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Reducing mercury emissions from coal combustion in the energy sector of the Russian Federation

Prepared by:
Scientific Research Institute
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Disclaimer

Based on the agreement between the United Nations Environment Programme (UNEP) and Scientific Research Institute for Atmospheric Air Protection (SRI Atmosphere), UNEP agreed to co-operate with SRI Atmosphere with respect to the project entitled: "Reducing mercury emissions from coal combustion in the energy sector" in the Russian Federation. General and specific information provided in this report is based on national energy statistics of the Russian Federation, data derived from open and internal sources of institutions, and experts that participated in the study. The contents, terms used and statements made in this report do not reflect the official views and policies of UNEP or the Government of the Russian Federation and related governmental bodies.

This report has been developed as a part of the above mentioned project for UNEP Chemicals Branch, Division of Technology, Industry and Economics. Material in this report can be freely quoted or reprinted. However, acknowledgement is requested together with a reference to the report.

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Acronyms and Abbreviations

ACAP	Arctic Contaminants Action Programme
As	arsenic
Ca	calcium
CCGT	combined cycle gas turbine
CE	coal equivalent
Cl	chlorine
CLATI	Center for Laboratory Analysis and Technical Measurements
CWS	coal-water slurry
CY	dry cyclone (Multi Cyclone)
EFA	Energy Forecasting Agency
ESP	electrostatic precipitator
FD	Federal District of the Russian Federation
FSK EES	Federal Grid Company of the Unified Energy System of Russia
g/t	grams per metric ton
GW	gigawatt
GOST	State Standard of the Russian Federation
GRES	state-owned regional electricity-generating station
Hg	mercury
Hg/kJ	amount of mercury per kilojoule
IEA CCC	International Energy Agency Clean Coal Centre
kcal/kg	kilocalories per kilogram
kWh	kilowatt hour
LOI	loss on ignition
mg/kg	milligrams per kilogram
mg/m^3	milligrams per meter cubed
MW	megawatt
Na	sodium
ng	nanogram
NO_X	nitrogen oxides
OGK	Wholesale Generation Company
PCC	pulverized coal combustion
POG	Process Optimization Guidance
PM	particulate matter
ppm	parts per million
RAO EES	Russian Joint Stock Company "Unified Energy System of Russia"
Rostechnadzor	Federal Service for Environmental, Technological and Atomic Supervision
RZD	Russian Railways
SC	wet Venturi scrubber
Se	selenium
SO_2	sulfur dioxide
SRI Atmosphere	Scientific Research Institute for Atmospheric Air Protection
SUEK	Siberian Coal Energy Company
TGK	Territorial Generating Company
TPP	thermal power plant
$\mu g/Nm^3$	micrograms per normal meter cubed
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UPS	United Power Systems
US EPA	United States Environmental Protection Agency
VTI	All-Russia Thermal Engineering Institute

Definitions

bituminous coal – coal rank most commonly used in coal-fired utility boilers, heating value higher than for sub-bituminous coal

brown coal – term used to describe low rank coals that generally have a brown color

coal ash content – ash determined upon combustion of the coal on an as-received basis

coal gross calorific value (or higher heating value) – the heat of combustion of the coal including the heat recovered condensing the water vapor formed in combustion to liquid water

coal moisture – moisture inherent in coal before combustion on an as-received basis

coal net calorific value (or lower heating value) – the heat of combustion of the coal without the heat that could be recovered condensing the water vapor formed in combustion to liquid water

humolite (or humic coal) – coal with low hydrogen content

lignite coal – the lowest rank coal, relatively soft and brown to black in color, usually with high moisture and low heating value

sub-bituminous coal – coal rank with less ash and generally cleaner burning than lignite coal

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1 Executive Summary

The national coordinator for the project entitled “Reducing mercury emissions from coal combustion in the energy sector” in the Russian Federation was the Scientific Research Institute for Atmospheric Air Protection (SRI Atmosphere, JSC), St. Petersburg, under the Small-Scale Funding Agreement MC/4030-09-04 with the United Nations Environment Programme (UNEP). The project was executed by the SRI Atmosphere in cooperation with the All-Russia Thermal Engineering Institute (VTI) and in consultations with UNEP-Chemicals, ARCADIS US Inc., International Energy Agency Clean Coal Centre (IEA CCC), and the United States Environmental Protection Agency (US EPA). The contents, terms used, and statements made in this report do not reflect the official views and policies of UNEP or the Government of the Russian Federation and related governmental bodies.

The project collected information on coal used, on Russian power plants, and on the status of air pollution control at power plants. Coal samples from the following selected coal mines and power plants were characterized by chemical analysis for mercury (Hg), arsenic (As), selenium (Se), chlorine (Cl), calcium (Ca), and sodium (Na) content: Azeyskiy, Berezovskiy, Borodinskiy, Donetskiy, Kuznetskiy, Nazarovskiy, Podmoskovniy, Rajchikhinskiy, Sakhalinskiy, Cheremkhovskiy, and Ekibastuzskiy. Information was provided for 120 coal-fired power plants This number included state-owned regional electricity-generating stations (GRES)[*] and thermal power plants (TPP), in the Russian Federation. Typically, GRES is a regional electricity-generating station with installed capacity of over 1000 MW, whereas TPP is a thermal power plant generating both electricity and heat with installed capacity of less than 1000 MW. Main types of particulate matter control equipment deployed at power plants were described and included cold-side electrostatic precipitators (ESP), wet Venturi scrubbers (SC), and dry cyclones (CY). No other type of air pollution control equipment is in use across the energy sector in the Russian Federation. Air pollutant emission monitoring is performed at all power plants periodically, mostly with portable devices.

This report presents updated and new information on coal consumption for electric and heat power generation in the Russian Federation in 2007, and projections for 2020 and 2030, taking into account the current economic situation throughout the world. The report also presents an updated inventory of mercury emissions from the sector and mercury emission projections. As mercury content in coals, as well as mercury emission control efficiency, are subject to significant variation, the total emissions of mercury from coal fired electricity and heat generation in 2007 were estimated to be between 6.7-18 metric tons (mean and maximum values respectively). Future mercury emissions were estimated based on the status quo and emission control implementation scenarios. Mercury concentration in flue gas was measured at two power plants. The measurement campaign was carried out in May 2010 with technical support from ARCADIS US, Inc. and US EPA. The two power plants tested were Kashirskaya GRES-4 (OGK-1, Kashira, Moscow oblast) and Reftinskaya GRES (OGK-5, Sverdlovsk oblast). The average mercury concentration in the flue gas from two ducts fed by a common unit in the Kashirskaya power station was 2.54 µg/Nm^3 (at 3% O_2) corresponding to 1.07 ng of Hg/kJ of coal input. Two units at Reftinskaya were tested (Unit 1 and Unit 9). Unit 1 was emitting mercury at 3.2 µg/Nm^3 (at 3% O_2) while Unit 9 was emitting at 9.58 µg/Nm^3 (at 3% O_2) corresponding to 0.98 and 2.94 ng of Hg/kJ of coal input for Units 1 and 9, respectively.

[*] Initially the state had full ownership of regional electricity-generating stations. Since 1990s major number of GRES was privatized. Generally, ownership reference is no longer valid.

2 Introduction

This section presents mandate, objectives, and scope of the project and gives the background for conducting the project in the Russian Federation. Methods used to collect information given in this report are also discussed in this section.

2.1 Mandate, objectives and scope

At its 25th session in February 2009, the Governing Council of UNEP requested that UNEP conduct a study, in consultation with the countries concerned, on various types of mercury-emitting sources, as well as current and future trends of mercury emissions, with a view to analyzing and assessing the cost and effectiveness of alternative control technologies and measures (paragraph 29 of the UNEP GC decision 25/5). The purpose of the study was to inform the work of the intergovernmental negotiating committee established to prepare a global, legally-binding instrument on mercury.

To contribute to this study, the project entitled "Reducing mercury emissions from coal combustion in the energy sector" was initiated by UNEP. The project focused on China, India, Russia and South Africa and aimed to develop guidance materials, the Process Optimization Guidance (POG), to reduce mercury emissions from coal combustion, and improve mercury emission inventories and related information. In September 2009, UNEP and SRI Atmosphere (SRI Atmosphere, JSC), St. Petersburg signed the agreement to co-operate with respect to the project entitled "Reducing mercury emissions from coal combustion in the energy sector" in Russia. The project was executed by SRI Atmosphere in cooperation with VTI, Moscow, and in consultations with UNEP-Chemicals, ARCADIS US Inc., IEA CCC, and the US EPA.

Results of the project have been fed into the study on various types of mercury-emitting sources, called for in paragraph 29 of the UNEP GC decision 25/5. The project outcomes are also intended to supply the government of the Russian Federation, i.e., the Ministry of Natural Resources and Environment and the Ministry of Energy and their subsidiary bodies, with up-to-date information on mercury emissions inventory from the coal-fired energy sector, and appropriate methods and practices to tackle related mercury releases.

The scope of the project was to collect information on the coal used and the status of air pollution control in Russian power plants. Coal samples from selected coal mines and power plants were analyzed. Information on measurements of mercury in stack flue gases were collected from literature. Mercury from flue gas was measured at two power plants. The information collected was used to develop an inventory of mercury emissions from coal-fired power plants in Russia. Future mercury emissions were estimated based on the status quo and the emission control implementation scenario.

The project encompasses the following objectives:

1. Promote approaches to mercury release control and abatement in the coal-fired energy generation sector through optimization and enhancement of pollution abatement techniques and processes in conjunction with energy and resource efficiency improvements.

2. Update and further develop existing inventories of mercury releases in the coal-fired power sector through comprehensive analysis of statistical and experimental data.

3. Inform industry, decision-makers and the expert community on the problems of mercury releases in the sector and promote emission reductions.

This report presents updated and new information on coal consumption for electric and heat power generation in the Russian Federation in 2007 and projections for 2020 and 2030; results of chemical analyses of samples taken of typical Russian coals (including Hg, As, Se, Cl, Ca and Na content); an updated inventory of mercury emissions from the sector; and mercury emission projections.

Major tasks in the study are as follows:

Task 1. Collection and analysis of available information on coal: amount of coal used by coal type, results of coal analysis (including Hg, As, Se, Cl, Ca, and Na content) and information on extent of coal preparation by coal type. Collection of available information (or estimation) of coal consumption (projected coal use) for energy generation for the target years 2020 and 2050, if possible. Chemical analysis of selected samples of coal for Hg, As, Se, Cl, Ca, and Na to present a general representative picture of Russian coals fired for energy generation.

Task 2. Collection of available information on coal-fired power plants: installed power plant capacity by combustion process, approximate locations of power plants, air pollution control configuration and efficiency by pollutant (particulate matter [PM], sulfur dioxide [SO_2], nitrogen oxides [NO_X] and Hg) and by plant, plant capacity factor, plant heat rate, boiler operating conditions, and ash split; information on any available results of measurements of PM, SO_2, NO_X or Hg emissions in power plants.

Task 3. Development of example Hg emission factors based on data sets from selected power plants which have as complete datasets as possible.

Task 4. Comparison of example emission factors to emissions based on actual measurements, as available.

Task 5. Revision of existing emission factors, as necessary, based on the above collected information.

Task 6. Development of improved emission inventories based on the results from the above tasks (coal use, power plant information, and revised emission factors), and analysis of uncertainties of the data calculated.

Task 7. Distribution of improved emission inventories to the network of experts and stakeholders for comments.

Task 8. Prediction of future mercury emission trends for the status quo and for the POG mercury control implementation scenario.

2.2 Background

The coal-fired power generation sector of the Russian Federation has been identified as one of the major anthropogenic sources of mercury emissions both locally and globally. A study carried out by the Arctic Contaminants Action Programme (ACAP), a working group under the Arctic Council, was the first comprehensive attempt to assess levels of mercury emissions from anthropogenic sources in the Russian Federation (ACAP, 2005). This study reported that some 8 metric tons per year of mercury were potentially released to the air in 2001/2002 due to coal combustion for power generation at large industrial electricity and heat power production facilities. This indicates that the sector was accountable for 27% of the net mercury emissions released by major potential industrial mercury emitters in the country, such as non-ferrous metallurgy, cement production, the chlor-alkali industry, and waste incineration.

The Global Atmospheric Mercury Assessment (UNEP Chemicals, 2008) suggests that the fossil fuel-fired power and heat generation sector of the Russian Federation was accountable for 74 metric tons of mercury emitted in 2005, some 65% of which comes from the energy sector.

2.3 Methods

The current study to estimate mercury emissions from coal-fired power plants in the Russian Federation is based on a literature review, including state energy reports and international studies, plant-specific national energy statistics, historical data on coal characteristics, and results of practical chemical analyses and industrial tests.

Primary sources of the Russian energy sector information were reports from the Ministry of Energy of the Russian Federation in cooperation with the Energy Forecasting Agency. Mercury emissions forecasts were built in accordance with the scenario conditions of electric power industry development for the period up to 2030. Data on coals fired for energy generation in Russia, as well as power plant-specific information, were aggregated from the national energy statistics database for 2007.

Preliminary analysis of major coals fired for power generation as well as for major power stations determined coal sampling and industrial test strategies. As a result, samples of coals from three major basins – Ekibastuzskiy, Kansko-Achinskiy and Kuznetskiy – were taken for analysis of major chemical and physical characteristics. Also, two power plants – Kashirskaya GRES-4 (1910 MW) and Reftinskaya GRES (3800 MW) – were selected and visited for full-scale industrial mercury emission tests.

Considering the large variations of coal characteristics identified even within one basin, limited amount of previous analysis data, uncertain margins of error with regard to the mercury removal efficiency of basic air pollution control devices, as well as time and resource constraints of the current study, the derived potential mercury emission values should be treated as preliminary and indicative only. More in-depth studies are required to develop a comprehensive national energy sector-specific Hg emission factor database.

Statistical and empirical data were employed for development of model mercury emission factors and comprise the inventory of potential mercury emissions from the coal-fired power sector of the Russian Federation.

An emission factor for mercury releases to the atmosphere from coal fired power plants is an effective tool for estimating the sector emissions associated with energy production. The general equation for estimation of emissions using an emission factor is presented below (as adopted from US EPA AP-42):

$$E = A \times EF \times [1-(ER/100)]$$

where:

E = emissions;

A = activity rate (production, fuel consumption)

EF = uncontrolled emissions factor, and

ER = emission reduction efficiency of control equipment, %.

For coal fired power plants, emission reduction efficiency has been incorporated into the emission factor for control equipment and fuel type combinations:

$$E = A \times EF_i \times 10^6$$

where:

- E = emissions; metric tons per year
- A = coal use rate, metric tons per year
- EF_i = mercury emission factor for i-control equipment and fuel type combination, gram per metric ton of coal burned; where “i” can be ESP, SC, CY or their combinations.

Sets of data of acceptable quality on previously measured mercury emissions from coal combustion in Russia were found unavailable, preventing empirical mercury emission factors development.

Instead, collected data on coal fired for power generation in Russia in 2007, mercury content in typical coals from reference literature, analyses carried out under the project, and mercury emission reduction coefficients derived from US EPA Base Case 2006 (V.3.0) served for development of the example emission factors on the basis of the following equation:

$$EF_i = Hg_i \times k \times [1-(ER_i/100)],$$

where:

- EF_i = mercury emission factor for i-control equipment and fuel type combination, gram per metric ton of coal burned; where “i” can be ESP, SC, CY or their combinations.
- Hg_i = mercury content in i-coal, gram per metric ton, where “i” represents particular coal type.
- k = coefficient of mercury liberation from coal to the atmosphere.
- ER_i = mercury emission reduction efficiency of i-control equipment and fuel type combination, %; where “i” can be ESP, SC, CY or their combinations.

The basic assumptions are as follows:

- Mercury present in coals in all forms is the only source of mercury emissions in the coal fired power generation sector;
- Coefficient of mercury liberation, $k = 0.9$, as adopted from Mniszek (1995).

3 Overview of the Russian coal-fired power sector

The overview of the Russian coal-fired electricity generating sector begins with the overview of available and newly generated information on coals used by the sector. Projections are also presented for future coal use scenarios in 2020 and 2030. Profile of coal-fired power plants in Russia is discussed and detailed information on power plants is given in appendices.

3.1 Coals fired for electricity and power generation in Russia

The structure of the national power generation in the Russian Federation in 2004-2008 is presented in Figure 1 below.

