Accepted at 5TH EUROPEAN CONFERENCE ON COAL RESEARCH AND ITS APPLICATIONS
DRAFT VERSION

# Current Situation of Coal fired Power Plants in Russia Federation and the Implementation Options of Clean Coal Technologies

E. Kakaras[1], A. Tumanovsky[2], V. Kotler[2], N. Koukouzas[1], and E. Karlopoulos[1]

1. Centre for Research and Technology Hellas/Institute for Solid Fuels Technology and Applications
4th km N.R.Ptolemaida-Kozani
P.O. BOX 95, 50200, Ptolemaida, Greece
Tel: +30 2463 053842
Fax: +30 24630 53843
E-mail:isfta@lignite.gr

2. All-Russian Thermal Engineering Institute
14/23 Avtozavodskaya str.
109280, Moscow, Russia
Tel: (095) 275 34 83
Fax: (095) 234 74 27
E-mail: vti@cnt.ru

## Abstract

*In Russia Federation, coal fired power plants account for about 29% of the total electricity generation. Russia's "Energy strategy until the year 2020" projecting a 75% increase in coal production as well as a significant increasing role for coal in electricity production. The long operating period of the majority of the coal-fired boilers resulted in considerably reduced efficiency and availability, while the repair and maintenance expenses made about 12% of the primary cost of the electricity production. Therefore, it is important to encourage the use of modern, efficient and cleaner coal combustion technologies. This paper presents the most significant problems related to the current operation of the coal power plants in Russia and estimates the most relevant options to implement the clean coal technologies in Russians coal power sector.*

*Key words: coal, clean coal technologies, Russia, power plants*

## 1. Introduction

With its capacity of 215 GW, the Russian power industry is the world's fourth largest, after the US, China and Japan. While installed capacity changed only a little, production decreased in response to the steep decline of demand, falling about 20% from its 1990 Soviet-era peak. In July 2001, the Russian government approved the decree to restructure the Russian power sector. According to the decree, the Russian power sector is to be steadily restructured with the objective of creating a deregulated market with a functioning price mechanism up until 2004. With 157 billion tons in proven coal reserves, which accounts 16% of the total world reserves, Russia Federation holds the world's second largest coal reserves, behind only the United States. Between 1999 and 2010 it is expected that there will be a doubling of coal consumption for electricity and heat production, while coal exports will be stay constant about 30 million tones per year. The aim of this paper is to present the current situation of coal fired power plants in Russia Federation and to give an implementation option of clean coal technologies in this country.

## 2. The importance of coal for the Russian industry

For more than 150 years, coal was the dominant fuel supporting Russia's industries, and many industrial centers were located near coal deposits. In the 1960s, oil and natural gas overtook coal when plentiful reserves of those fuels became available and the coal shafts of the European Soviet Union - located primarily in what is today Ukraine - were being exhausted. In the last decade the coal production in Russia followed the common trend in power generation showing a decrease in the beginning of the 90s till 1998. In 1988 coal production in Russia reached the highest level of 425.4 Mt, but then annual production gradually decreased. A historical statistic of coal production in Russia Federation is shown in Figure 1. The majority of mines were old, the average depth of underground workings became critical, the danger of rock bumps, fires, roof falls and gas outbursts increased. Fatal accidents became frequent. The beginning of reform in Russia was the result of persistent struggle of miners for 1993-1997 were the first stage of coal industry reforming. More than ninety (90) underground loss-making and dangerous mines and one (1) opencast mine were closed with reduction of personal by one third. At the same time 11 new highly productive underground and 15 opencast

mines were under construction in Kuzbass, as well as in Rostov, Amur, Far East and Buryatiya regions with the total capacity of 57 million tons per year. The cost of coal production decreased. Russian machine-building plants mastered the manufacturing of modern affective equipment.

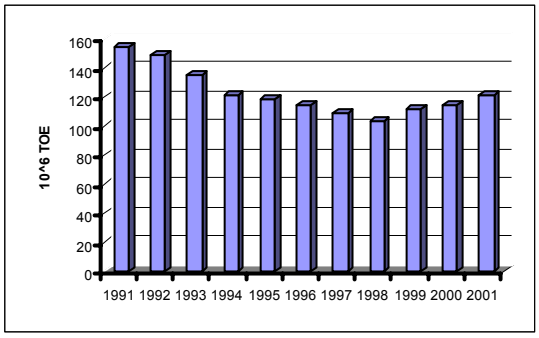


**Figure 1:** Coal Production in Russia (BP statistical review 2002)

In the foreseeable future, the main consumers of coal and products of its processing will be power plants, industrial boilers and utilities, heating furnaces and coke plants, as it shown in figure 2. Between 1999 and 2010 it is expected that there will be a doubling of coal consumption for electricity and heat production. Coal exports will be stay constant about 30 million tones per year.

