids Operation.

The industry lacks a uniform data base on overhauls, there is a lack of full and reliable information on the condition of equipment and results of maintenance operations. Thus, it is impossible to analyze the results of the completed repairs and to have an impression of the equipment condition.

Previously in our country there was an effective unified information and analytical base of the Main Computer Center of the Power Sector. This system does not exist any longer. It is necessary to reactivate the information and analytical data base in the power sector.

9. PRESERVATION AND DEVELOPMENT OF THE NATIONAL POWER PLANT INDUSTRY

The major part of the existing power equipment in Russia is that of the national manufacturers. The national power plant industry potential has been largely lost. The national policy implying the uncontrolled by the state of thermal generation development has turned out to be mistaken. The development of national advanced manufacturing research has slowed. After termination of existence of RAO “UES of Russia” there is no integrated customer of the national power plant machinery.

The wide use of foreign equipment bears the risk of loss of the national energy safety. The stake on the foreign equipment implies the following risks:

- The lack of sufficient orders by Russian manufacturers now will not enable them to get prepared to the solving of large-scale tasks of modernization and putting of capacities into service in the years to come.
- The use of foreign equipment implies spare parts supplies including those that are not manufactured in Russia. The maintenance of CCPP by foreign companies is rather expensive. Normally after the 1st year of foreign gas turbine operation they require the substitution of turbine blades which cost is nearly equal to that of the turbine itself.

The major problem is to satisfy the needs of the Russian power sector for gas turbines. Currently the national power plant industry is able to cover only 20–25 % of the demand for gas turbines.

The deficit in the gas turbines supply to the national power sector may be covered only subject to the accelerated development of the manufacturing facilities of the national companies.

Development of the national power unit for supercritical steam conditions, manufacturing of the necessary equipment and import substitution will allow our country to avoid financial losses and will create conditions for further development of the national science and technology, science-intensive products and for power plant industry in general.

10. THE TECHNICAL REGULATION ISSUE

Currently the normative base of the state technical regulation which pursuant to the Federal Law On Technical Regulation must be in place by 2010, does not exist. The normative act bearing the force of the law for all electric power facilities is technical regulations (TR). The areas for which TRs must be adopted are provided for in the Federal Law On the Electric Power Industry, however, none of the TRs has been adopted yet, and those being developed address technical and technological safety issues only. It is urgently necessary to develop the legislative framework for the state regulation of the electric power sector, in particular addressing power equipment operation, including maintenance and modernization.

11. DEVELOPMENT OF THE SCIENTIFIC SCHOOL

Preservation and development of the power plant industry is not possible without development of the scientific school and of new technologies that meet the global standards. A significant role here must be played by the national science.

Modernization of Russian power sector is not possible without ensuring the priority development of the R&D sector and drawing

up of the R&D consolidated coordination plan which would consolidate all R&D plans of power companies under the supervision of and in accordance with the development priorities developed by the Ministry of Energy of Russia. In the previous years to support R&D the funds were formed to which up to 80% of the funds designated for R&D were allocated. There is no such centralization practice now. It is necessary to bring back the centralized system of R&D funding by a legal framework or by Russian Government resolution. The modernization and innovation challenges faced by the power sector require coordinated efforts in various fields of academic and applied science by engineering companies.

There is a lack of commercialization of scientific ideas and developments, lack of coordination between engineering organizations that are ready to bring the innovations to the market, the market itself is not prepared to accept innovations. On the background of the developing market economy with new owners appearing and additional funding available it is important to find effective methods and mechanisms to stimulate scientific research, development and introduction of new technological solutions. The important guidelines for the R&D development include:

- Development and mastering of commercial production of the national single-shaft thermal module CCPP of 40, 100 and 170 MW capacity.
- Development and mastering of commercial production of the national highly efficient gas turbines of 300 – 350 MW capacity on the basis of JSC “Power Machines,” FGUP “NPTs Gas Turbine Building “Salyut,” GK “Rostekhnologii”, GK “Rosnanotekhnologii.” Development on the basis thereof of highly efficient natural gas-run condensed CCPP of 500–1000 MW capacity with efficiency of over 60 %. The first project to be implemented – Units 5 and 6 at Nizhnevartovskaya GRES.
- Development of standard module cogeneration CCPP of 100 and 170 MW capacity with efficiency over 53–55 % for HEPs. The first projects to be implemented –

TETs-9 Mosenergo (extension) and GTES Scherbinka (green field project).