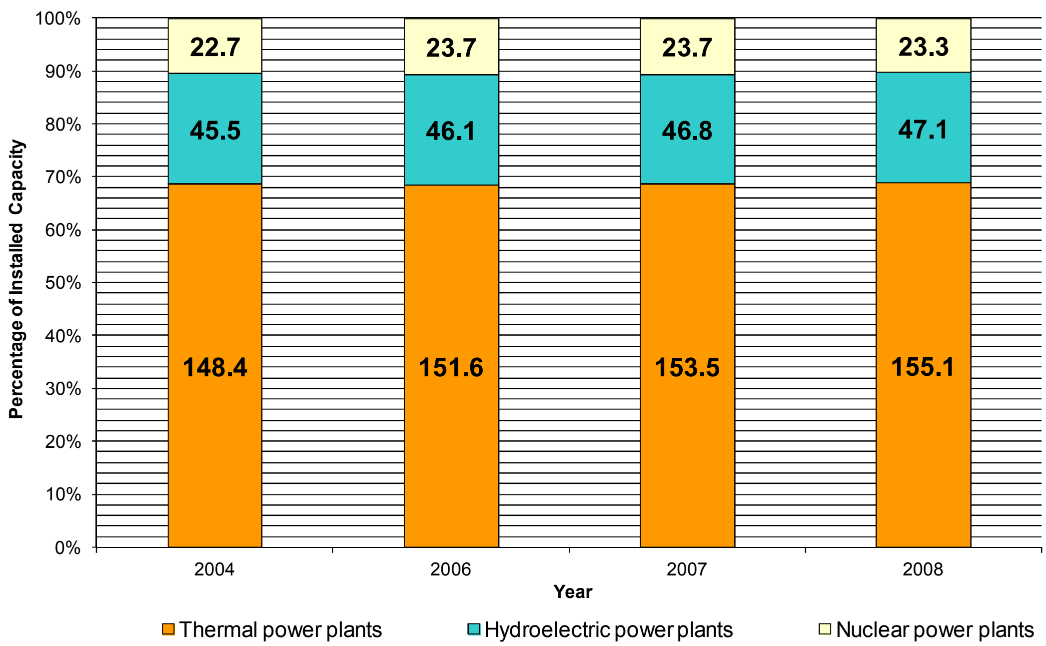

Figure 1. Structure of the power generation capacity in Russia, numbers indicate installed capacity in GW (EFA, 2008).

The overall national energy generation balance has been stable since 2003. Thermal power plants account for 68% of capacity, followed by hydroelectric power plants at 21% and nuclear power plants at 11%. The net installed energy generation capacity has been slowly growing from 216.6 gigawatt (GW) in 2004 to 225.5 GW in 2008 (Fig. 1). Changes shown in Figure 1 are mainly attributed to reassessment of individual energy units capacities as well as to installation of new generating capacity.

The fuel balance structure of the thermal power generation sector generally settled in 2003-2004 and remained within 2% margins in 2006-2008 (Fig. 2). Figure 2 presents the share of fuels utilized for thermal power generation. Natural gas, at 69-71% of the fuel balance, is the main fuel fired for power generation in the Russian Federation. Coal is the second commonly used fuel and accounts for 26-28% of the fuel balance. Heavy oil and other fuels, such as peat and wood, comprise 2-4% of the total balance.

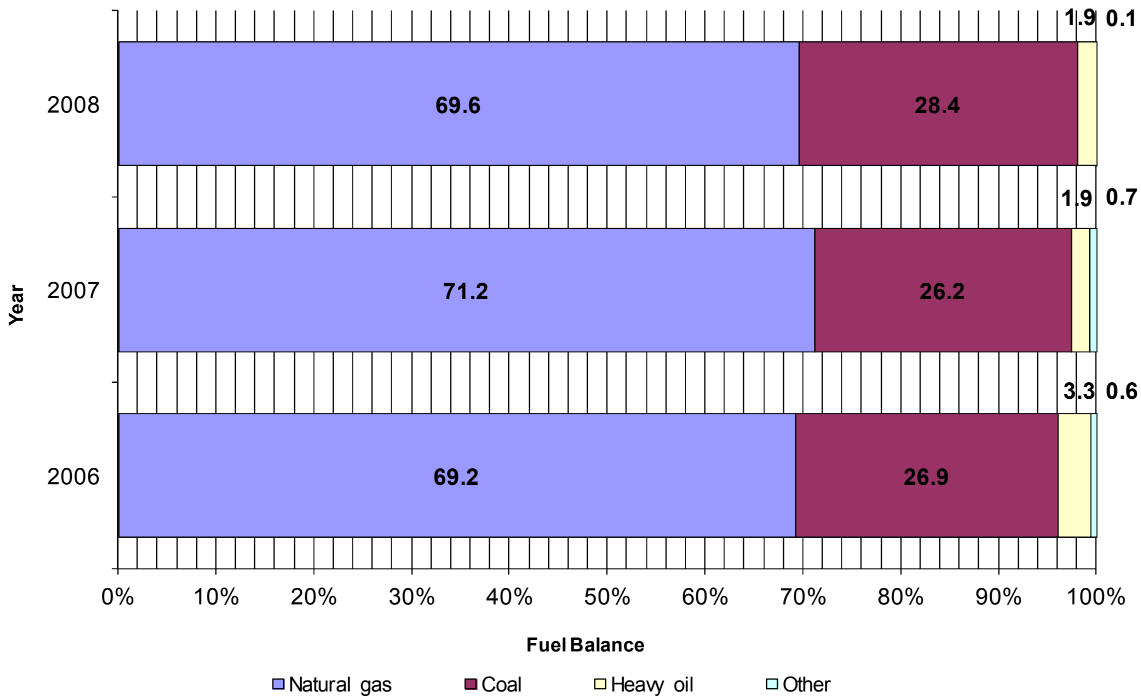

Figure 2. Fuel balance of the thermal power generation in the Russian Federation in 2006-2008, % (EFA, 2008).

3.1.1 Overview of information on coals

Coal-fired power plants utilize coals originating from some 170 different coal basins and fields of the Russian Federation, Kazakhstan and Ukraine. Major coal basins providing coal for the power generation sector of the Russian Federation are shown on Figure 3. Figure 4 presents information on consumption of coals from different basins for electrical and heat power generation in 2007 (for detailed information see ANNEX I).

Most commonly used coals for power generation in the Russian Federation are: Kuznetskiy (20.5%) aggregated over grades (G + D, SS, T, other), Ekibastuzskiy (19.7%), and Kansko-Achinsk basin coals (19.2% as sum of Berezovskiy, Nazarovskiy, Borodinskiy and Kanskiy coals) (additional information on classification of coal grades adopted in the Russian Federation can be found in ANNEX I).

Table 1 below summarizes data on coal consumption for power generation in the Russian Federation by coals constituting over 2% of the coal fuel balance of the power generation sector.

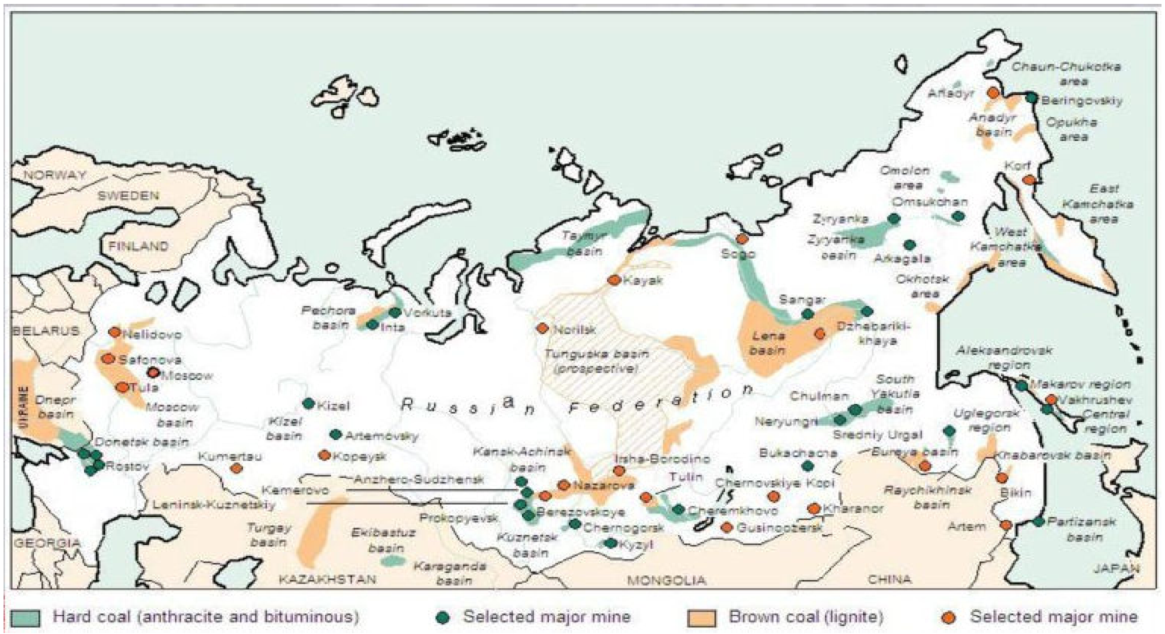

Figure 3. Major coal basins supplying the power generation sector of the Russian Federation (VTI, 2009).

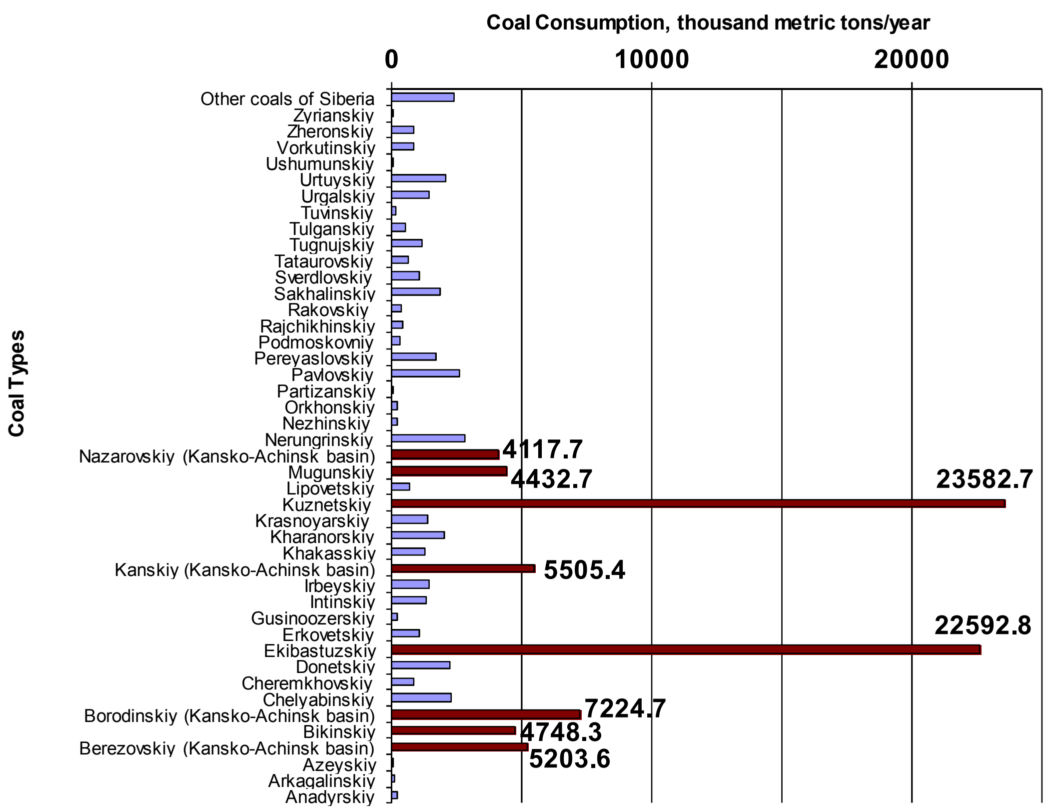

Figure 4. Consumption of coals for power generation in Russian Federation in 2007 (thousand metric tons/year) (VTI, 2009).

Table 1. Consumption of most commonly used coals for power generation in Russian Federation in 2007 (VTI, 2009).

Coal	Consumption, metric tons/year	Fraction, %
Kuznetskiy (all grades)	23,582,670	20.54
Ekibastuzskiy	22,592,769	19.68
Kansko-Achinsk basin coals (total), including:	22,051,509	19.2
Borodinskiy	*7,224,721*	*6.29*
Berezovskiy	*5,203,605*	*4.53*
Kanskiy	*5,505,448*	*4.80*
Nazarovskiy	*4,117,735*	*3.59*
Mugunskiy	4,432,718	3.86
Nerungrinskiy	2,811,709	2.45
Bikinskiy	4,748,263	4.14
Sum	**80,219,638**	**69.87**
Other coals (about 160)	***35,338,163***	***30.13***
TOTAL	**115,557,801**	**100**

Kuznetskiy coal, being the most widely used for power generation in Russia, is considered transitional from humolite to a hard coal by its genetics. Power plants burn different grades of Kuznetskiy coal: of the fuel balance at power plants, “G” – gas and “D” – long-flaming grades make up ~ 13%, “SS” – low-caking grade makes up ~ 6%, “T” – lean grade makes up ~ 3%.

Ekibastuzskiy coal, being the second most widely used coal fired in Russia, is imported from the Pavlodar region of Kazakhstan bordering the southern part of Western Siberia. It has historically been one of the main coals used for power generation across the ex-Soviet Union. Ekibastuzskiy coal is classified as a hard coal of high ash content. In particular, similar to the “T”-grade of Kuznetskiy coal, fly ash of Ekibastuzskiy coal can be hard to capture by electrostatic precipitators due to its electro-physical properties. Therefore, residual dust content in flue gases generated at TPPs burning Ekibastuzskiy coal may reach significant levels of ~450 mg/m^3 and above.

The **Kansko-Achinsk coal basin** includes ***Borodinskiy***, ***Berezovskiy***, ***Kanskiy*** and ***Nazarovskiy*** coal fields (coals are named accordingly). These coals are considered brown (lignite), have similar physical and chemical parameters, and are mainly burnt in Siberia. Recently, Berezovskiy coal is also utilized in the European part of Russia in limited quantities.

Mugunskiy coal is mined in Eastern Siberia, to the west of Lake Baikal. It is considered brown and is mainly utilized locally at power plants of JSC “IRKUTSKENERGO”.

Nerungrinskiy and **Bikinskiy**, hard and brown coals respectively, are also locally mined and fired in the Far East region of Russia (including Yakutia, Khabarovskiy and Primorskiy krai).

Table 2 presents the main characteristics of selected coals such as net calorific values, moisture and ash content.

Table 2. Main characteristics of selected coals.

Coal	Q^r_n, kcal/kg	W^r, %	A^r, %	Type
Kuznetskiy coal (all grades)	**4548 - 6148**	**7 - 19**	**14 - 23**	Bituminous
Ekibastuzskiy coal	**3880 - 4150**	**5 - 7**	**38 - 41**	Sub-bituminous
Kansko-Achinsk coals	**3244 - 3950**	**30 - 39**	**4 - 10**	Sub-bituminous
Borodinskiy coal	3787-3950	30 - 32	5 - 8	-
Berezovskiy coal	3565-3831	34	4-8	-
Kanskiy coal	3563-3805	30-36	7-10	-
Nazarovskiy coal	3244	39	6	-
Mugunskiy coal	**4071**	**22**	**25**	Sub-bituminous
Neryungrinskiy coal	**5516-5991**	**6 - 10**	**18 - 26**	Bituminous
Bikinskiy coal	**2122**	**39**	**24**	Sub-bituminous

Where: $\mathbf{Q^r_n}$ – gross calorific value of coal, kcal/kg; $\mathbf{W^r}$ – moisture content of coal, $\mathbf{A^r}$ – ash content of coal

Coals listed in Table 2 are classified as either bituminous or sub-bituminous in accordance with the United Nations Economic Commission for Europe (UNECE) Classification of coals (UNECE, 1998) for application of US EPA mercury release calculation methodologies. Depending on the particular field of the Kuznetskiy basin this coal may be considered either bituminous or sub-bituminous. For the purpose of the study Kuznetskiy coal is classified as bituminous. Moreover, as ranges in Table 2 suggest, coal characteristics may substantially vary within the same basin (for more information on basic characteristics of Russian coals, see ANNEX I).

The dynamics of coal use over the 2006-2007 period are shown in Figure 5. The coal consumption balance was formed (with minor exceptions) over the years 2003-2006 (VTI, 2009).

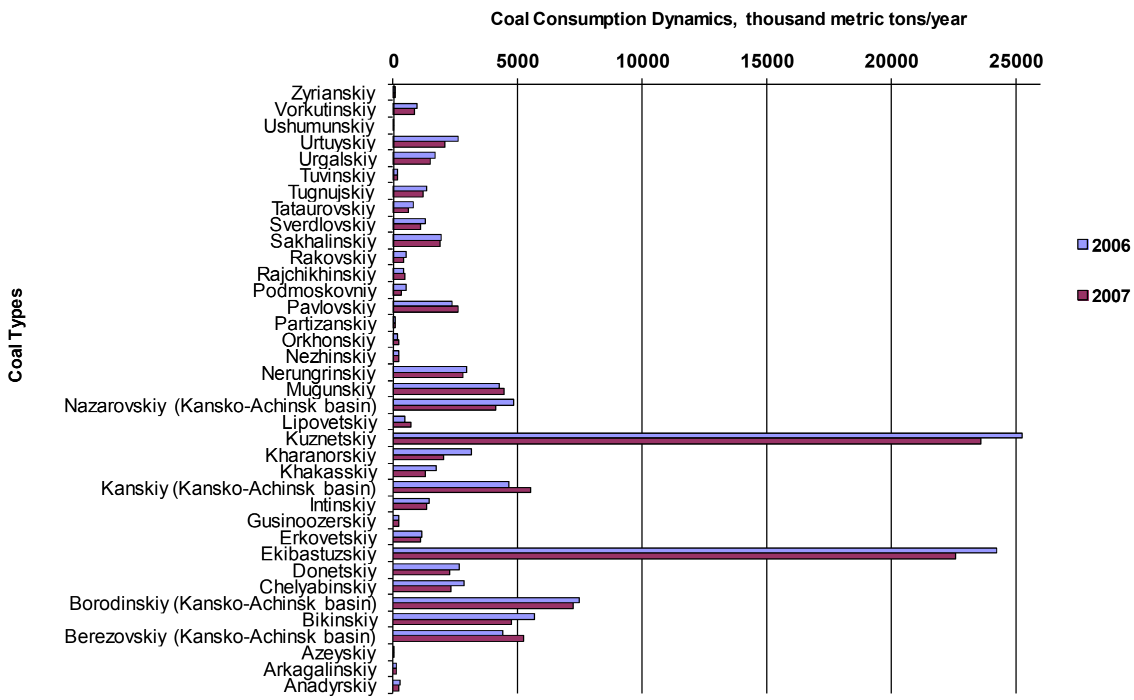

Figure 5. Dynamics of coal consumption for energy generation in Russian Federation in 2006-2007 (thousand metric tons/year) (VTI, 2009).