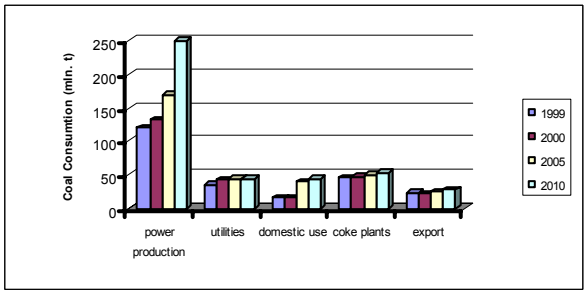


**Figure 2:** Coal Consumption forecast for the Russian Federation

The volume of coal reserves will last for 500-800 years in Russia, while the proved industrial gas reserves for only 60-70 years. This was pointed out at a meeting of the Deputy Chairman of Gazprom's Executive Board Alexander Ananenkov with governor of the Kemerovo region Aman Tuleyev, which was held on 14th August 2002. Here at, coal reserves of Russia have a great degree of prospecting, which speaks for the possibility of building powerful enterprises on the base of them with long lasting lifetime of operation.

## 3. Contribution of coal to electricity production

The power sector is a basic industry in the Russian economy, serving both the internal needs of domestic economy and the export of electricity. The federal monopoly called "Unified Energy Systems" (UES) currently controls about 74% of the installed capacity, either directly or through regional power companies. About two thirds of power production in Russia comes from thermal power stations, 19% from hydroelectric stations, and 5% from nuclear power stations, with the share of unconventional renewable sources of energy is quite insignificant and less than 0.1%. Distribution of power generation by types of fuel is presented in figure 3. A large number of Russian generation assets are old and, in many cases, have already served their expected technical life expectancy. Virtually no investments have been made in generation over the past ten years. For this reason, price levels in the wholesale market are not expected to fall after deregulation of prices, as they did in the Nordic countries. On the contrary, it is expected that prices will increase by the factor of 2 to 3 to attract the investments necessary.

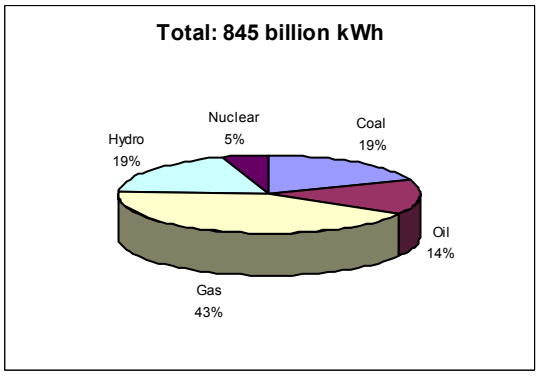


**Figure 3:** Distribution of power generation in Russia by types of fuel

The length of power transmission lines of all voltage classes is 2.5 million km, including 150,000 km of 220 to 1150 kV networks. Over 90% of this potential is united within Unified Energy System (UES) of Russia, covering all the inhabited territory of the country, and is one of the largest centrally managed utilities in the world.

## 4. Current situation of the coal-fired power sector in Russia

### 4.1 Age and Efficiency of the Coal-fired TPPs

In Russian there are 25 thermal coal-fired power stations of total capacity 29,298 $MW_{el}$. Almost 40% of the installed capacity exists in the regions of Krasnoyarskiy, Sverdlovskiy and Moskovski. About 30% of the Russian Coal Units - in terms of number of Units- are between 100-200 MWel, as far as the installed capacity is concerned 50% corresponds in Units between 200-300 $MW_{el}$. Figure 4 illustrates the distribution of number of Units and installed capacity as a function of the Units electric capacity in $MW_{el}$.

About 80% of the power plants - in terms of installed capacity- belong to RAO EES, which provides about 70 % of the total electricity in Russia. The companies that follow RAO EES in installed capacity is Mosenergo and Kuzbassenergo with 1310 MWel and 1272 MWel installed capacity respectively. RAO EES has also in its property high voltage electric lines and substations forming the Unified Power System of Russia.

