Environmental Considerations Related to Generation Facilities in the Regions of the Asian Part of Russia

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***Abstract* — The features unique to the operation of energy facilities in the Asian part of Russia influence environmental agenda setting in these regions. The Asian regions account for a large share of Russia's mix of air pollutant emissions and production of coal ash, with boiler houses responsible for a significant part of their amounts. Particulate matter and sulfur oxides dominate the ingredient composition of pollutant emissions, unlike in European Russia. From an environmental point of view, what makes regions of the Asian part of Russia stand apart in a rather egregious way is the large proportion of cities with high levels of air pollution. Of the 37 such cities in the country, 27 are located in Siberia and the Russian Far East. The regions of the Asian part of Russia, due to the predominance of coal in their fuel balances, are characterized by a high share of CO2 emissions from generation facilities. Specific carbon dioxide emissions in the Asian regions are 1.5 times higher than in the European part of the Russian Federation. Given that in the near future it is unlikely for coal to be completely eliminated from fuel balances of the Asian regions, in order to decarbonize Russia's energy sector, a number of strategies of low-carbon development should be developed for these regions.**

***Index Terms*: Energy facilities, coal balance, pollutant emissions, carbon dioxide emissions, decarbonization strategies.**

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I. Introduction

The environmental features unique to energy facilities in the Asian regions of Russia are shaped by the mix of pollutant emissions from large and small generation facilities, the ingredient composition of emissions, the volume of fuel consumed and its mix, and the use of treatment equipment. In order to identify such features unique of energy facilities in the Asian regions of Russia we assess their contribution to environmental impacts.

In this study, such environmental assessment was performed for two key metrics: emissions of pollutants into the atmosphere and production of coal ash. Furthermore, we estimated carbon dioxide (CO_2) emissions from TPPs and boiler houses in the context of decarbonization of the economy, including the country's energy sector.

Calculations of emissions from power facilities were made on the basis of data on the consumption of fuel and energy resources by TPPs and boiler houses in Russia in 2020 (statistical reporting form 4-TER), highlighting the Asian regions.

II. Calculation Methods

For quantitative environmental assessments we used the techniques approved in the Russian Federation for calculating gross emissions of air pollutants from TPPs and boiler houses [1–3], as well as methodological guidelines for quantitative assessment of coal ash produced by power facilities [4, 5]. The calculations used data on the quantity and quality of combustible fuels and data on the types of power equipment.

Pollutant emissions were calculated for four main ingredients: particulate matter, sulfur dioxides, nitrogen oxides, and carbon oxides. The calculations assumed that at large coal-fired power houses, both in Russia on average and in the Asian regions of the country, the efficiency of ash capture is not less than 92%. There is

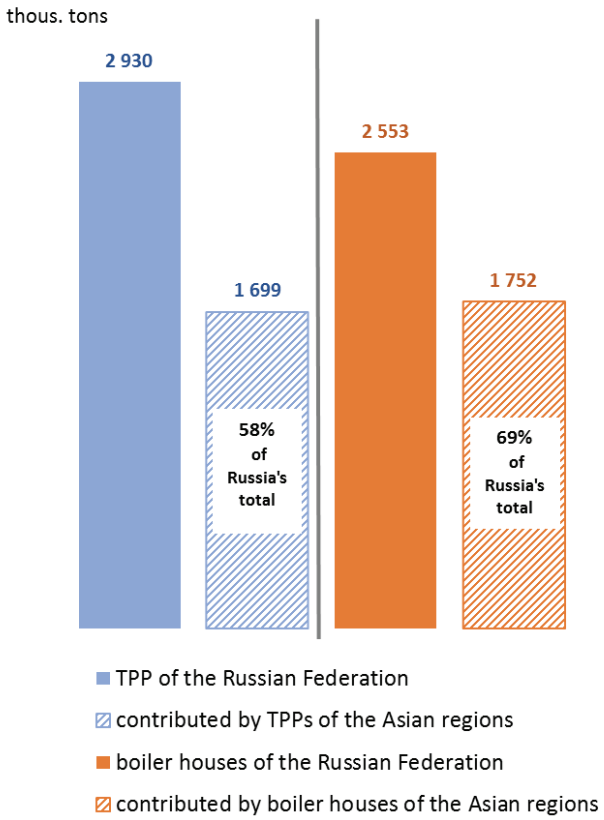

Fig. 1. Estimated emissions of air pollutants from TPPs and boiler houses in Russia and its Asian regions in 2020.

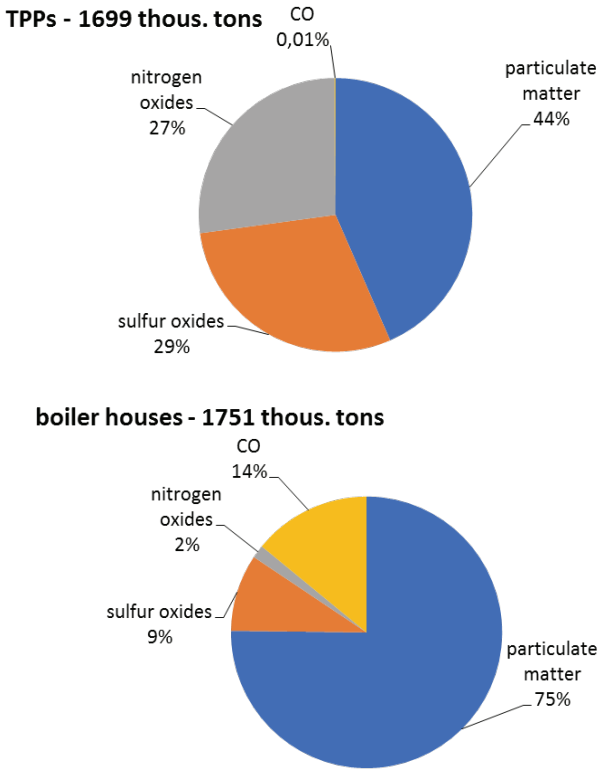

Fig. 2. Ingredient composition of air pollutant emissions from TPPs and boiler houses in the Asian regions of Russia in 2020.