Fluctuations in coal consumption shown in Figure 5 result from changes in regional energy demand. For instance, Artemovskaya TPP utilizing Lipovetskiy coal increased its power and heat generation in 2007. Lower electrical and heat power output at Vladivostokskaya TPP-2 and Khabarovskaya TPP-3 led to the decrease of Kharanorskiy coal consumption. In addition, the shift of power plants from coal to natural gas also contributed to a certain change in coal consumption. Specifically, Mosenergo TPP-17 and Ryazanskaya GRES substituted natural gas for Podmoskovniy coal during 2007 thus reducing its utilization. However, overall divergences between coal consumption rates in 2007 and 2006 can be considered marginal.

Accurate data on the content of mercury and some other elements in typical Russian coals are limited and subject to uncertainties. A number of coal mines, energy companies and research institutions have performed analysis of coals for their internal purposes, but major research results date back to the 1970s, 1980s, and early 1990s or are not available to the public. The ACAP (2005) comprehensive report presents only aggregated national information and suggests that Kuznetskiy coal may contain ~0.01-0.5 g of mercury per metric ton (about 0.01-0.5 ppm). Large variations are also observed in other major coal basins in European, Siberian and Far East parts of Russia. Table 3 presents data from past mercury in coal studies performed by VTI as well as reference values of mercury content in coals of countries around the world.

Table 3. Mercury content of Russian coals and coals from other countries.

Country	Coal deposit/type	Hg content (mean), g/t (mg/kg)	Hg content (range/maximum), g/t (mg/kg)	Reference
Russia*	Azeyskiy (sub-bituminous)	0.17	0.5	VTI, 2009
	Berezovskiy (Kansko-Achinsk) (sub-bituminous)	0.04	0.04	
	Borodinskiy (Kansko-Achinsk) (sub-bituminous)	0.02	0.1	
	Donetskiy (bituminous)	0.094	0.1	
	Kuznetskiy (bituminous)	0.08	0.11	
	Nazarovskiy (Kansko-Achinsk) (sub-bituminous)	0.1	0.1	
	Podmoskovniy (sub-bituminous)	0.02	0.02	
	Rajchikhinskiy (sub-bituminous)	0.4	0.4	
	Sakhalinskiy (bituminous)	0.11	0.11	
	Cheremkhovskiy (bituminous)	0.17	0.25	
	Ekibastuzskiy (sub-bituminous)	0.02	0.02	
Australia	Bituminous	0.215	0.03-0.4	UNEP, 2011
Brazil	Bituminous	0.19	0.04-0.67	
Poland	Bituminous		0.01-1.0	
South Africa	Bituminous		0.01-1.0	
USA	Sub-bituminous	0.1	0.01-8.0	
	Lignite	0.15	0.03-1.0	
	Bituminous	0.21	<0.01-3.3	
	Anthracite	0.23	0.16-0.30	

*Note: Analyses were performed in accordance with ISO 15237: 2003 equivalent and "Cold vapor" method with three samples of each coal analyzed with atomic adsorption spectrometers Pye Unicam SP-2900 and Carl Zeis AAS-1. Main coal deposits in bold.

Based on VTI data, the amount of high-mercury content coals in the coal energy balance can be considered marginal. For instance, the share of Azeiskiy coal equals 0.02%, Podmoskovniy coal to 0.15%, and the Cheremkhovskiy coal to 0.89%.

Concerning data on the content of other chemicals found in Russian coals, only some information on the chlorine content was found. Namely, Ekibastuzskiy coal chlorine content equals ~ 0.55% on a dry weight basis, with Berezovskiy coal (Kansko-Achinsk basin) at ~0.019 and Kuznetskiy coal at ~0.022.

3.1.2 Coal preparation

Methods of coal preparation (pre-treatment) include conventional coal washing, coal beneficiation, coal blending and the use of coal additives. Currently, these methods are not widely used in the Russian Federation for coals fired at power plants. Only few coal pretreatment methods have been tested and partially approved for application at a limited number of power stations in the Russian Federation. These methods are listed and briefly described below:

a) **Coal-water slurry (CWS)** normally consists of coal (40-75%), water (24-59%), moisture reducing additives and stabilizing agents. Commercial trials of CWS were carried out at Belovskaya GRES and Novosibirskaya TPP-5. During CWS tests at Novosibirskaya TPP-5, the boiler efficiency decreased by 3% provisionally due to the flue gas temperature increase and incomplete burning. Partially it could be explained by lower (than it had been envisaged within the project) CWS quality and its dispersion.

b) **EKOVUT** – a mixed, water-dispersed fuel whose composition and properties may be specified according to individual requirements. The ultimate composition of this fuel includes both organic and mineral elements, each of which plays a specific role in the formation of physical, mechanical and thermal properties of the fuel. However, this type of fuel has not been used at TPPs.

c) **Coal drying** – installations for preliminary coal drying are utilized at two TPPs burning high-moisture coals (W^r = 32-35%). A drying installation consists of a raw-coal storage hopper, dryer (a steam panel dryer – at Nazarovskaya GRES), coal mill, filter, fan, ground coal storage hopper and a pneumatic pump. Dried and milled coal is fed to boiler burners. The use of pre-dried coal improves the efficiency of a boiler compared to situation when high-moisture coal is used.

Coal gasification which is not a coal beneficiation process but a process in which combustible syngas is produced from coal has also been tested. This technology is in operation at Zakamskaya TPP which is equipped with a combined cycle gas turbine (CCGT).

3.1.3 Projected coal consumption for power generation in 2020 and 2030

In 2008, the Government of the Russian Federation adopted *The General Scheme for Deploying Electric Power Industry Facilities up to 2020* (RF, 2007). *The General Scheme* was developed in 2006 and coordinated with concerned federal entities such as the Federal Atomic Energy Agency (Rosatom), Federal Grid Company of the Unified Energy System of Russia (FSK EES), Russian Railways (RZD) and major energy resource production and generation companies in 2007 (VTI, 2009; EFA, 2009a).

The General Scheme is the document adopted by the Government of the Russian Federation describing projected changes in energy demand though 2030. The document was developed prior to the international financial crisis of 2008 and was based on an increased energy demand scenario. The initial version of the scheme implied a significant increase of coal use in the fuel balance of power plants – from 26-28% in 2006-2007 up to almost 36% in 2020. The total coal consumption was estimated to reach 289 million metric tons in 2020, in comparison to some 115 million metric tons in 2007 and the installed power generation capacity – 227.6 GW. One of the drivers for power plants to switch to coal was, according to the scheme developers, an accelerated increase of price for natural gas. It was also expected that the natural gas price would increase by a factor of 2.2, while the coal price was expected to increase by a factor of 1.5.

The actual increase of coal prices in 2006-2008 followed the projections of *The General Scheme*. However, the natural gas prices did not reach initially expected values and thus did not become a driver for generation companies to switch from natural gas to coal. In addition, the legal status of *The General Scheme* as a strategic approach to the development of the energy sector was not set and private investors were not required to follow its targets. Up to the year 2010, targets for installations of additional energy generating capacity set in *The General Scheme* were not met. In

2010, strategic indicators on newly installed capacity, energy production, and related issues were 2.0-2.3 times less than those projected in *The General Scheme*. Furthermore, by mid-2010, no information was available on investment proposals for construction of new coal-fired facilities envisaged in *The General Scheme* for the towns of Novgorod, Kaluga, Petrovsk and some others; neither was information available on the expansion of the existing plants – Smolenskaya GRES, Reftinskaya GRES, Yuzhno-Uralskaya GRES and Kemerovskaya GRES. Furthermore, energy generating capacities at Shaturskaya GRES, Verkhnetagilskaya GRES, and Ryazanskaya GRES, as well as at other power plants, have been reoriented from coal to natural gas.

Economic crisis effects and related changes in short- and medium-term planning of the Russian energy sector development were taken into account in *The Scenario Conditions of the Energy Generation Sector Development up to 2030* forecast developed by the Energy Forecasting Agency (EFA) at the request of the Ministry of Energy of the Russian Federation (EFA, 2009b). In contrast to *The General Scheme*, which is a program document, *The Scenario Conditions* reflects currently practical intentions of energy companies. In particular, *The Scenario Conditions* suggests an adjusted figure of generation capacity, approximately 187.8 GW to be installed by 2020 instead of the 227.6 GW initially proposed in *The General Scheme*. Similarly, respective estimated coal consumption by 2020 has also decreased from 289 million metric tons to approximately 237.8 million metric tons. Figure 6 presents projected coal consumption for power generation in the Russian Federation until 2030.

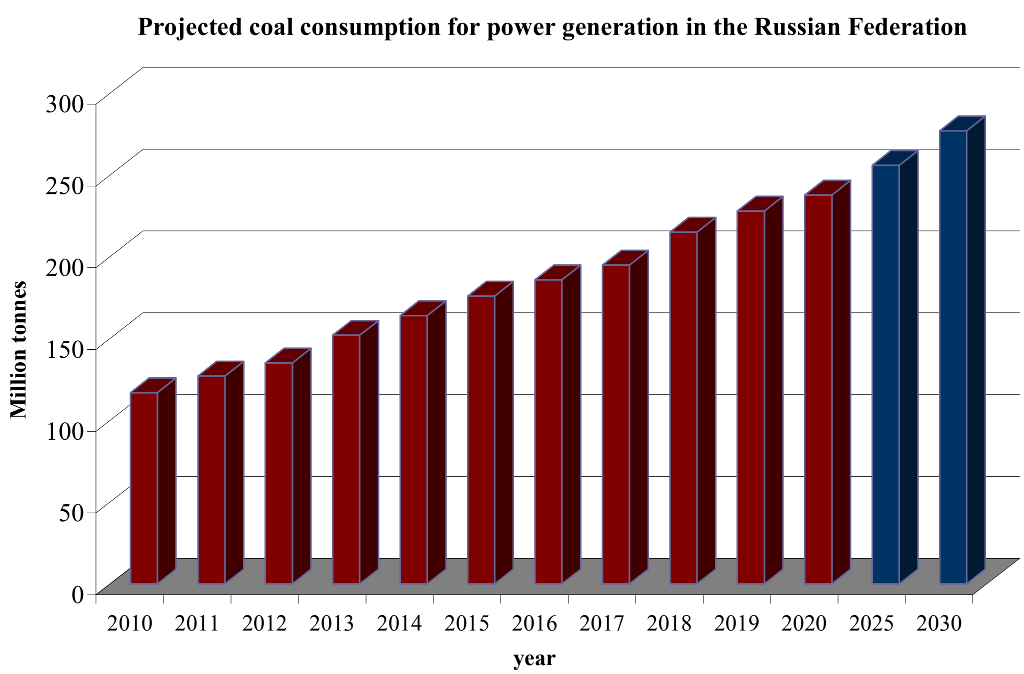

Figure 6. Projected coal consumption for power generation in the Russian Federation.

The Scenario Conditions also includes expected electric power generation levels for 2008-2020 subject to the moderate energy demand scenario both for the central energy supply zone and for individual ***united power systems*** (UPS), as shown in Table 4.

Table 4. Electric power generation in Russia in accordance with *The Scenario Conditions* (moderate energy demand scenario, total and per UPS), 10^9*kWh (EFA, 2009b)[†].

	2008	2009	2010	2015	2020
Total electricity generation in Russia including:	1018.4	974.2	981.1	1145.1	1333.9
Nuclear power plants	164	163.7	170.4	202.4	225.8
Hydroelectric power plants	160.1	160.3	159.4	189.7	198.1
Hydroelectric pumped storage power plants	1.9	1.9	1.9	3	5.4
Thermal power plants (TPP)	691.9	648	649	749.3	903.7
Alternative energy sources (renewable)	0.4	0.5	0.5	0.8	1
UPS of the Northwest Region					
Electricity generation including:	102.4	100.8	102.5	112.1	129
TPPs	50.5	51.1	46.8	55.3	67.4
UPS of the Central Region					
Electricity generation including:	229.1	214.9	217.4	248.3	287.6
TPPs	145.4	128.8	133.8	143	178.4
UPS of the Middle Volga Region					
Electricity generation including:	108.3	99.5	101.2	117.2	130.1
TPPs	54.2	48.2	50.2	66.7	78.5
UPS of the Southern Region					
Electricity generation including:	77.9	81.3	81.3	94.6	110.9
TPPs	49.7	53.5	49.4	53.4	57.4
UPS of the Ural Region					
Electricity generation including:	254.8	236.3	236.3	267.8	301.3
TPPs	244.5	227.2	227.5	255.9	285.2
UPS of the Siberian Region					
Electricity generation including:	205.3	200.5	200.5	235.2	295.7
TPPs	121.5	114.8	119.8	126.5	184.4
UPS of the Eastern Region					
Electricity generation including:	28.6	29.2	30.2	55.9	62.2
TPPs	20.4	20.2	18.2	43.9	46.4

The General Scheme and *the Scenario Conditions* imply the increase of coal share in the fuel balance of power plants. It would mean an increase in consumption of coals at United Power Systems (UPS) of the Central and Ural Regions and at UPS of the Siberian Region (Novosibirskenergo, Kuzbassenergo). Increasing consumption of Kizelovskiy coals may be expected at power plants of the Ural region. Kansko-Achinsk coals (Borodinskiy, Berezovskiy, Nazarovskiy, and Kanskiy), as well as Irbeyskiy, Mugunskiy, Cheremkhovskiy and Rajchikhinskiy coals can be utilized to a larger extent at the UPS of the Siberian region. Also, an increase in consumption of coals from Far East coal basins (Rajchikhinskiy, Kharanorskiy, Nerungrinskiy and other coals) may be expected at UPS of the Eastern Region.

[†] United power systems of the Russian Federation geographically correspond with the Federal Districts of the Russian Federation shown later in Figure 10.

According to *The Scenario Conditions*, the highest absolute values and often relatively high average annual rate of electricity demand increases are expected throughout energy systems of Moscow and the Moscow Region, Belgorod Region, Vologda Region, Kaluga Region, Kursk Region, Voronezh Region, Tula Region, Tver Region, Leningrad Region and Saint-Petersburg, Novgorod Region, Kaliningrad Region, Krasnodar Territory, Rostov Region, Volgograd Region, the Republic of Tatarstan, Nizhny Novgorod Region and Samara Region.

In addition to *The General Scheme* and *The Scenario Conditions*, the *Decree № 1715-r* of 13 November 2009 was adopted by the Government of the Russian Federation establishing *"The Energy Strategy of Russia for the Period up to 2030"* (RF, 2009). According to *the Energy Strategy*, the demand for solid fuel – coal, peat, shale, and firewood – for power production is expected to reach 131-185 million metric tons of coal equivalent (CE) by 2030 which is consistent with estimates on the basis of the energy balance projection. Furthermore, projections of coal production for the period up to 2030 imply an increase from 185 to 201-205 million metric tons for the Kuznetskiy coal basin, from 50 to 90-115 million metric tons for the Kansko-Achinsk coal basin, from 44 to 58-60 million metric tons for coals of East Siberian coal basins, and from 32 to 44-57 million metric tons for coals of Far East basins.

Furthermore, it is expected that high electricity demand increase would be traditionally typical for the Tyumen and Sverdlovsk regions, Irkutsk and Omsk regions, Zabaikalsk, Krasnoyarsk and Altai territories, and Kemerevo Region. The focus on the accelerated development of the Far East, which has been declared by the Government of the Russian Federation and by administrations of Subjects of the Federation, should lead to the appropriate electricity demand increase at the territories of energy systems of Primorsk and Khabarovsk territories, the Republic of Sakha, and the Amur and Magadan territories, including Chukotka.

Trends of energy consumption (demand) – generated by all types of thermal power plants - projected until 2020 on regional level are presented in Figure 7 below.