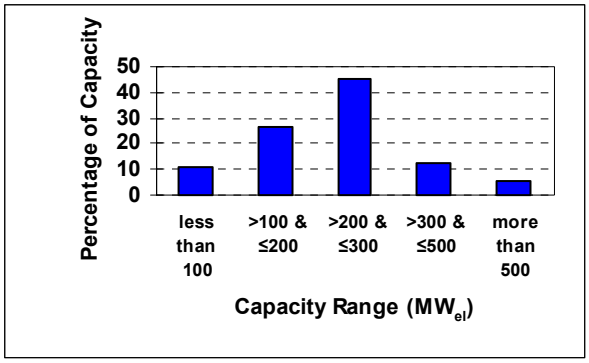


**Figure 4:** Capacity of the Russian coal-fired Units

The Russian coal-fired power sector may be characterized as of advanced age. More than 50% of the installed capacity corresponds to Units older than 30 years old and about 25% of the installed capacity is less that 30 but older that 20 years old. In terms of number of units more than 60% are older than 30 years old while about 20% is in the range of 20 – 30 years.

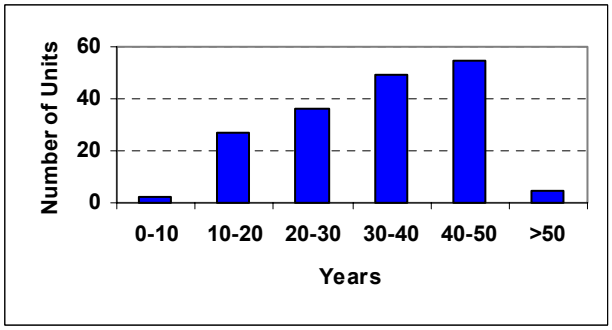


**Figure 14:** Age of power plants in terms of number of Units.

The availability of the Russian coal-fired power plants varies in the range of 30% to 70%. The Russian coal-fired power plants are characterized by low efficiency because of the few renovations activities that took place in the last decades as well as in the fact that the power plants are of advanced age. Most of the Units' efficiencies varying between 30% and 35%. Only few, mainly supercritical or quite new Units, achieve rates of efficiency more than 38%.

### 4.2. Environmental Performance

Over 25% of coals fired at the TPPs in Russia have an ash content of above 40% which makes the problem of flue gas cleaning of particulate matter a rather urgent problem. The fly ash is collected in the multicyclones, wet scrubbers or electrostatic precipitators (ESP). Cyclones feature low collection efficiency (75-85 %) are remained in operation only at old boilers installed in 50-60s. Later boilers, employ wet scrubbers ($\eta$ = 92-97%) or electrostatic precipitators ($\eta$ = 94-99%). In some cases, the series connected cyclones-scrubbers or cyclones-ESP combinations are applied. The fly ash collection efficiency on the power industry-wide level is 95.5%. The fabric filters and emulsifiers (wet fly ash collection emulsifiers) are under stage of designing. The distribution of the coal-fired TPP capacities by the fly ash collection equipment is illustrated in figure 5.

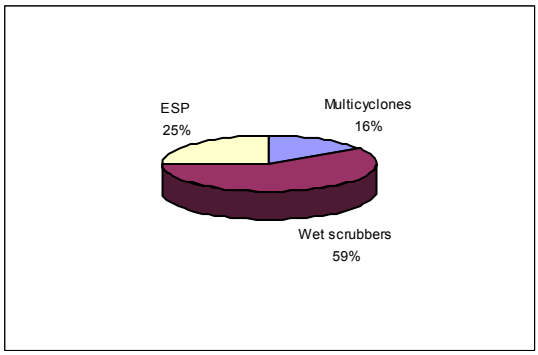


**Figure 5:** Equiment used by fly ash collection in Russians TPPs

Flue gas desulfurization is urgent only for TPPs firing high-sulfur coals from the Pechora and the near-Moscow coal fields, as well as anthracite for the Eastern Donbas region. Today, the problems with $SO_2$ emissions is being solved at the majority of power stations by coal and gas combined combustion, or by addition of a low-sulfur coal. For example, the share of the high-sulfur coals from the near-Moscow coal field fired at the 300 MW units of the Ryzan TPP is reduced to 20% with the balance (80%) being the 0.2-0.4% sulfur content Kansk-Achinsk brown coal. Coal from the Kuzbas, Siberia and the Far East are low-sulfur coals and are now fired without using the DeS0x systems. When firing the Kansk-Achinsk coals which ash contains a great deal of CaO, $SO_2$ is fixed in the furnace chamber. Because of that, the sulfur dioxide emissions from the boilers firing the Beresovo and Nasarovo coals (Kansk-Achinsk basin) are reduced by 20-50%. The problem of $NO_x$ emission reduction at the Russian coal-fired TPPs is being solved by implementing the primary (in-furnace suppression) methods. The flue gas cleaning systems using ammonia (based on the well-known SNCR method) were installed at two boilers of the Tolliatti CHP.