- Development of ecologically friendly coal-run condensed power units for supercritical steam conditions with efficiency of 43–46 % and capacity of 660–800 MW. The project to be implemented – Petrovskaya GRES (green field project), the Town of Shatura, the Moscow Region, 4000 MW.
- Development of the national power units with coal fuel gasification of 200 – 250 MW capacity using synthetic gas in the combined cycle, development of the demonstration object at the construction site of Novo-Tul'skaya HEP based on the based on the ГТД-110 type GTP manufactured by NPO "Saturn," UK "ODK," GK "Rostekhnologii".
- Development of gasification-based combined cycle plant of high capacity (460–600 MW) with prototype to be built at Severo-Sosvinskaya GRES of 1200–1350 MW capacity using brown coal from Severo-Sosvinskoe field under the federal purpose program "Ural Promyshlenny – Ural Polyarny" on the basis of the national GTP of 300 – 350 MW capacity (GK "Rostekhnologii," GK "Rosnano-Tekhnologii," GK "Rosatom," ZAO "Alyans Group").

12. THE LEADING ROLE OF THE STATE IN THE MODERNIZATION OF THE POWER SECTOR

The Russian power sector modernization challenge cannot be met without the leading role of the state. In this regard, the Ministry of Energy of Russia shall develop the following:

- Program for modernization of the Russian power sector and implementation of the program by each particular power unit while retaining the same power supply reliability.
- The normative base for technical regulation, including operation, overhaul and modernization of the power equipment.
- Methods and criteria for power generating and electrical equipment wear rate assessment as well as methods to extend the service life thereof and withdrawal thereof from service.

It is expedient to restore the unified overhauls data base in order to be able to obtain full and accurate information on the equipment condition and on the results of repair services.

The Russian Ministry of Energy should propose the Russian Government to amend the Rules for Approval of Investment Programs for Electric Power Entities in which the State Holds Interests and for Network Organizations and the Rules for Exercising Control over Implementation of Investment Programs of Electric Power Entities in terms of strengthening of controlling powers of the state in the field of investment activities conducted by electric power entities.

13. CONCLUSION

The Russian gas-run power sector is not efficient. The major task of the state is the development of the national GTP of 300 – 350 MW capacity and, on the basis thereof – of a CCPP of 500 – 1000 MW capacity with efficiency of over 60%. The 3rd power unit of Nizhnevartovskaya GRES can become the demonstration unit for the new technology. The national power plant industry is unable to solve by its own means the task of development of the national high capacity GTP within the terms fixed in the Russian Energy Strategy for the Period until 2030. To achieve this, cooperation with foreign manufacturers of high capacity GTP is necessary. Such cooperation can be developed on the basis of the Leningrad Metal Plant of JSC "Power Machines" which has already acquired a license from Siemens to manufacture a GTP-260. The state should take the burden of organization of the work related to the manufacture of high capacity GTP in Russia.

The manufacturing of the model power unit of 660 MW capacity for supercritical steam conditions will create conditions for the significant raise in efficiency of coal-run power plants.

It is necessary to develop the industry criteria and methods for power generating and electrical equipment wear rate assessment and further to develop measures for withdrawal thereof from service and extension of service

life, modernization or substitution with more efficient equipment.

To ensure the proper power generating equipment operation and maintenance it is expedient to establish the relevant state body to be in charge of the state energy supervision taking the benefit of the experience of the State Inspection for Power Plants and Grids Operation.

14. BIOGRAPHICAL DATA



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