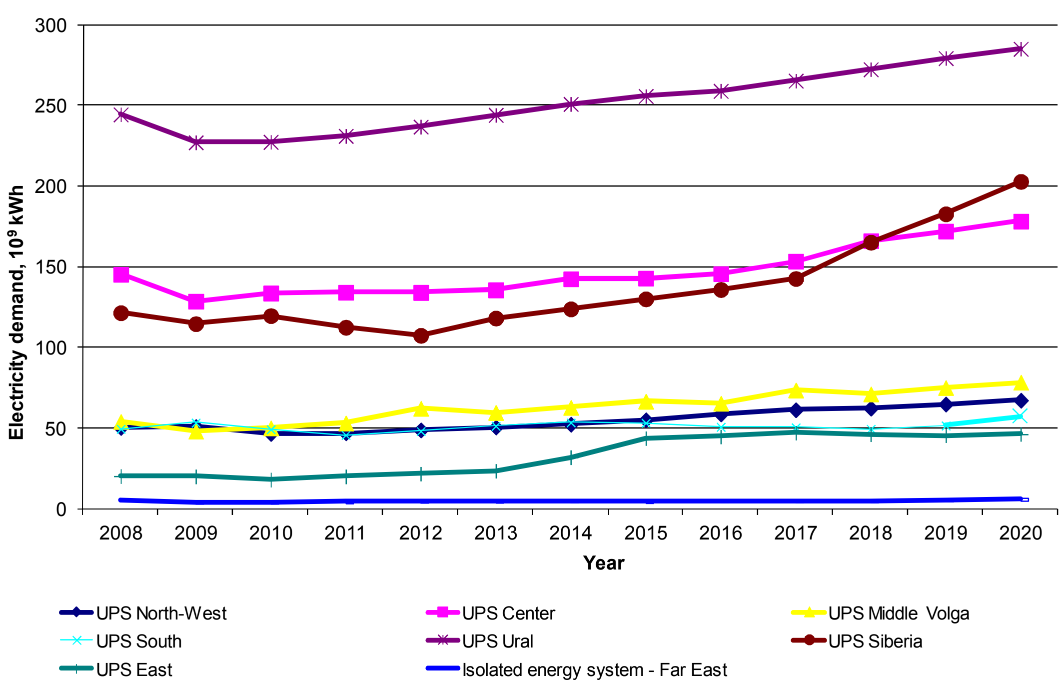

Figure 7. Projected energy consumption (demand) on regional level in the Russian Federation by 2020 (EFA, 2009a).

Trends of energy consumption (demand) – generated by all types of thermal power plants - projected till 2030 on national level in the Russian Federation are presented in Figure 7 below. As can be seen from Figure 8, the projected energy demand is 1384x 10^9 kWh under the target scenario and 1277x10^9 kWh under the moderate scenario.

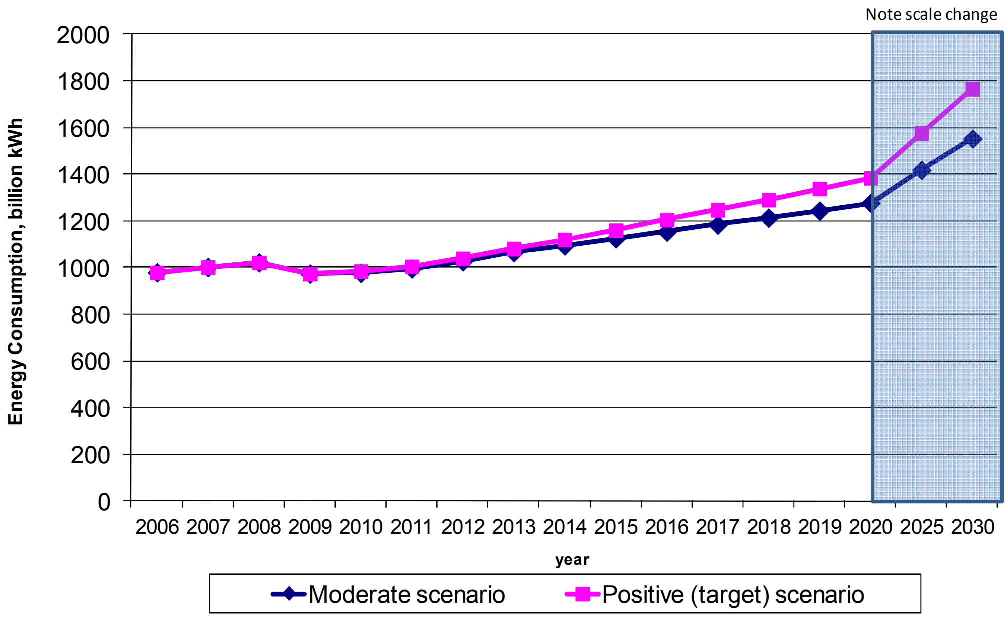

Figure 8. Projected energy consumption (demand) on national level in the Russian Federation by 2030 (EFA, 2009a).

3.1.4 Results of selected coal sample analyses

As mentioned above, coals of the Ekibastuzskiy, Kuzetskiy and Kansko-Achinsk basins comprise about 60% of the fuel balance of coal fired power plants across regions of Russia. Therefore, these coals were selected for detailed analysis on chemical composition and main fuel-related physical properties in order to develop a general profile of the coals fired for power generation in Russia.

Technical and administrative practicalities determined the sampling strategy by which coal samples were collected at the following coal fired power plants:

- **Nazarovskaya GRES** – Kansko-Achinsk coal (*Borodinskiy*);
- **Omskaya TPP 4**, **Omskaya TPP 5**, and **Reftinskaya GRES** – Ekibastuzskiy coal;
- **Kashirskaya GRES-4** and **Toghlyattinskaya TPP** – Kuznetskiy coal.

Each of the listed power plants has been designed to fire a specific type of coal and design coals are supplied in accordance with contracts by one or several mining companies, depending on specific local condition of a power plant. In general, coal supply contracts are mid- and long-term.

Specifically, Nazarovskaya GRES (located within the area of the Kansko-Achinsk coal basin) is supplied by the Siberian Coal Energy Company ("SUEK"), which mines several coal fields of the Kansko-Achinsk coal basin (including Borodinskiy and Nazarovskiy). Omskaya TPP 4, Omskaya TPP 5 and Reftinskaya GRES fire Ekibastuzskiy coal and are supplied directly from the Ekibastuzkiy coal basin (fields *Bogatyr* and *Vostochniy*) in the Pavlodar region of Kazakhstan, bordering Russian Western Siberia. Kashirskaya GRES-4 and Toghlyattinskaya TPP are supplied by different coal mining companies mining the Kuznetskiy coal basin. In all cases, coals from different fields of the same basin may be fired in mixtures at the power plants.

Six samples were collected and analyzed in three independent laboratories in Saint-Petersburg, Russia: LUMEX, State University, and Mekhanobr Analytics. Results of the chemical and physical analysis are summarized in Table 5.

Physical and chemical analyses of coal samples were carried out in accordance with relevant international standards and procedures (for details see ANNEX II).

Generally, results in Table 5 indicate that samples of typical coals fired for power generation in Russia are low in sulfur, chlorine, selenium and mercury. Kansko-Achinsk coal is found to be of the highest quality among the tested coals. Kuznetskiy coal may be considered the second and Ekibastuzskiy coal the third, having the highest average ash, sulfur, and mercury content.

Analytical results show substantial dispersion of values linked to physical and chemical parameters of coals originating from the same coal basins. In particular, ash content and gross calorific values for Ekibastuzskiy coals vary significantly, preventing characterization of the coal type with small uncertainty. A similar problem arises when mercury content values are scrutinized. Analyses revealed that mercury distribution in coal samples was non-homogenous. This resulted in a wide range for mercury content values with resultant large uncertainty considerations. The widest mercury distributions were detected in samples from Ekibastuzskiy coals and Kuznetskiy coals.

Table 5. Results of analysis of selected coal samples (average of each sample)

Parameter	Kansko-Achinsk basin, Borodinskiy field[a]	Ekibastuzskiy basin, Vostochniy and Bogatyr fields (Kazakhstan)[b]	Ekibastuzskiy basin, Vostochniy and Bogatyr fields (Kazakhstan)[c]	Ekibastuzskiy basin, Bogatyr field (Kazakhstan)[d]	Kuznetskiy basin[e]	Kuznetskiy basin[f]
Total moisture, weight %	23.9	2.06	2.38	1.80	3.12	8.03
Ash, weight %	4.03	49.7	30.41	19.33	37.56	14.03
Gross calorific value for dry matter, kcal/kg	6567	3598	5593	6807	4799	6175
Gross calorific value as fired, kcal/kg	4949	3465	5492	6665	4646	5960
Net calorific value as fired, kcal/kg	4631	3338	5326	6498	4461	5729
Chlorine (**Cl**), weight %	<0.01	<0.01	<0.01	<0.01	0.056	<0.01
Selenium (**Se**), weight %	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Arsenic (**As**), weight %	<0.00005	<0.00005	<0.00005	0.00075	0.00050	0.00024
Calcium (**Ca**), weight %	0.66	0.37	0.03	0.39	0.40	0.59
Sodium (**Na**), weight %	<0.01	0.12	0.09	0.17	0.14	0.04
Sulfur (**S**), weight %	0.11	0.40	0.63	0.28	0.76	0.51
Mercury (**Hg**) (mean), gram/metric ton 1st/2nd set of runs	<0.002 <0.002	0.049 0.036	0.018 0.031	0.116 0.105	0.065 0.065	0.016 0.018

Notes: Mass of each coal sample for analysis, about 300 g. Previously, wide variability of mercury concentration in samples of coal from Kuznetskiy and Ekibastuzskiy basins has been reported (Mashyanov and Ozerova, 2010).

a. Sample 1: sampled on April 5, 2010 at Nazarovskaya GRES coal stock, integrated sample

b. Sample 2: sampled on March 30, 2010 at Omskaya TPP 5, integrated sample

c. Sample 3: sampled on March 30, 2010 at Omskaya TPP 4, integrated sample

d. Sample 4: sampled on April 1, 2010 at Reftinskaya GRES, integrated sample;

e. Sample 5: sampled on March 25, 2010 at Kashirskaya GRES-4, integrated sample;

f. Sample 6: sampled on April 2, 2010 at Toghlyattinskaya TPP, integrated sample.

3.2 Profile of coal fired power plants in Russia

There are 123 coal-fired power plants – GRES and TPP – equipped with various types of main technological equipment (boilers and turbines) in the Russian Federation. Historically, GRES stood for "state-owned regional electricity-generating station". Nowadays, ownership reference no longer applies to GRES as they can be both state-owned and privately owned; GRES is an electricity-generating station with high installed capacity, typically over 1000 MW. Most of GRES generate electricity only. TPP stands for thermal power plant, including both electricity and heat generating stations with typical capacity of less than 1000 MW.

ANNEX III includes detailed information on location, capacity, boiler type, type of coal used and other major parameters of 120 coal-fired power plants. These data are derived from the Russian federal energy statistics for the year 2007 and are based on information received directly from power plants in accordance with the "Energy statistics form 6-tp". The following power plants are not included in the ANNEX III due to marginal coal consumption, i.e., less than 100 metric tons per year: Bryanskaya GRES, Kurskaya TPP-1 and Gubkinskaya TPP. Meanwhile, four major gas-fired power plants using coal as a reserve fuel instead of heavy oil are listed in Table AIII-2 in ANNEX III. Partly aggregated data on power plants of JSC "Irkutskenergo" (JSC IE) were used for the study due to the incomplete data set provided by the company in the reference year.

The majority of coal-fired power plants use heavy oil and/or natural gas for ignition or as a reserve fuel as well as for other internal purposes. There are only a few plants operating on coal only, i.e., Barnaulskaya TPP-1, Vorkutinskaya TPP-2 and Intinskaya TPP. All power plants are equipped with pulverized coal-type boilers.

The following GRESs can be considered to be major: Reftinskaya GRES with installed electrical capacity of 3800 MW, Troitskaya GRES with 2059 MW and Berezovskaya GRES with 1500 MW. The following TPPs can be considered to be major: Mosenergo TPP-23 with installed electrical and thermal capacities of 1310 MW and 2147 Gcal/hour, respectively; Novosibirsk TPP-5 with 1200 MW and 1440 Gcal/hour, Khabarovskaya TPP-3 with 720 MW and 1040 Gcal/hour, and TPP LuTEK with 1467 MW and 327 Gcal/hour, respectively.

Three main types of particulate matter control equipment are employed at power plants: electrostatic precipitators (ESP), wet Venturi scrubbers (SC) and dry inertial collectors – battery cyclones (CY) and their combinations. ESPs are installed at 205 boiler units (39% of total steam capacity), SC at 471 boiler units (46%), CY at 172 boiler units (10%), and some boilers are equipped with combined PM controls (5% of total steam capacity). No other type of air emissions control equipment is in use across the energy sector. Only cold-side ESPs are operated in the sector and have fly ash capture efficiency of 90-99% depending on the fly ash type and its properties. There are several modifications of Venturi scrubbers, e.g., MV-UO ORGRES, MS VTI, MMK, and others with operating efficiency in the range of 93-99%. Several types of cyclones are in operation at power stations, e.g., BCU, BC-512, and CBR. The fly ash capture efficiency of muticyclone separators varies in the range of 65-90%. Air pollutant emission monitoring is performed at all power plants periodically, mainly with the aid of portable devices.

Data in ANNEX III are arranged in accordance with the energy generating companies' structure, which has been established upon the restructuring of the Russian Joint Stock Company "Unified Energy System of Russia" (RAO EES). Within this process, power generating companies of the wholesale energy market (OGK) and territorial generating companies (TGK) were established. OGKs consolidate major – federal – power generation stations across the country. TGKs integrate smaller generation stations and are region-specific. Figure 9 below shows locations of

OGKs, TGKs and independent energy companies across the country. Six OGKs (OGK 1 to 6) integrate the vast majority of large GRESs (each OGK consists of several power plants, total capacity of each OGK is equal approximately to 9 GW).

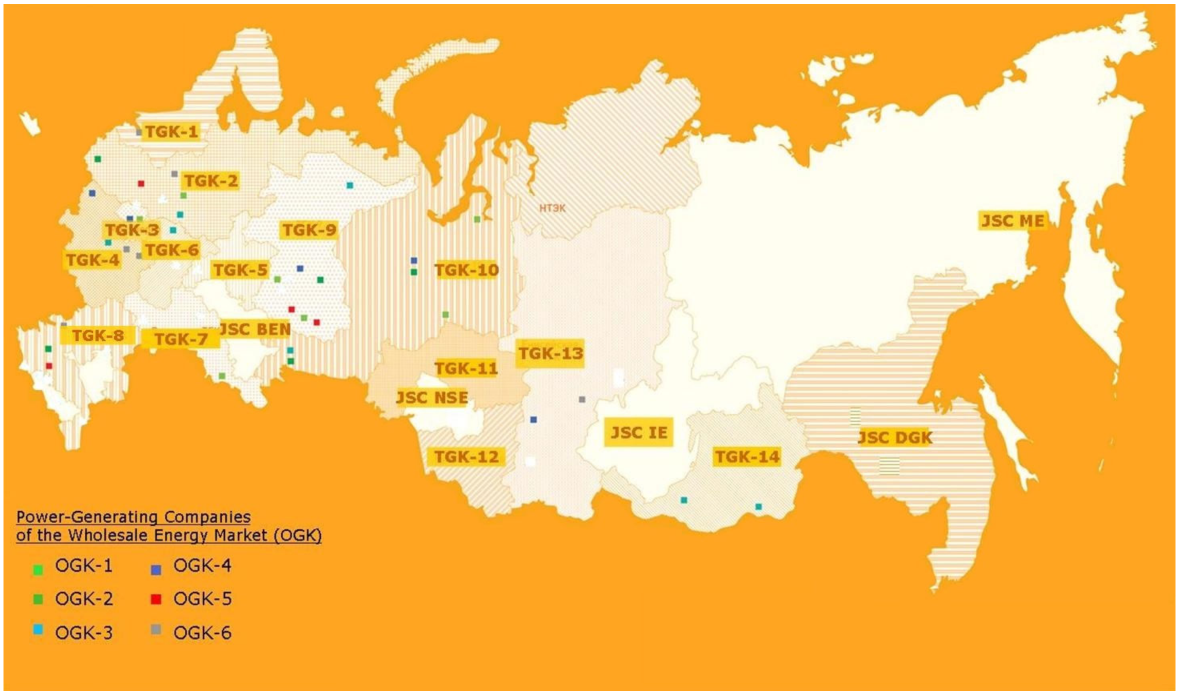

Figure 9. Distribution of OGK and TGK across the Russian Federation (EFA, 2010).

Fourteen TGKs were established on the basis of one or several RAO EES subsidiaries (so called AO-Energo, or JSC-Energo), excluding major hydro-electric power plants (integrated into RusGidro) and major thermal power plants (integrated into OGKs). They produce electricity and heat for local and sub-regional consumers.

Apart from TGKs, there are regional energy companies (regional energy systems) which for various reasons did not participate in the general restructuring process. These are the following such energy systems: Bashkirenergo, Biyskenergo, Chukotenergo, Dalnevostochnaya GK (Generation of the Far East), Irkutskenergo, Kurganskaya-GK, Magadanenergo, Novosibirskenergo, Sakhalinenergo, Tatenergo, Yakutskenergo, and Yantarenergo (the Kaliningrad Region).

The coal-fired power sector in Russia is also categorized by specific geographical distribution of the power plants across the country's Federal Districts (FDs) as shown in Figure 10. There are eight such defined administrative regions in the Russian Federation: Far Eastern FD, Siberian FD, Urals FD, Northwestern FD, Volga FD, Central FD, Southern FD, and North Caucasian FD.