Among the above-mentioned primary (in-furnace suppression) methods implemented at a large number of

the coal-fired boilers of wide use are two-stage combustion, various options of three-stage combustion, concentric combustion in the tangentially-fired furnaces and low-nox burners (LBN). For the indirect-fired pulverized systems, the method of high-density pulverized coal transport is applied capable of reducing $NO_x$ emissions by 20-40%. The pulverized coal preheating is being also under way. The best results obtained at the Russian coal-fired TPPs are as follows: 350-400 mg/m3 (dry, 6 % $O_2$) in firing high volatile matter bituminous coal and 250-300 mg/$m^3$ in firing brown coal.

### 4.3 Main problems related to coal-fired operation TPPs

The age, the long operating period of the majority of the coal-fired boilers resulted in considerably reduced efficiency and reliability, and higher repair expenses. In 2000, the total repair expenses made about $1 bln. or 12% of the primary cost of the electricity generation.
In addition, the equipment installed in 50-70s was not designed to meet the rigid emission control norms adopted in 80-90s. Partly, reliability was increased and ecological problems were overcome due to switching most coal-fired boiler TPPs in the European part of Russia to fire natural gas or due to increasing the share of the latter in the fuel balance of the TPPs to 40-80%. However, in connection with expected price rise for natural gas such approach to solve the problem can be appreciated as a temporary one.
For the long-term perspective, the scientific and engineering organizations of the RAO - UES in cooperation with the boiler manufacturers have prepared the plan of repowering the industry considering the type and age of individual coal-fired TPPs. The implementation of this plan is delayed due to the lack of financing, however the preparatory works are under way. The measures taken to upgrade the coal-fired boilers of large TPPs will increase the economic efficiency, extend the control range and ensure efficient combustion of coals with varying characteristics. This will require higher steam parameters, application of new structural materials and designs of the heating surfaces with external and internal fins. During repowering, the old boilers firing low-grade coals will be replaced by CFB boilers.It is expected that in reconstruction or repowering, the ecological problems will be solved simultaneously by installing the up-to-date electrostatic precipitators, DeNOx and DeSOx systems.

## 5. Clean Coal Technologies in Russia

Coal-fired power generation in Russia Federation is assumed to continue, due to the very low cost of electricity produced by these plants – lower than in the gas-fired combined cycle plants. However, it is not likely, that many new conventional coal-fired power plants will be built in the future. There is a range of new design solutions, which are developed in the framework of the National Scientific Research Programme "Environmentally Friendly Energy". The programme is meant to promote development and introduction of new solid fuel combustion technologies into industrial production. This programme is financed from the state budget and is currently pursued at a slow pace, due to the scarcity the available funding. Some design solutions supported by the programme are:

- 800 MW brown coal-fired power generation unit with gradual combustion of preheated coal dust and fabric filters for ash and sulphur dioxide collection
- 300 MW coal-integrated gasification / combined cycle power generating unit
- 300 MW coal-fired unit using anthracite and bituminous low quality coals as a fuel combusted in a furnace with circulating fluidized bed

It is planned to develop 300 and 500 MWel clean brown coal-fired power generating units, which will have a full range of pollution reduction equipment in full compliance with the international standards. Introduction of the new rehabilitation and equipment design solutions in thermal condensing power plants will also increase the efficiency of those plants up to 45%.

Despite the urgent need to reduce environmental pollution and increase efficiency of the power generation, marginal electricity production cost in the coal-fired power plants will keep those in operation for several years to come. Further improvement of the economic situation in Russia will bring along wider introduction of gas-fired combined cycle plants. Coal- integrated gasification/combined cycle power generating technology will have little chances in the market in the decades immediately ahead, in case investment decisions by the utilities will be made strictly out of price considerations. This, in its turn, will heavily effect technology development and manufacturing companies, as it is hard to expect that the state will bear the full costs and invest in their survival. It is likely, that in this particular technology the sub-sector will loose substantial share of its market to successful joint ventures, new entries or international competitors.

The Russians have extensive experience of the construction of large efficient supercritical pulverised fuel (pf) power plant and are seeking to construct advanced supercritical units. The main areas where Western experience can be applied to these plants lie in emissions abatement systems, control and instrumentation and in operator practices applicable to a privatised generation market. The preferred technology for new power plants is likely to be supercritical pf-fired units where low sulphur coal is available and circulating fluidised beds for higher sulphur coals.