1 – Far Eastern FD; **2** – Siberian FD; **3** – Urals FD; **4** – Northwestern FD;
5 – Volga FD; **6** – Central FD; **7** – Southern FD; **8** – North Caucasian FD

Figure 10. Federal Districts of the Russian Federation.

Historically, coal has been mainly mined eastwards of the Ural Mountains. A large variety of energy-intensive industrial facilities such as metallurgy, chemical industry, machinery, etc. has also been located in the Asian part of Russia. These facts determined development of large coal-fired power stations – mainly GRES – in the Ural, the Siberian, and the Far East FDs of Russia. Therefore, these three FDs accommodate most of power plants both in number and in installed capacity. Figures 11 and 12 show distribution of the plants across FDs in Russia.

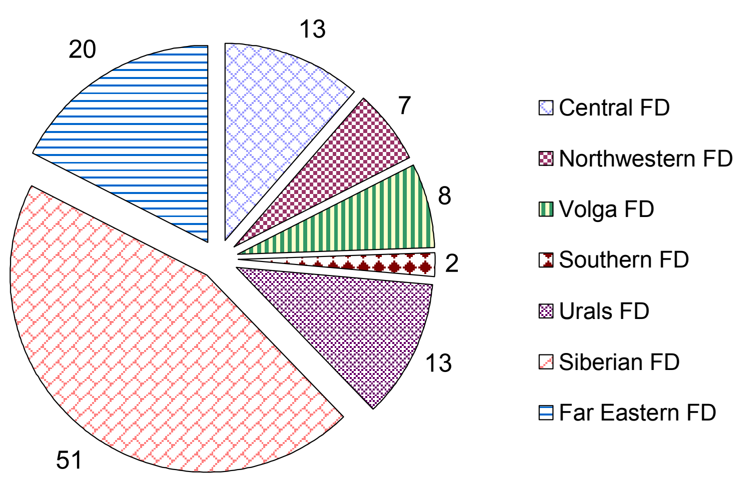

Figure 11. Distribution of coal-fired power plants across Federal Districts of the Russian Federation (number of power plants in each FD).

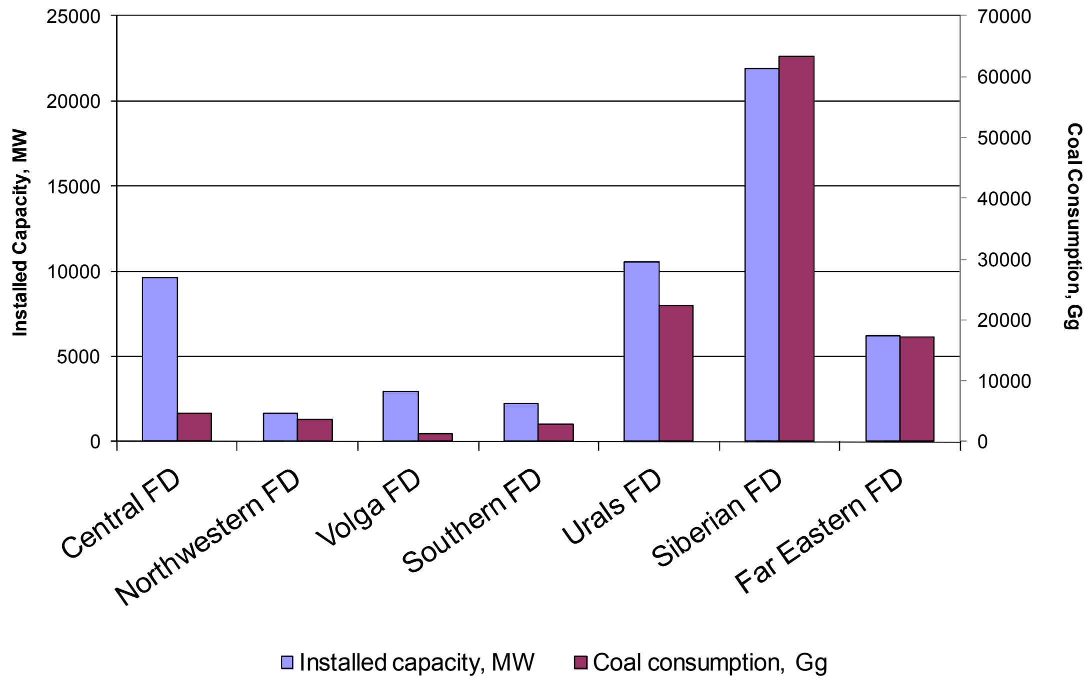

Figure 12. Distribution of installed coal-fired power generating capacities and coal consumption in the Federal Districts in Russian Federation.

Figures 11 and 12 clearly show that about 2/3 of energy generating capacities as well as coal consumed for power generation are attributed to three FDs – Urals, Siberian and the Far Eastern. Such disproportionate distribution of potential mercury pollution sources across the Russian Federation is likely to lead to elevated mercury levels in the Asian part of Russia resulting in an Asian transboundary air flows of mercury.

4 Mercury emission inventories

This section presents the results of two field campaigns conducted to measure mercury stack emissions at two power plants are also presented. Potential mercury emissions from Russian coal-fired power sector are given and related uncertainties are discussed.

4.1 Example mercury emission factors

Using the methodology explained earlier in Section 2.3, example emission factors were calculated for coals from three major basins and various PM emission controls. Example emission factors are presented in Table 6.

Table 6. Example mercury emission factors for coal fired power plants in Russia and their determinants.

Coal Basin	Coal Type	Hg Content, gram/metric ton (reference)	Hg content, gram/metric ton (measured, averaged)	PM emission control/ER_i (%)	Example Emission Factor, gram/metric ton (literature-based/ analysis-based)
Kuznetskiy	Bituminous	0.08	0.04	ESP/ 36	0.046/ 0.023
				SC/ 10	0.064/ 0.032
				SC+ESP/ 23	0.055/ 0.027
Ekibastuzskiy	Subbituminous	0.02	0.06	ESP/ 3	0.017/ 0.052
				SC/ 9	0.016/ 0.049
				SC+ESP/ 6	0.016/ 0.050
Kansko-Achinsk (Borodinskiy)	Subbituminous	0.02	0.01**	ESP/ 3	0.017/ 0.008
				CY*/ 1	0.017/ 0.008
				CY+ESP/ 2	0.017/ 0.008

* for CY Hg emission reduction is assumed to be 1%

** adopted for calculation purposes due to the lack of comprehensive analysis data.

4.2 Experimental mercury measurements and related emission factors

A mercury emissions measurement campaign was carried out in May 2010 with the technical support of the US EPA. The following power plants were tested: Kashirskaya GRES-4 (OGK-1, Kashira, Moscow oblast) and Reftinskaya GRES (OGK-5, Sverdlovsk oblast). Table 7 presents the main characteristics of the power plants tested.

Table 7. Mercury emissions test sites characteristics.

Power plant	**Kashirskaya GRES-4**	**Reftinskaya GRES**	
Coal type	**Kuznetskiy**	**Ekibastuzskiy**	
Energy units (blocks)	No.1, 300 MW 2 sections (2 ducts)	No.1, 300 MW 2 sections (2 ducts)	No.9, 500 MW 2 sections (2 ducts)
Control Equipment	ESP	ESP	ESP
Daily output (during test), MW-h	6205	7130	11590
Coal feed rate (24h), metric tons	1734	4116	6668
Coal feed rate, metric tons/hour (projected)	114	170	266
Coal gross calorific value (projected) (kcal/kg)	5800	3900	

The emissions measurements were conducted utilizing EPA's Mercury Monitoring Toolkit which consists of all equipment necessary to collect and analyze emissions samples collected in accordance with EPA's Method 30B, the accepted Reference Method for total mercury measurements from coal-fired utilities in the United States. The testing consisted of replicate (2-3 replicates) emissions tests for each sampling or measurement location. An additional, specialized sampling trap was sampled concurrently to enable an estimate of the distribution of elemental and oxidized mercury. Stack gas oxygen measurements were also performed. For supplementary informational purposes, coal, bottom ash, and fly ash samples were also collected. These samples were analyzed to determine mercury content as well as unburned carbon which was measured as loss on ignition (LOI).

The measured stack concentrations were normalized to standard temperature (20 °C) and pressure (1 atm). The reported concentrations are normalized to a reference 3% oxygen concentration for informational purposes based upon the oxygen concentration measured in the flue gas:

$$R = C_{Hg} \times (20.9-3)/(20.9-\%O_{2d})$$

where:

R = Mercury emission rate expressed in $\mu g/m^3$ at 3% O_2

C_{Hg} = Mercury concentration as measured in flue gas at 20 °C and 1 atm., $\mu g/m^3$ dry basis

$\%O_{2d}$ = Oxygen concentration representative of the measured flue gas, % dry basis

Emission rates were converted to energy units using a dry F factor, the calculated flue gas volume per fuel energy input at 0% oxygen, based on fuel analysis and respective heat input of each fuel.

$$R = H_T/H_{Coal} \times C_{Hg} \times 20.9/(20.9-\%O_{2d}) \times F_d \times 10^6$$

where:

R = Mercury emission rate expressed in ng/kJ gross heat input from coal

H_T = Gross heat input of all fuels burned; kJ/h

H_{Coal} = Gross heat input of coal burned; kJ/h

C_{Hg} =Mercury concentration as measured in flue gas at 20 °C and 1 atm., μg/m^3 dry basis

$\%O_{2d}$= Oxygen concentration representative of the measured flue gas, % dry basis

F_d = dry F-factor, m^3/J

The results of the testing at Kashirskaya GRES-4 are shown in Table 8 and can be summarized as follows. The average mercury concentration in the flue gas from the two ducts fed by a common unit (including common ESP) was 2.54 μg/m^3 normalized to 3% oxygen. The results also indicate that most of the mercury is emitted in the oxidized form. It is interesting to observe that the average measured values for each duct differ significantly. The observed difference is not associated with the measurement approach and is likely attributed to performance of the PM control system.

The corresponding Hg emission rates are also shown in Table 8 using table values for F_d from the regulation 40 CFR Part 60, Appendix A, Method 19. The reported 1.08 ng of Hg per kJ coal input is an estimated value based upon several considerations. The Kashirskaya unit tested fired a mixture of coal and natural gas; the heat input derived was estimated using the mass of coal fed for the 24-h day with a gross calorific value of 5800 kcal/kg, and the natural gas volume fed for the 24-h day and an assumed heating value of 37.25 kJ/m^3 (1000 Btu/ft^3). As a result, the reported emission rate is associated with the coal input only.

Table 8. Results of the mercury emissions tests at Kashirskaya GRES-4 and Reftinskaya GRES.

Kashirskaya GRES-4 *(Unit 1, 300 MW)*			
	Hg Partitioning, Hg^{2+} %	Hg Emission Rate	
		μg/m^3@3%O_2	ng/kJ
Duct 1	94.82	1.61	0.68
Duct 2	95.45	3.47	1.47
Average	**95.13**	**2.54**	**1.08**
Reftinskaya GRES *(Unit 1, 300 MW)*			
	Hg Partitioning, Hg^{2+} %	Hg Emission Rate	
		μg/m^3@3%O_2	ng/kJ
Duct 1	61.84	3.35	1.03
Duct 2	58.11	3.04	0.93
Average	**59.98**	**3.20**	**0.98**
Reftinskaya GRES (*Unit 9, 500 MW)*			
	Hg Partitioning, Hg^{2+} %	Hg Emission Rate	
		μg/m^3@3%O_2	ng/kJ
Duct 1	68.20	9.27	2.85
Duct 2	68.84	9.88	3.03
Average	**68.52**	**9.58**	**2.94**

At Reftinskaya GRES, two units were tested. Both units fired coal exclusively and the same coal when tested. The results of these tests are presented in Table 8. The average Hg emission concentration measured for Unit 1 was 3.20 μg/m^3 normalized to 3% oxygen while average Hg emission concentration measured for Unit 9 was 9.58 μg/m^3. Converting the emission rates to energy units results in 0.98 and 2.94 ng mercury per kJ coal input for Units 1 and 9, respectively. The energy unit emission rates were derived using the F-Factors contained in US EPA Method 19. The oxidized mercury distribution ranged between 60 and 70% at both units. It is interesting to observe the difference in Hg emissions between the two units, as they are both configured similarly and were both firing the same coal. However, the emissions from Unit 9 were significantly greater. The LOI analyses performed on collected fly ash varied significantly between the two units, with higher LOI associated with the Unit 1 fly ash samples. The increased carbon content of the fly ash can serve to capture gaseous Hg, reducing Hg emissions. It is believed that this difference in LOI accounts for most of the difference in mercury capture between the two units.

Another general observation from the tests at Kashirskaya GRES-4 and Reftinskaya GRES is that the concentration of mercury in the collected fly ash varied from field to field within the ESP. A general trend was for the Hg concentration to be higher in the last set of fields where the particulate captured is mostly very fine and the affinity for mercury higher. Unfortunately, because the amount of ash that is deposited in the ESP fields is not proportional (most is deposited in the first and second fields) it is difficult to collect representative samples of the fly ash and perform a meaningful Hg capture mass balance. However, the inclusion of the fly ash Hg and LOI analyses is an effective process measurement that can aid in understanding Hg control behavior in coal combustion processes.

An important observation resulting from these tests is that many factors impact Hg emissions, even when testing similarly configured EGU units, making it very challenging to extrapolate these particular results to other plants based on assumed Hg capture performance. Factors such as combustion and ESP performance are difficult to predict and are a poor substitute for comprehensive emission measurements.

4.3 Potential mercury emissions from the coal-fired sector and related uncertainties

Based on collected information characterizing the coal-fired power sector in the Russian Federation, potential mercury emissions inventory has been prepared. Results suggest that in 2007, based on mean mercury content in energy coals, the overall emissions equaled to 6.741 metric tons, while at minimum mercury concentration, the emissions could reach the level of 4.738 metric tons, and at maximum mercury concentration – up to 18.484 metric tons.

ANNEX III contains estimated potential emissions of mercury from all coal-fired power plants, except for those using coal as a reserve fuel. Coal mercury content factors employed for both mean and maximum emission calculations were averaged on the basis of values taken from Table 3 and from the ACAP study (ACAP 2005). In the cases of Borodinskiy, Ekibastuzskiy, and Kuznetskiy coals, chemical analysis data generated within the project were taken for performing the calculations.

As data on mercury content in coals as well as on mercury emission control efficiency are subject to large variations that can be seen in the ANNEX III, the overall level of uncertainty on the power sector mercury emissions is high. In particular, coals chemical analysis showed a ±50 to 70% range of mercury content results. Therefore, the overall uncertainty of the inventory results reaches 100% and more, as the total estimates remain within 6.7-18 metric tons of mercury release.

It should also be noted that the potential emission estimates are directly dependent on the reliability of the coal Hg content measurements. The available information is limited and the high variability of the limited number of samples is a significant source of uncertainty. These uncertainties could be reduced by increasing the number of samples collected as well as ensuring the representativeness of the samples collected.

5 Mercury emission projections

Projections of mercury emissions from the coal-fired power plants are directly affected by the uncertainties discussed above, making estimations tentative and requiring more accurate data. Meanwhile, the projection estimations were carried out on the basis of *The Scenario Conditions* (EFA, 2009) in terms of energy production up to 2030 and the related expected increase in coal use from the current 27-28% to some 36% by 2020 and to 39% by 2030, and assuming mean and maximum mercury content in coals. Figure 13 presents the results of the tentative mercury emission projections.

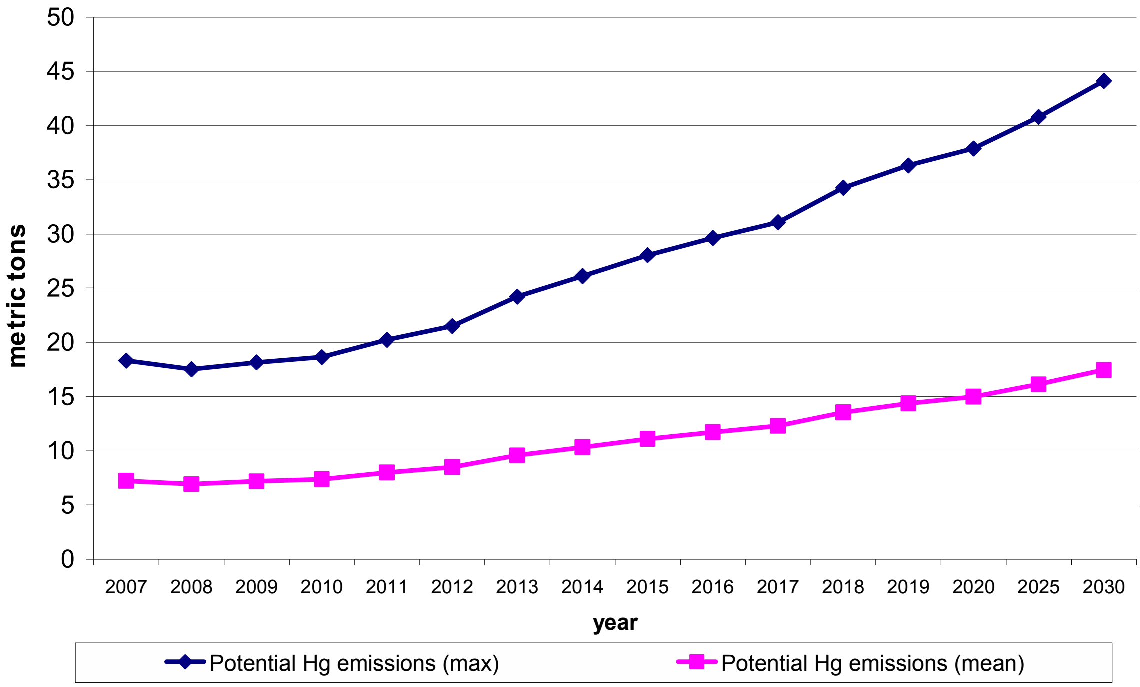

Figure 13. Calculated projections of mercury emissions from coal-fired power plants in the Russian Federation by 2030, metric tons.

6 Future Considerations

The accuracy and confidence of mercury emissions estimate for the coal fired power sector in the Russian Federation presented in this report could be improved with more extensive emission testing. Systematic mercury emissions tests would allow for the development of mercury emission factors. As discussed in this report, EPA Mercury Monitoring Toolkit has been demonstrated to offer portability and ease of use while providing high data quality. Therefore, the feasibility of procuring a toolkit (both, financial and technical aspects) and developing mercury sampling methodology should be investigated.

Another area of activity should include compilation of accurate data on the content of mercury and other trace elements in Russian coals. Available coal data are limited and subject to uncertainties. The most comprehensive study [ACAP (2005)] presents only aggregated national information. However, large variations in coal mercury content are observed for major coal basins in the European, Siberian and Far Eastern parts of the Russian Federation.

7 References

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ANNEX I: Coal Consumption and Characteristics

Table AI.1. Coal consumption rates, 2007.

Coal	Coal consumption rate, metric tons/year	Fraction of Total Use, %
Anadyrskiy	217,704	0.19
Arkagalinskiy	105,102	0.09
Azeyskiy	27,066	0.02
Berezovskiy (Kansko-Achinsk basin)	5,203,605	4.53
Bikinskiy	4,748,263	4.14
Borodinskiy (Kansko-Achinsk basin)	7,224,721	6.29
Chelyabinskiy	2,317,498	2.02
Cheremkhovskiy	879,658	0.77
Donetskiy	2,246,090	1.96
Ekibastuzskiy	22,592,769	19.68
Erkovetskiy	1,092,867	0.95
Gusinoozerskiy	227,395	0.20
Intinskiy	1,318,474	1.15
Irbeyskiy	1,453,325	1.27
Kanskiy (Kansko-Achinsk basin)	5,505,448	4.80
Khakasskiy	1,284,383	1.12
Kharanorskiy	2,022,608	1.76
Krasnoyarskiy	1,393,667	1.21
Kuznetskiy	235,82,670	20.54
Lipovetskiy	700,255	0.61
Mugunskiy	4,432,718	3.86
Nazarovskiy (Kansko-Achinsk basin)	4,117,735	3.59
Nerungrinskiy	2,811,709	2.45
Nezhinskiy	220,315	0.19
Orkhonskiy	227,129	0.20
Partizanskiy	72,660	0.06
Pavlovskiy	2,591,087	2.26
Pereyaslovskiy	1,718,604	1.50
Podmoskovniy	335,344	0.29
Rajchikhinskiy	443,175	0.39
Rakovskiy	389,640	0.34
Sakhalinskiy	1,889,645	1.65
Sverdlovskiy	1,079,874	0.94
Tataurovskiy	621,854	0.54

Coal	Coal consumption rate, metric tons/year	Fraction of Total Use, %
Tugnujskiy	1,204,549	1.05
Tulganskiy	515,686	0.45
Tuvinskiy	160,215	0.14
Urgalskiy	1,468,121	1.28
Urtuyskiy	2,081,001	1.81
Ushumunskiy	37,211	0.03
Vorkutinskiy	859,616	0.75
Zheronskiy	885,251	0.77
Zyrianskiy	58,521	0.05
Other coals of Siberia	2,421,572	2.11
TOTAL	**115,557,156**	**100**

Table AI.2. Main characteristics of coals burned in Russia.

Coal	As per analysis by power plants burning this type of coal			Weighted average values		
	Q^r_n, kcal/kg	W^r, %	A^r, %	Q^r_n, kcal/kg	W^r, %	A^r, %
Anadyrskiy	3912-3970	22-24	17-18	3938	23	18
Arkagalinskiy	4456-4829	19-20	8	4483	19	8
Azeyskiy	3880-3942	25-26	21	3881	25	21
Bashkirskiy	1862	41	14	1862	41	14
Berezovskiy	3565-3831	34	4-8	3831	34.4	4.17
Bikinskiy	2122	39	24	2122	39	24
Borodinskiy	3787-3950	30-32	5-8	3886	31	7
Chelyabinskiy	2796-3084	10-12	42-46	2880	11.5	43.6
Cheremkhovskiy	4524-5110	14-15	21-23	4766	14	21
Donetskiy	4895-5110	7-10	26-29	5096	8.3	26.8
Ekibastuzskiy	3880-4150	5-7	38-41	3990	5	40
Erkovetskiy	3023	36	13	3023	36	13
Gusinoozerskiy	3817	23	17	3817	23	17
Intinskiy	2553-3940	12-17	23-34	3867	13	29
Irbeyskiy	3660	28	13	3660	28	13
Kanskiy	3563-3805	30-36	7-10	3737	33	8
Khakasskiy [abakanskiy]	4551	16	19	4551	16	19
Khakasskiy [chernogorskiy]	4280-5220	11-20	14-19	4842	15.6	16.1
Khakasskiy [izykhskiy]	3795	10-22	17-26	4417	15.0	20.9
Khakasskiy other	4571	15	19	4571	15	19

Coal	As per analysis by power plants burning this type of coal			Weighted average values		
	Q^r_n, kcal/kg	W^r, %	A^r, %	Q^r_n, kcal/kg	W^r, %	A^r, %
Kharanorskiy	2775-3221	38-41	8-11	3121	39	10
Kuznetskiy coal, G+D grades	4701-5383	10-19	14-20	4960	13	18
Kuznetskiy coal, SS grade	5012-6148	9-11	17-23	5724	9	18
Kuznetskiy coal, T grade	5557-6025	7-11	18-20	5755	9	19
Lipovetskiy	4076-4236	8	33-35	4079	8	35
Mugunskiy	4071	22	25	4071	22	25
Nazarovskiy	3244	39	6	3244	39	6
Nerungrinskiy	5516-5991	6-10	18-26	5793	8	20.4
Nezhinskiy	2394-2424	33	25	2423	33	25
Orkhonskiy	3538-3761	24	20	3567	24	20
Other Krasnoyarsk coal	3558	35	8	3558	35	8
Other Kuznetskiy coal	4548-6053	7-20	14-22	5421	12	17
Partizanskiy	4660	16	25	4660	16	25
Pavlovskiy	2422	42	17	2422	42	17
Pereyaslovskiy	4003-4099	27-31	7-10	4029	27	10
Podmoskovniy	1750-2571	27-32	33-38	2073	27	36
Rajchikhinskiy	2688-3135	36-39	11-13	2817	38	13
Rakovskiy	2096-2261	39-40	20-24	2229	40	20.4
Sakhalinskiy	3579-4338	18-20	19-27	3999	19	22.6
Sverdlovskiy	2214-2253	20-21	31-36	2251	21	35.8
Tataurovskiy	3426-3441	32	11	3441	32	11
Tugnujskiy	4715-4956	10	21	4792	10	21
Tulganskiy	1690	52	14	1690	52	14
Tuvinskiy	6092	7	10	6092	7	10
Urgalskiy	3903-4735	8-13	20-32	4316	12.7	31
Urtuyskiy	3636-4122	29-34	7-10	3927	31	8
Ushumunskiy	2906	40	13	2906	40	13
Vorkutinskiy	5678-5689	6-7	19-21	5685	6.5	20.5
Zyrianskiy	5921	14	11	5921	14	11
Other Siberian coals	3876-4182	22	16	3944	22	16

Where: $\mathbf{Q^r_n}$ – calorific value of coals, kcal/kg; $\mathbf{W^r}$ – moisture content of coals, $\mathbf{A^r}$ – ash content of coals

Table AI.3. Coal consumption for energy production in Russia in 2006-2007.

Coal Deposit	Coal consumption rate, metric tons/year		2007/2006 Ratio, %
	2006	2007	
Anadyrskiy	275,836	217,704	78.9
Arkagalinskiy	104,114	105,102	100.9
Azeyskiy	28,071	27,066	96.4
Berezovskiy	4,419,336	5,203,605	117.7
Bikinskiy	5,659,409	4,748,263	83.9
Borodinskiy	7,438,057	7,224,721	97.1
Chelyabinskiy	2,843,612	2,317,498	81.5
Donetskiy	2,666,919	2,246,090	84.2
Ekibastuzskiy	24,224,350	22,592,769	93.3
Erkovetskiy	1,146,652	1,092,867	95.3
Gusinoozerskiy	210,298	227,395	108.1
Intinskiy	1,429,507	1,318,474	92.2
Kanskiy	4,617,969	5,505,448	119.2
Khakasskiy	1,743,507	1,284,383	73.7
Kharanorskiy	3,155,095	2,022,608	64.1
Kuznetskiy	25,230,856	23,582,670	93.5
Lipovetskiy	460,679	700,255	152.0
Nazarovskiy	4,826,001	4,117,735	85.3
Nerungrinskiy	2,958,410	2,811,709	95.0
Nezhinskiy	240,446	220,315	91.6
Orkhonskiy	152,277	22,712,9.2	149.2
Partizanskiy	60,880	72,660	119.4
Pavlovskiy	2,376,614	2,591,087	109.0
Podmoskovniy	504,772	335,344	66.4
Rajchikhinskiy	433,702	443,175	102.2
Rakovskiy	489,187	389,640	79.7
Sakhalinskiy	1,912,400	1,889,645	98.8
Sverdlovskiy	1,307,966	1,079,874	82.6
Tataurovskiy	778,386	621,854	79.9
Tugnujskiy	1,331,912	1,204,549	90.4
Tuvinskiy	168,890	160,215	94.9
Urgalskiy	1,660,391	1,468,121	88.4
Urtuyskiy	2,582,804	2,081,001	80.6
Ushumunskiy	32,459	37,211	114.6
Vorkutinskiy	968,810	859,616	88.7
Zyrianskiy	67,753	58,521	86.4

Table AI.4. Classification of main coal grades in the Russian Federation (GOST, 1988).

Coal grades	Abbreviation	Output of volatile organic matter V, %	Carbon content C, %	Heat output Q^{higher}, kcal/kg
Brown coal *(Buriy)*	B (Б)	>40	<76	6900-7500
Long-flame coal *(Dlinnoplamenny)*	D (Д)	>39	76	7500-8000
Gas coal *(Gazovy)*	G (Г)	36	83	7900-8600
Fat coal *(Zhirny)*	ZH (Ж)	30	86	8300-8700
Coking coal *(**K**oksovy)*	K (К)	20	88	8400-8700
Weakly caking coal *(**S**labo **s**pekayuschiysya)*	SS (СС)	17	89	8450-8780
Meagre coal *(Toschy)*	T (Т)	12	90	7300-8750
Anthracite coal	A (А)	<8	>91	8100-8750

Note: Original Russian nomenclature for coal grades is used

ANNEX II: Standards and Procedures used for Coal Analysis

The following standards and procedures were employed for coal sample analysis:

- *Coal sample pretreatment* (conditioning for analysis) – GOST (State Standard of the Russian Federation) 23083-78 (updated in 2009);
- *Moisture content in coals* – GOST R 52911-2008 (ISO equivalents: ISO 589:2003; ISO 5068-1:2007);
- *Ash content in coals* – GOST 11022-95 (updated in 2010) (ISO equivalent: ISO 1171:1997);
- *Sulfur content in coals* – GOST 2059-95 (updated in 2010) (ISO equivalent: ISO 351:1996);
- *Gross and net calorific values of coals* – GOST 147-95 (updated in 2009) (ISO equivalent: ISO 1928:1976);
- *Chlorine content in coals* – GOST 9326-2002 (updated in 2009) (ISO equivalent: ISO 587:1997);
- *Arsenic content in coals* – GOST 10478-93 (updated in 2009) (ISO equivalent: ISO 601:1981; ISO 2590:1973);
- *Calcium and Sodium content in coals* – GOST 10538-87 (updated in 2010);
- *Selenium and Arsenic content in coals* – sample decomposition: GOST 10478-93 (updated in 2009) (ISO equivalent: ISO 601:1981; ISO 2590:1973); element identification: atomic adsorption spectrometry method;
- *Mercury content in coals* – US EPA Method 7473 (atomic adsorption spectrometry with Zeeman AAS spectrometers) and US EPA Method 30B (LUMEX RA-915+ and PYRO-915 attachment).

ANNEX III: Coal-fired Power Plants in Russia

Table AIII.1. Coal-fired power plants in Russia: corporate status and location.

No.	Plant Name	Parent Company	Location
1	Verhnetagilskaya GRES*	OGK-1	Verkhni Tagil, Sverdlovskaya obl.
2	Kashirskaya GRES-4*	OGK-1	Kashira Moskovskaya obl.
3	Serovskaya GRES*	OGK-2	Serov
4	Troitskaya GRES	OGK-2	Troitsk, Chelyabinskaya obl.
5	Gusinoozerskaya GRES*	OGK-3	Gusinoozersk, Buryatia
6	Kharanorskaya GRES*	OGK-3	Yasnogorsk
7	Cherepetskaya GRES	OGK-3	Suvorov Tulskaya obl.
8	Yuzhno-Uralskaya GRES*	OGK-3	Yuznouralsk, Chelyabinskaya obl.
9	Berezovskaya GRES-1	OGK-4	Sharapovo, Krasnoyarsky kray
10	Smolenskaya GRES*	OGK-4	Ozerniy Smolenskaya obl.
11	Shaturskaya GRES-5*	OGK-4	Shatura Moskovskaya obl.
12	Yayvinskaya GRES*	OGK-4	Yaiva, Permskiy kray
13	Reftinskaya GRES	OGK-5	Reftinskiy, Sverdlovskaya obl.
14	Krasnoyarskaya GRES 2	OGK-6	Zelenogorsk, Krasnoyarskiy kray
15	Novocherkasskaya GRES	OGK-6	Novocherkassk
16	Ryazanskaya GRES*	OGK-6	Novomichurinsk, Ryazanskaya obl.
17	Cherepovetskaya GRES	OGK-6	Kadui, Vologodskaya obl.
18	Apatitskaya GRES	TGK-1	Apatiti, Murmanskaya obl.
19	Pervomayskaya TPP 14*	TGK-1	St.Petersburg
20	Dubrovskaya TPP*	TGK-1	Kirovsk, Leningradskaya obl.
21	Novgorodskaya TPP 14*	TGK-2	Vekikhiy Novgorod
22	Tverskaya TPP 3*	TGK-2	Tver'
23	Yaroslavskaya TPP 2*	TGK-2	Yaroslavl'
24	Severodvinskaya TPP 1	TGK-2	Severodvinsk, Arkhangelskaya obl.
25	Mosenergo TPP 17*	TGK-3	Stupino, Moskovskaya obl.
26	Mosenergo TPP-23*	TGK-3	Dzerzhinsk, Moskovskaya obl.
27	Aleksinskaya TPP*	TGK-4	Aleksin, Tulskaya obl.
28	Voronezhskaya TPP 1*	TGK-4	Voronezh
30	Novomoskovskaya GRES*	TGK-4	Novomoskovsk, Tulskaya obl.
31	Pervomayskaya TPP*	TGK-4	Shekino, Tulskaya obl.
32	Izhevskaya TPP2*	TGK-5	Izhevsk
33	Kirovskaya TPP 3*	TGK-5	Kirovochepetsk Kirovskaya obl.
34	Kirovskaya TPP 4*	TGK-5	Kirov
35	Kirovskaya TPP 5*	TGK-5	Kirov