## 6. Future Trends in Russians coal power generation

The renewal program for the main TPP equipment of the RAO-UES for the period of up to 2010 is based on the assumption that the energy consumption in Russia will be at 1020-1135 bln. kWh in year 2010, with 65% of that being generated at TPPs. The share of coal fired will increase from 28% in 2001 to 34% in 2010, and the share of natural gas will decrease from 66 to 61%.

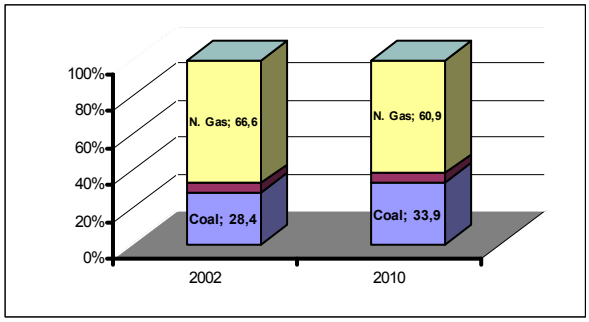


**Figure 6:** Contribution of fuels to energy production in 2002 and forecast for 2010

The price of the natural gas in the European part of Russia during that period will increase from 12 -15 $/t to 44-77 $/tfe, whereas the coal price will increase only up to 29-48 $/t . In Siberia, the natural gas price will be lower (23-44 $/t)., but the coal will also be considerably cheaper (16-27 $/t). In the Eastern regions, both natural gas and coal will be more expensive than in the European part of Russia.

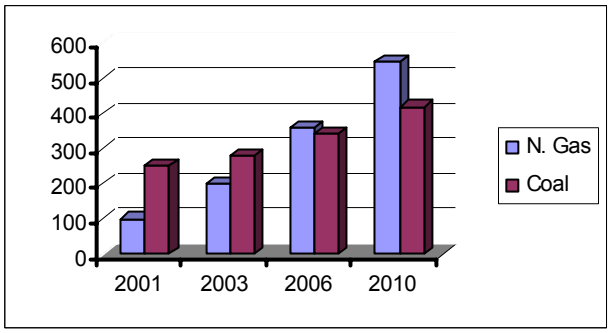


**Figure 7:** Evolution of fuels prices for energy production in Russia ( N. Gas = 100 in 2001)

The extent of the implementation and dates of the «Program» realization will be established with due account for the readiness of the national works to supply the new advanced items of equipment (gas turbines, equipment rated at 30 MPa, 600-650 $^0$C, CFB boilers, etc.). In all cases, when replacing the coal-fired boilers with expired service life, the new boilers will be more efficient, have wider control range and higher rates of load rise). When increasing steam parameters, the new materials and designs will be applied.

The new boilers will use the up-to-date process control systems, low-NOx burners, stage combustion, as well as the dedicated flue gas cleaning facilities. Special attention will also be paid to the auxiliary systems and equipment (fuel-preparation systems, draft equipment, devices for heating surface cleaning).

### 7. References

1. J. Salinski, Energy Reserves in the Central-East European Countries, World Energy Council, 2001, London
2. B.G. Saneev, A.V.Lagerev, A.V. Tchemezov, “Outlooks of Russia’s power industry development in the 21st century and greenhouse gas emissions”, Proceedings of the international Conference, 9-13, 2002, Irkutsk Russia
3. N. Malyshen, “Restructuring of the coal mining industry of Russia-Objectives, Problems and Achievements”, Moscow, Russia.
4. World Energy Council, “Restructuring and privatizing the coal industries in central and eastern Europe and the CIS”, August 2000, London –UK.
5. CERTH/ISFTA, “Promotion of Renovation Activities in the Russian energy Sector”, CARNOT Action 2001, Ptolemais-Greece, 2003.
6. BP Statistical review of world energy, June 2002, (www.bp.com/centres/energy)
7. F. Hubert, A. Natthey, A. Andrianonov, “Reform of Russian Power Industry”, Higher School of Economics, Moscow, June 2003.
8. Commission of the European Communities, “Energy dialogue with Russia”, SEC (2003) 473, Brussels, 2003
9. Czech Power Engineering (www.mpo.cz/xqw)
10. EBRD (www.ebrd/com/new/stories/2003)
11. C. Hurst, K. Uppenberg, “Investment issues in South-Eastern Europe”, European Investment Bank, Report 2000/02, Luxembourg, 2000