No.	Plant Name	Parent Company	Location
36	Ivanovskaya TPP 2	TGK-6	Ivanovo
37	Ivanovskaya TPP 3	TGK-6	Ivanovo
38	Toghlyattinskaya TPP*	TGK-7	Toghlyatti
39	Artemovskaya TPP*	TGK-9	Artemovsk
40	Bogoslovskaya TPP*	TGK-9	Krasnoturinsk, Sverdlovskaya obl.
41	Vorkutinskaya TPP 1	TGK-9	Vorkuta
42	Vorkutinskaya TPP 2	TGK-9	Vorkuta
43	Zakamskaya TPP 5*	TGK-9	Krasnokamsk
44	Intinskaya TPP	TGK-9	Inta-9
45	Krasnogorskaya TPP*	TGK-9	Kamensk-Uralsky Sverdlovskaya obl.
46	Nizhneturinskaya GRES*	TGK-9	Nizhnyaya Tura
47	Tchaikovskaya TPP*	TGK-9	Tchaikovskiy
48	Argayashskaya TPP*	TGK-10	Nagorniy, Chelyabinskaya obl.
49	Tcheliabinskaya TPP 1*	TGK-10	Tcheliabinsk
50	Tcheliabinskaya TPP 2*	TGK-10	Tcheliabinsk
51	Omskaya TPP 2*	TGK-11	Omsk
52	Omskaya TPP 4	TGK-11	Omsk
53	Omskaya TPP 5	TGK-11	Omsk
54	Tomskaya GRES 2*	TGK-11	Tomsk
55	Abakanskaya TPP	TGK-13	Abakan, Krasnoyarskiy kray
56	Kanskaya TPP	TGK-13	Kansk
57	Krasnoyarskaya TPP 1	TGK-13	Krasnoyarsk
58	Krasnoyarskaya TPP 2	TGK-13	Krasnouralsk
59	Krasnoyarskaya TPP 3	TGK-13	Krasnoyarsk
60	Minusinskaya TPP	TGK-13	Minusinsk
61	Nazarovskaya GRES	TGK-13	Nazarovo
62	Priargunskaya TPP	TGK-13	Priargunsk, Chitinskaya obl.
63	Ulan-Udenskaya TPP 1	TGK-14	Ulan-Ude
64	Ulan-Udenskaya TPP 2	TGK-14	Ulan-Ude
65	Chitinskaya TTP 1	TGK-14	Chita
66	Chitinskaya TTP 2	TGK-14	Chita
67	Sherlovogorskaya	TGK-14	Sherlova gora, Chelyabinskaya obl.
68	Barnaulskaya TPP 1	TGK-12	Barnaul
69	Barnaulskaya TPP 2	TGK-12	Barnaul
70	Barnaulskaya TPP 3	TGK-12	Barnaul
71	Belovskaya GRES	TGK-12	Belovo, Kemerovskaya obl
72	Kemerovskaya GRES	TGK-12	Kemerovo
73	Kemerovskaya TPP*	TGK-12	Kemerovo

No.	Plant Name	Parent Company	Location
74	Kuznetskaya TPP	TGK-12	Novokuznetsk
75	Novo-kemerovskaya TPP	TGK-12	Kemerovo
76	Tom'-Usinskaya GRES	TGK-12	Miski-5, Kemerovskaya obl
77	Barabinskaya TPP	JSC NSE	Kuibishev, Novosibirskaya obl.
78	Novosibirskaya TPP 2	JSC NSE	Novosibirsk
79	Novosibirskaya TPP 3	JSC NSE	Novosibirsk
80	Novosibirskaya TPP 4*	JSC NSE	Novosibirsk-27
81	Novosibirskaya TPP 5	JSC NSE	Novosibirsk-126
82	Kumertausskaya TPP	JSC BEN	Kumertau, Bashkiria
83	Blagoveshenskaya TTP	JSC DGK	Blagoveshensk, Amurskaya obl.
84	Raichikhinskaya GRES	JSC DGK	Progress-1, Amurskaya obl.
85	Artemovskaya TPP	JSC DGK	Artemovsk, Primorsky kray
86	Partizanskaya GRES	JSC DGK	Partizansk, Primorsky kray
87	Vladivostokskaya TTP 2	JSC DGK	Vladivostok
88	Nerungrinskaya GRES	JSC DGK	Serebrianniy bor, Republic of Sakha
89	Amurskaya TPP*	JSC DGK	Amursk, Khabarovsky kray
90	Komsomolskaya TPP 2*	JSC DGK	Komsomolsk-na-Amure
91	Maiskaya GRES	JSC DGK	Maiskiy, Khabarovsky krai
92	Khabarovskaya TPP 3	JSC DGK	Berezovka, Khabarovsky kray
93	Birobidzhanskaya TPP	JSC DGK	Birobidzhan, Evreyskiy Autonomous District
94	TTP LuTEK	JSC DGK	Luchegorsk, Khabarovsky krai
95	Bijskaya TPP	BE LLC	Bijsk
96	Kurganska TPP*	JSC KGK	Kurgan
97	Arkagalinskaya GRES	JSC ME	Myaundzha Magadanskaya obl.
98	Magadanskaya TPP	JSC ME	Magadan
99	Sakhalinskaya GRES	JSC SE	Lermontovka Sakhalinskaya obl.
100	Yuzhno-Sakhalinskaya TPP	JSC SE	Yuzhnosakhalinsk
101	Eksperimentalnaya TPP	-	Krasniy Sulin Rostovskaya obl.
102	Zapadno-Sibirskaya TPP	-	Novokuznetsk
103	Yuzhnokuzbasskaya GRES	-	Kaltan Kemerovskaya obl.
104	Anadirskaya TPP	JSC ME	Anadyr, Chukotka
105	Chaunskaya TPP	JSC ME	Pevek, Chukotskiy Autonomous District
106	Egvekinotskaya TPP	JSC ME	Magadan
107	Chulmanskaya TPP	-	Yakutia
108	Irkutskaya TPP 1	JSC IE	Angarsk, Irkutskaya obl.
109	Irkutskaya TPP 3	JSC IE	Zima, Irkutskaya obl.

No.	Plant Name	Parent Company	Location
110	Irkutskaya TPP 5	JSC IE	Shelekhov, Irkutskaya obl.
111	Irkutskaya TPP 6	JSC IE	Bratsk-18, Irkutskaya obl.
112	Irkutskaya TPP 7	JSC IE	Bratsk-9, Irkutskaya obl.
113	Irkutskaya TPP 9	JSC IE	Angarsk, Irkutskaya obl.
114	Irkutskaya TPP 10	JSC IE	Angarsk, Irkutskaya obl.
115	Irkutskaya TPP 11	JSC IE	Usolye-Sibirskoe, Irkutskaya obl.
116	Irkutskaya TPP 12	JSC IE	Cheremkhovo, Irkutskaya obl.
117	Irkutskaya TPP 16	JSC IE	Zheleznogorsk-Ilimsky Irkutskaya obl.
118	Novo-Ziminskaya TPP	JSC IE	Sayansk, Irkutskaya obl.
119	Ust-Ilimskaya TPP	JSC IE	Ust-Ilimsk-10, Irkutskaya obl.
120	Novoirkutskaya TPP	JSC IE	Irkutsk

Power plants marked with "*" burn coal as a reserve fuel only.

Note:

TPP	Thermal power plant
GRES	State Electricity Generating Station (traditional abbreviation for electricity generating power plants; ownership reference no longer applies)
OGK-x (1-6)	Joint Stock Company "(…) Power-Generating Company of the Wholesale Energy Market"
TGK-x (1-14)	Joint Stock Company "Territorial Generating Company (…)"
JSC NSE	Joint Stock Company NOVOSIBIRSKENERGO
JSC BEN	Joint Stock Company BASHKIRENERGO
JSC DGK	Joint Stock Company Dalnevostochnaya GK
BE LLC	Limited Liability Company BIYSKENERGO
JSC KGK	Joint Stock Company KURGANSKAYA-GK
JSC ME	Joint Stock Company MAGADANENERGO
JSC SE	Joint Stock Company SAKHALINENERGO
JSC IE	Joint Stock Company IRKUTSKENERGO

Table AIII.2. Coal-fired power plants in Russia: capacity, coal basin, type and consumption rate in 2007.

No.	Plant name	Number of units in plant	Electricity Generating Capacity (MW)	Thermal Generating Capacity(Gkal/h)	Boiler type	Coal burned (thousand metric tons/year)	Origin of coal	Type of coal
1	Verhnetagilskaya GRES*	18	1497	543	PCC	1053.2	Ekibastuzskiy	hard (sub-bituminous)
2	Kashirskaya GRES-4*	8	1910	430	PCC	643	Kuznetsky	hard (bituminous)
3	Serovskaya GRES*	12	526	220	PCC	1340.3	Ekibastuzskiy	-'/-
4	Troitskaya GRES	14	2059	315	PCC	5624.6	Ekibastuzskiy	-'/-
5	Gusinoozerskaya GRES*	6	1260	221	PCC	2480.9	Tugnujskiy	hard (bituminous)
6	Kharanorskaya GRES*	2	430	418	PCC	1487.6	Kharanorskiy	brown (sub-bituminous)
7	Cherepetskaya GRES	11	1425	94	PCC	1261.3	Kuznetskiy	-'/-
8	Yuzhno-Uralskaya GRES*	15	882	395	PCC	1711.4	Chelyabinsky	brown (sub-bituminous)
9	Berezovskaya GRES-1	2	1500	380	PCC	5169.5	Berezovsky (Kansk-Achinsk)	brown (sub-bituminous)
10	Smolenskaya GRES*	6	630	66	PCC	50.9	Kuznetskiy	-'/-
11	Shaturskaya GRES-5*	9	1100	244	PCC	18.7	Kuznetskiy	-'/-
12	Yayvinskaya GRES*	4	600	69	PCC	20.5	Kuznetskiy	-'/-
13	Reftinskaya GRES	10	3800	350	PCC	9531.7	Ekibastuzskiy	-'/-
14	Krasnoyarskaya GRES 2	18	1250	976	PCC	3451.5	Kanskiy (Kansk-Achinsk)	brown (sub-bituminous)
15	Novocherkasskaya GRES	7	2112	75	PCC	2614.4	Donetskiy+Kuznetskiy	hard (bituminous) +antracite
16	Ryazanskaya GRES*	6	2650	120	PCC	1888.5	Kansky+Borodinskiy	brown (sub-bituminous)
17	Cherepovetskaya GRES	3	630	39	PCC	1009	Khakasskiy+Intinskiy and others	hard (bituminous)
18	Apatitskaya GRES	10	323	735	PCC	429.5	Kuznetskiy+ Intinskiy and others	bituminous+antracite

No.	Plant name	Number of units in plant	Electricity Generating Capacity (MW)	Thermal Generating Capacity(Gkal/h)	Boiler type	Coal burned (thousand metric tons/year)	Origin of coal	Type of coal
19	Pervomayskaya TPP 14*	*gas-fired station*				0.3	Kuznetskiy	*reserve fuel*
20	Dubrovskaya TPP*	*gas-fired station*				1.6	Kuznetskiy	*reserve fuel*
21	Novgorodskaya TPP 14*	4	190	512	PCC	220	Kuznetskiy	-'/-
22	Tverskaya TPP 3*	7	170	314	PCC	30.4	Kuznetskiy	-'/-
23	Yaroslavskaya TPP 2*	10	50	705	PCC	30.6	Donetskiy	hard (bituminous)
24	Severodvinskaya TPP 1	7	188.5	499	PCC	986.2	Kuznetskiy+Intinskiy	bituminous
25	Mosenergo TPP 17*	9	192	512	PCC	62.2	Kuznetskiy	-'/-
26	Mosenergo TPP-23*	22	560	2174	PCC	414.7	Kuznetskiy	-'/-
27	Aleksinskaya TPP*	*gas-fired station*				5.8	Intinskiy	*reserve fuel*
28	Voronezhskaya TPP 1*		168	515	PCC	45.4	Donetskiy	-'/-
29	Dorogobuzhskaya TPP*	*gas-fired station*				8.4	Khakasskiy	*reserve fuel*
30	Novomoskovskaya GRES*	9	261	866	PCC	32.8	Podmoskovniy+Intinskiy	brown (sub-bituminous) +bituminous
31	Pervomayskaya TPP*	6	105	674	PCC	30.2	Intinskiy	bituminous
32	Izhevskaya TPP2*	6	390	695	PCC	103.2	Kuznetskiy	-'/-
33	Kirovskaya TPP 3*	11	160	413	PCC	119.7	Kuznetskiy	-'/-
34	Kirovskaya TPP 4*	14	320	658	PCC	90.9	Kuznetskiy	-'/-
35	Kirovskaya TPP 5*	6	450	730	PCC	201.8	Kuznetskiy	-'/-
36	Ivanovskaya TPP 2	10	184	557	PCC	99.8	Kuznetskiy	-'/-
37	Ivanovskaya TPP 3	9	330	676	PCC	128.7	Kuznetskiy	-'/-
38	Toghlyattinskaya TPP*	19	710	1897	PCC	87.9	Kuznetskiy	-'/-
39	Artemovskaya TPP*	5	17	75	PCC	18.2	Kuznetskiy	-'/-

No.	Plant name	Number of units in plant	Electricity Generating Capacity (MW)	Thermal Generating Capacity(Gkal/h)	Boiler type	Coal burned (thousand metric tons/year)	Origin of coal	Type of coal
40	Bogoslovskaya TPP*	12	141	834	PCC	1041.6	Sverdlovskiy	bituminous
41	Vorkutinskaya TPP 1	7	25	111	PCC	185	Vorkutinskiy	bituminous
42	Vorkutinskaya TPP 2	9	280	415	PCC	670.8	Vorkutinskiy	-'/-
43	Zakamskaya TPP 5*	*gas-fired station*				10.7	Kuznetskiy	*reserve fuel*
44	Intinskaya TPP	6	18	107	PCC	143	Intinskiy	bituminous
45	Krasnogorskaya TPP*	10	121	704	PCC	605.1	Ekibastuzskiy	-'/-
46	Nizhneturinskaya GRES*	9	284	510	PCC	548.3	Ekibastuzskiy	-'/-
47	Tchaikovskaya TPP*	4	170	466	PCC	34.7	Kuznetskiy	-'/-
48	Argayashskaya TPP*	9	250	576	PCC	562.4	Chelyabinsky	brown (sub-bituminous)
49	Tcheliabinskaya TPP 1*	8	170	653	PCC	70.8	Chelyabinsky	-'/-
50	Tcheliabinskaya TPP 2*	11	320	596	PCC	168.5	Chelyabinsky	-'/-
51	Omskaya TPP 2*	9	240	417	PCC	24.3	Chelyabinsky	-'/-
52	Omskaya TPP 4	12	535	1404	PCC	1173.3	Ekibastuzskiy	-'/-
53	Omskaya TPP 5	12	695	1100	PCC	2633.3	Ekibastuzskiy	-'/-
54	Tomskaya GRES 2*	10	281	568	PCC	238.2	Kuznetskiy	-'/-
55	Abakanskaya TPP	10	270	481	PCC	897.8	Borodinskiy (Kansk-Achinsk)	brown (sub-bituminous)
56	Kanskaya TPP	7	17	110	PCC	203.3	Borodinskiy (Kansk-Achinsk)	-'/-
57	Krasnoyarskaya TPP 1	17	506	1583	PCC	2338.6	Borodinskiy (Kansk-Achinsk)	-'/-
58	Krasnoyarskaya TPP 2	8	439	810	PCC	1915.9	Borodinskiy (Kansk-Achinsk)	-'/-
59	Krasnoyarskaya TPP 3	9	--	442	PCC	473.6	Borodinskiy (Kansk-Achinsk)	-'/-
60	Minusinskaya TPP	6	80	474	PCC	377.8	Borodinskiy (Kansk-Achinsk)	-'/-
61	Nazarovskaya GRES	14	1210	870	PCC	4175	Nazarovskiy (Kansk-Achinsk)	brown (sub-bituminous)

No.	Plant name	Number of units in plant	Electricity Generating Capacity (MW)	Thermal Generating Capacity(Gkal/h)	Boiler type	Coal burned (thousand metric tons/year)	Origin of coal	Type of coal
62	Priargunskaya TPP	3	24	110	PCC	73.1	Urtuyskiy	brown (sub-bituminous)
63	Ulan-Udenskaya TPP 1	10	118.4	353	PCC	527.87	Tugnujskiy	hard (bituminous)
64	Ulan-Udenskaya TPP 2	2	-	-	PCC	172.4	Tugnujskiy	-'/-
65	Chitinskaya TTP 1	13	471	760	PCC	1906.1	Urtuyskiy+Tataurovskiy	brown (sub-bituminous)
66	Chitinskaya TTP 2	7	6	34	PCC	201.5	Kharanorskiy	brown (sub-bituminous)
67	Sherlovogorskaya	4	12	55	PCC	96.4	Kharanorskiy	-'/-
68	Barnaulskaya TPP 1	7	15.2	170	PCC	79.4	Kuznetskiy	-'/-
69	Barnaulskaya TPP 2	16	339	993	PCC	909.6	Kuznetskiy	-'/-
70	Barnaulskaya TPP 3	14	430	720	PCC	1691.5	Kanskiy (Kansk-Achinsk)	-'/-
71	Belovskaya GRES	6	1200	123	PCC	3231.2	Kuznetskiy	-'/-
72	Kemerovskaya GRES	8	500	1308	PCC	1144.2	Kuznetskiy	-'/-
73	Kemerovskaya TPP*	9	55	397	PCC	127.08	Kuznetskiy	-'/-
74	Kuznetskaya TPP	15	96	356	PCC	584	Kuznetskiy	-'/-
75	Novo-kemerovskaya TPP	10	465	1247	PCC	1190.9	Kuznetskiy	-'/-
76	Tom'-Usinskaya GRES	14	1272	263	PCC	4123	Kuznetskiy	-'/-
77	Barabinskaya TPP	5	114	213	PCC	118.9	Kuznetskiy	-'/-
78	Novosibirskaya TPP 2	7	340	820	PCC	675.3	Kuznetskiy	-'/-
79	Novosibirskaya TPP 3	10	499.5	970	PCC	1393.7	Krasnoyarskiy	brown (sub-bituminous)
80	Novosibirskaya TPP 4*	8	369	774	PCC	287.1	Kuznetskiy	-'/-
81	Novosibirskaya TPP 5	6	1200	1440	PCC	3036.4	Kuznetskiy	-'/-
82	Kumertausskaya TPP	7	145	401	PCC	674.6	Tulganskiy	brown (sub-bituminous)
83	Blagoveshenskaya TTP	6	280	489	PCC	1268.3	Erkovetskiy	brown (sub-bituminous)

No.	Plant name	Number of units in plant	Electricity Generating Capacity (MW)	Thermal Generating Capacity(Gkal/h)	Boiler type	Coal burned (thousand metric tons/year)	Origin of coal	Type of coal
84	Raichikhinskaya GRES	8	219	65	PCC	253.6	Rajchikhinskiy	brown (sub-bituminous)
85	Artemovskaya TPP	10	400	303	PCC	1464.1	Lipovetskiy+Khakasskiy	hard (bituminous)
86	Partizanskaya GRES	5	212	175	PCC	372	Nerungrinskiy	hard (bituminous)
87	Vladivostokskaya TTP 2	14	575	1023	PCC	3040.3	Pavlovskiy	brown (sub-bituminous)
88	Nerungrinskaya GRES	6	570	520	PCC	1133.4	Nerungrinskiy	hard (bituminous)
89	Amurskaya TPP*	9	285	745	PCC	118.3	Kharanorskiy	-'/-
90	Komsomolskaya TPP 2*	15	265	681	PCC	307.15	Kharanorskiy	-'/-
91	Maiskaya GRES	6	98.85	130	PCC	147.4	Khakasskiy	bituminous
92	Khabarovskaya TPP 3	7	720	1040	PCC	1232.5	Nerungrinskiy	-'/-
93	Birobidzhanskaya TPP	7	40	338	PCC	240	Kharanorskiy	-'/-
94	TTP LuTEK	13	1495	237	PCC	5061.8	Bikinskiy	brown (sub-bituminous)
95	Bijskaya TPP	20	364	1058	PCC	1130.9	Kuznetskiy	-'/-
96	Kurganska TPP*	10	480	956	PCC	108.3	Ekibastuzskiy	-'/-
97	Arkagalinskaya GRES	7	224	151	PCC	70.8	Arkagalinskiy	hard (bituminous)
98	Magadanskaya TPP	8	96	210	PCC	253.4	Kuznetskiy	-'/-
99	Sakhalinskaya GRES	5	300	15	PCC	902.2	Sakhalinskiy	bituminous
100	Yuzhno-Sakhalinskaya TPP	5	225	409	PCC	1010.2	Sakhalinskiy	-'/-
101	Eksperimentalnaya TPP	3	105	35	PCC	205.9	Donetskiy	-'/-
102	Zapadno-Sibirskaya TPP	11	900	350	PCC	1800.8	Kuznetskiy	-'/-
103	Yuzhnokuzbasskaya GRES	11	554	581	PCC	1114.6	Kuznetskiy	-'/-
104	Anadirskaya TPP	2	84.6	140	PCC	121.2	Anadyrskiy	brown (sub-bituminous)
105	Chaunskaya TPP	4	34.5	99	PCC	58.5	Zyrianskiy	bituminous

No.	Plant name	Number of units in plant	Electricity Generating Capacity (MW)	Thermal Generating Capacity(Gkal/h)	Boiler type	Coal burned (thousand metric tons/year)	Origin of coal	Type of coal
106	Egvekinotskaya TPP	4	28	65	PCC	96.5	Anadyrskiy	-'/-
107	Chulmanskaya TPP	5	48	165	PCC	116	Nerungrinskiy	-'/-
108	Irkutskaya TPP 1	18	185	840	PCC			
109	Irkutskaya TPP 3	5	13.4	62	PCC			
110	Irkutskaya TPP 5	7	18	90	PCC			
111	Irkutskaya TPP 6	10	270	860	PCC	730.2	Cheremkhovskiy	hard (bituminous)
112	Irkutskaya TPP 7	9	12	40	PCC	872.1	Pereyaslovskiy	brown (sub-bituminous)
113	Irkutskaya TPP 9	12	475	1348	PCC	4389.8	Mugunskiy	brown (sub-bituminous)
114	Irkutskaya TPP 10	16	1110	593	PCC	1056.5	Irbeyskiy	hard (bituminous)
115	Irkutskaya TPP 11	8	350	960	PCC	884.9	Zheronskiy	hard (bituminous)
116	Irkutskaya TPP 12	8	7.5	40	PCC	570.6	Azeyskiy	brown (sub-bituminous)
117	Irkutskaya TPP 16	5	18	82.5	PCC	2183.3	Coals of Siberia	brown (sub-bituminous)
118	Novo-Ziminskaya TPP	4	240	630	PCC			
119	Ust-Ilimskaya TPP	7	525	1070	PCC			
120	Novoirkutskaya TPP	8	655	1142	PCC			

Power plants marked with "*" burn coal as a reserve fuel only.

Table AIII.3. Coal-fired power plants in Russia: PM controls, Hg emission coefficients, Hg emission potentials.

No.	Plant name	Hg content, average (gram/metric ton)	Hg content, maximum (gram/metric ton)	PM Emission control	Hg emission coefficient	Hg emission potential, mean (metric tons/year)	Hg emission potential, maximum (metric tons/year)
1	Verhnetagilskaya GRES*	0.06	0.12	SC	0.91	0.06	0.12
2	Kashirskaya GRES-4*	0.04	0.4	ESP	0.64	0.02	0.16
3	Serovskaya GRES*	0.06	0.12	SC	0.91	0.07	0.15
4	Troitskaya GRES	0.06	0.12	SC+ESP	0.94	0.32	0.63
5	Gusinoozerskaya GRES*	0.1	0.2	SC	0.9	0.22	0.45
6	Kharanorskaya GRES*	0.02	0.05	ESP	0.97	0.03	0.07
7	Cherepetskaya GRES	0.04	0.4	ESP	0.64	0.03	0.32
8	Yuzhno-Uralskaya GRES*	0.1	0.2	SC	0.91	0.16	0.31
9	Berezovskaya GRES-1	0.03	0.05	ESP	0.97	0.15	0.25
10	Smolenskaya GRES*	0.04	0.4	CY	0.98	0.00	0.02
11	Shaturskaya GRES-5*	0.04	0.4	SC	0.9	0.00	0.01
12	Yayvinskaya GRES*	0.04	0.4	CY+ESP	0.85	0.00	0.01
13	Reftinskaya GRES	0.06	0.12	ESP	0.97	0.55	1.11
14	Krasnoyarskaya GRES 2	0.02	0.04	CY	0.99	0.07	0.14
15	Novocherkasskaya GRES	0.15	0.3	CY+ESP	0.85	0.33	0.67
16	Ryazanskaya GRES*	0.02	0.04	ESP	0.97	0.04	0.07
17	Cherepovetskaya GRES	0.09	0.18	SC	0.9	0.08	0.16
18	Apatitskaya GRES	0.09	0.3	SC	0.9	0.03	0.12
19	Pervomayskaya TPP 14*						
20	Dubrovskaya TPP*						
21	Novgorodskaya TPP 14*	0.04	0.4	SC	0.9	0.01	0.08

No.	Plant name	Hg content, average (gram/metric ton)	Hg content, maximum (gram/metric ton)	PM Emission control	Hg emission coefficient	Hg emission potential, mean (metric tons/year)	Hg emission potential, maximum (metric tons/year)
22	Tverskaya TPP 3*	0.04	0.4	CY	0.98	0.00	0.01
23	Yaroslavskaya TPP 2*	0.09	0.18	SC	0.9	0.00	0.00
24	Severodvinskaya TPP 1	0.07	0.3	SC	0.9	0.06	0.27
25	Mosenergo TPP 17*	0.04	0.4	ESP	0.64	0.00	0.02
26	Mosenergo TPP-23*	0.04	0.4	ESP	0.64	0.01	0.11
27	Aleksinskaya TPP*						
28	Voronezhskaya TPP 1*	0.09	0.11	SC	0.9	0.00	0.00
29	Dorogobuzhskaya TPP*						
30	Novomoskovskaya GRES*	0.15	0.2	CY+ESP	0.92	0.00	0.01
31	Pervomayskaya TPP*	0.09	0.18	CY+ESP	0.85	0.00	0.00
32	Izhevskaya TPP2*	0.04	0.4	ESP	0.64	0.00	0.03
33	Kirovskaya TPP 3*	0.04	0.4	SC	0.9	0.00	0.04
34	Kirovskaya TPP 4*	0.04	0.4	SC	0.9	0.00	0.03
35	Kirovskaya TPP 5*	0.04	0.4	SC	0.9	0.01	0.07
36	Ivanovskaya TPP 2	0.04	0.4	SC	0.9	0.00	0.04
37	Ivanovskaya TPP 3	0.04	0.4	SC	0.9	0.00	0.05
38	Toghlyattinskaya TPP*	0.04	0.4	SC	0.9	0.00	0.03
39	Artemovskaya TPP*	0.04	0.4	CY	0.98	0.00	0.01
40	Bogoslovskaya TPP*	0.1	0.2	CY+SC	0.94	0.10	0.20
41	Vorkutinskaya TPP 1	0.05	0.1	CY	0.98	0.01	0.02
42	Vorkutinskaya TPP 2	0.05	0.1	CY+SC	0.94	0.03	0.06
43	Zakamskaya TPP 5*						
44	Intinskaya TPP	0.09	0.18	CY	0.98	0.01	0.03

No.	Plant name	Hg content, average (gram/metric ton)	Hg content, maximum (gram/metric ton)	PM Emission control	Hg emission coefficient	Hg emission potential, mean (metric tons/year)	Hg emission potential, maximum (metric tons/year)
45	Krasnogorskaya TPP*	0.06	0.12	CY+SC	0.96	0.03	0.07
46	Nizhneturinskaya GRES*	0.06	0.12	SC	0.91	0.03	0.06
47	Tchaikovskaya TPP*	0.04	0.4	ESP	0.64	0.00	0.01
48	Argayashskaya TPP*	0.1	0.2	CY	0.99	0.06	0.11
49	Tcheliabinskaya TPP 1*	0.1	0.2	SC	0.91	0.01	0.01
50	Tcheliabinskaya TPP 2*	0.1	0.2	SC	0.91	0.02	0.03
51	Omskaya TPP 2*	0.1	0.2	SC	0.91	0.00	0.00
52	Omskaya TPP 4	0.06	0.12	SC	0.91	0.06	0.13
53	Omskaya TPP 5	0.06	0.12	ESP	0.97	0.15	0.31
54	Tomskaya GRES 2*	0.04	0.4	SC+ESP	0.77	0.01	0.07
55	Abakanskaya TPP	0.01	0.12	ESP	0.97	0.01	0.10
56	Kanskaya TPP	0.01	0.12	CY	0.99	0.00	0.02
57	Krasnoyarskaya TPP 1	0.01	0.12	CY	0.99	0.02	0.28
58	Krasnoyarskaya TPP 2	0.01	0.12	ESP	0.97	0.02	0.22
59	Krasnoyarskaya TPP 3	0.01	0.12	CY	0.99	0.00	0.06
60	Minusinskaya TPP	0.01	0.12	CY+ESP	0.98	0.00	0.04
61	Nazarovskaya GRES	0.05	0.1	CY+ESP	0.98	0.20	0.41
62	Priargunskaya TPP	0.1	0.1	CY	0.99	0.01	0.01
63	Ulan-Udenskaya TPP 1	0.1	0.1	SC	0.9	0.05	0.05
64	Ulan-Udenskaya TPP 2	0.1	0.1	CY	0.98	0.02	0.02
65	Chitinskaya TTP 1	0.1	0.1	SC	0.91	0.17	0.17
66	Chitinskaya TTP 2	0.02	0.05	CY	0.99	0.00	0.01
67	Sherlovogorskaya	0.02	0.05	CY	0.99	0.00	0.00

No.	Plant name	Hg content, average (gram/metric ton)	Hg content, maximum (gram/metric ton)	PM Emission control	Hg emission coefficient	Hg emission potential, mean (metric tons/year)	Hg emission potential, maximum (metric tons/year)
68	Barnaulskaya TPP 1	0.04	0.4	CY	0.98	0.00	0.03
69	Barnaulskaya TPP 2	0.04	0.4	SC	0.9	0.03	0.33
70	Barnaulskaya TPP 3	0.02	0.04	ESP	0.97	0.03	0.07
71	Belovskaya GRES	0.04	0.4	SC	0.9	0.12	1.16
72	Kemerovskaya GRES	0.04	0.4	SC+ESP	0.77	0.04	0.35
73	Kemerovskaya TPP*	0.04	0.4	SC	0.9	0.00	0.05
74	Kuznetskaya TPP	0.04	0.4	CY+SC	0.94	0.02	0.22
75	Novo-kemerovskaya TPP	0.04	0.4	SC	0.9	0.04	0.43
76	Tom'-Usinskaya GRES	0.04	0.4	SC	0.9	0.15	1.48
77	Barabinskaya TPP	0.04	0.4	CY	0.98	0.00	0.05
78	Novosibirskaya TPP 2	0.04	0.4	SC	0.9	0.02	0.24
79	Novosibirskaya TPP 3	0.1	0.2	SC+ESP	0.94	0.13	0.26
80	Novosibirskaya TPP 4*	0.04	0.4	SC	0.9	0.01	0.10
81	Novosibirskaya TPP 5	0.04	0.4	ESP	0.64	0.08	0.78
82	Kumertausskaya TPP	0.1	0.1	CY	0.99	0.07	0.07
83	Blagoveshenskaya TTP	0.1	0.1	SC	0.91	0.12	0.12
84	Raichikhinskaya GRES	0.1	0.1	CY+SC	0.96	0.02	0.02
85	Artemovskaya TPP	0.1	0.1	SC	0.9	0.13	0.13
86	Partizanskaya GRES	0.1	0.1	SC	0.9	0.03	0.03
87	Vladivostokskaya TTP 2	0.09	0.18	SC+ESP	0.94	0.26	0.51
88	Nerungrinskaya GRES	0.1	0.1	SC+ESP	0.77	0.09	0.09
89	Amurskaya TPP*	0.02	0.05	SC	0.91	0.00	0.01
90	Komsomolskaya TPP 2*	0.02	0.05	SC	0.91	0.01	0.01

No.	Plant name	Hg content, average (gram/metric ton)	Hg content, maximum (gram/metric ton)	PM Emission control	Hg emission coefficient	Hg emission potential, mean (metric tons/year)	Hg emission potential, maximum (metric tons/year)
91	Maiskaya GRES	0.1	0.2	SC	0.9	0.01	0.03
92	Khabarovskaya TPP 3	0.1	0.1	ESP	0.64	0.08	0.08
93	Birobidzhanskaya TPP	0.02	0.05	SC	0.91	0.00	0.01
94	TTP LuTEK	0.1	0.1	SC	0.91	0.46	0.46
95	Bijskaya TPP	0.04	0.4	SC+ESP	0.77	0.03	0.35
96	Kurganska TPP*	0.06	0.12	SC	0.91	0.01	0.01
97	Arkagalinskaya GRES	0.1	0.1	SC	0.9	0.01	0.01
98	Magadanskaya TPP	0.04	0.4	CY+SC	0.94	0.01	0.10
99	Sakhalinskaya GRES	0.11	0.22	SC	0.9	0.09	0.18
100	Yuzhno-Sakhalinskaya TPP	0.11	0.22	SC	0.9	0.10	0.20
101	Eksperimentalnaya TPP	0.09	0.11	-	1	0.02	0.02
102	Zapadno-Sibirskaya TPP	0.04	0.4	SC+ESP	0.77	0.06	0.55
103	Yuzhnokuzbasskaya GRES	0.04	0.4	SC	0.9	0.04	0.40
104	Anadirskaya TPP	0.1	0.1	CY	0.99	0.01	0.01
105	Chaunskaya TPP	0.1	0.1	CY	0.98	0.01	0.01
106	Egvekinotskaya TPP	0.1	0.1	CY	0.99	0.01	0.01
107	Chulmanskaya TPP	0.1	0.1	CY	0.98	0.01	0.01
108	Irkutskaya TPP 1			ESP			
109	Irkutskaya TPP 3			SC		-	
110	Irkutskaya TPP 5			SC			
111	Irkutskaya TPP 6	0.17	0.34	SC+ESP	0.9	0.11	0.22
112	Irkutskaya TPP 7	0.1	0.1	ESP	0.9	0.08	0.08
113	Irkutskaya TPP 9	0.1	0.1	SC	0.9	0.40	0.40

No.	Plant name	Hg content, average (gram/metric ton)	Hg content, maximum (gram/metric ton)	PM Emission control	Hg emission coefficient	Hg emission potential, mean (metric tons/year)	Hg emission potential, maximum (metric tons/year)
114	Irkutskaya TPP 10	0.1	0.1	SC	0.9	0.10	0.10
115	Irkutskaya TPP 11	0.1	0.1	SC	0.9	0.08	0.08
116	Irkutskaya TPP 12	0.17	0.34	CY+SC	0.9	0.09	0.17
117	Irkutskaya TPP 16	0.1	0.2	SC	0.9	0.20	0.39
118	Novo-Ziminskaya TPP			SC			
119	Ust-Ilimskaya TPP			CY		-	
120	Novoirkutskaya TPP			SC+ESP			

Power plants marked with "*" burn coal as a reserve fuel only.