Table 1. Consumption of fuel and energy resources at TPPs and boiler houses in Russia in 2020, thousand tce

Fuel	Generation facilities		Total
	TPP	boiler houses	
Coal	46,053	10,452	56,505
Fuel oil	412,000	1,353	1,765
Natural gas	10,859	3,986	14,845
Total	57,324	15,791	73,115

no reliable information about the efficiency of ash capture at coal-fired boiler houses. According to expert estimates, ash treatment, especially at many small boiler houses, is not provided for or is not carried out properly, and it was assumed to be zero in our calculations.

For quantitative assessment of greenhouse gas emissions from generation facilities, we used the methodological guidelines as per the approved Order of the Ministry of Natural Resources of the Russian Federation No. 300 [6]. The scope of our calculations for combustion of fuels at power facilities covered only carbon dioxide. The calculation was based on the data on the amount of fuel burned and its type (coal, natural gas, fuel oil, etc.), as well as emission factors recommended by both the International Panel on Climate Change (IPCC) and those adopted in this country [6].

III. Quantitative Assessments of the Environmental Performance of Generation Facilities

Data on the amount of consumption of fuel and energy resources at the power facilities of the Asian regions of Russia are presented in Table 1.

On the basis of the techniques referred to above, we performed calculations of air pollutant emissions. The estimated amount of pollutant emissions in 2020 originating from power facilities (TPPs and boiler houses) of the Russian Federation was estimated at 5.5 million tons, of which 63% (or 3.5 million tons) was contributed by the Asian regions of the country (Fig. 1).

Among power facilities located in the Asian regions, the largest amount of emissions came from boiler houses (almost 1.8 million tons), the main pollutant being particulate matter. When compared to European Russia, boiler houses emitted 2.2 times fewer pollutants and 3.3 times fewer particulate matter into the atmosphere. Comparing air emissions from TPPs in the Asian regions, it should be noted that along with particulate matter emissions (40–43% of total emissions) almost 30% were sulfur dioxide emissions, whereas in the case of large houses in the European part of the country the predominant air contaminant was nitrogen oxides (up to 40% of total TPP emissions of the European part of Russia). In the Asian regions of Russia, particulate matter is the main

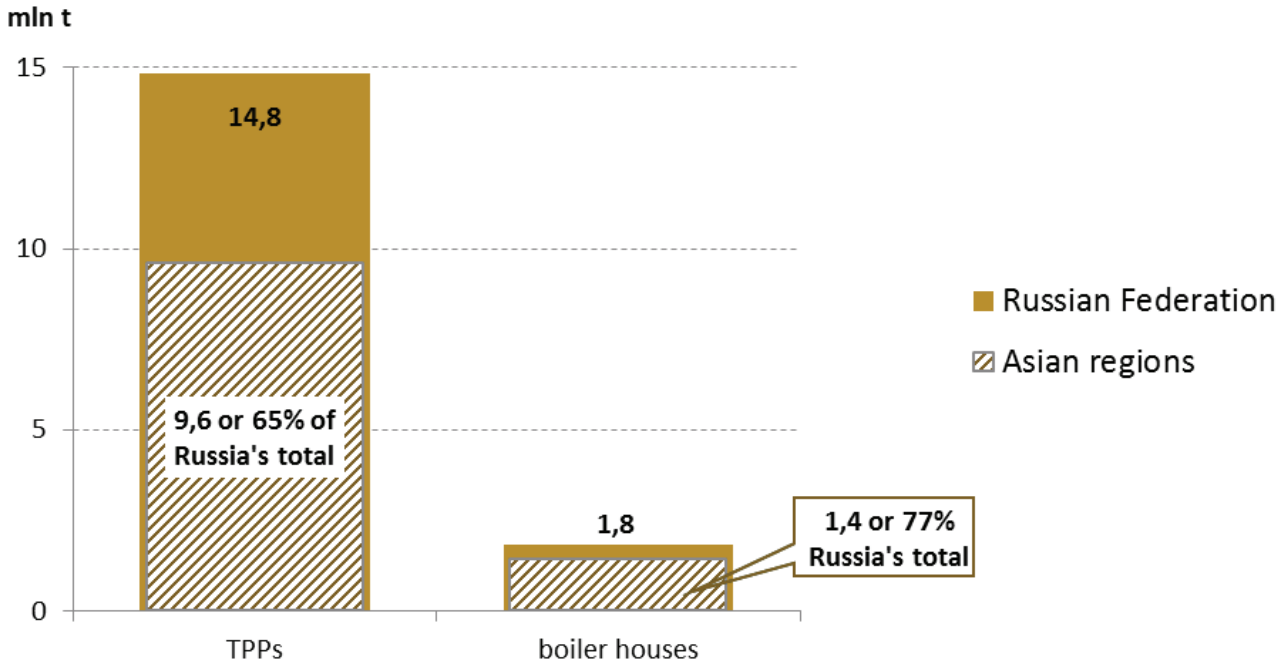

Fig. 3. Estimated amount of coal ash from power facilities in Russia and its Asian regions in 2020.

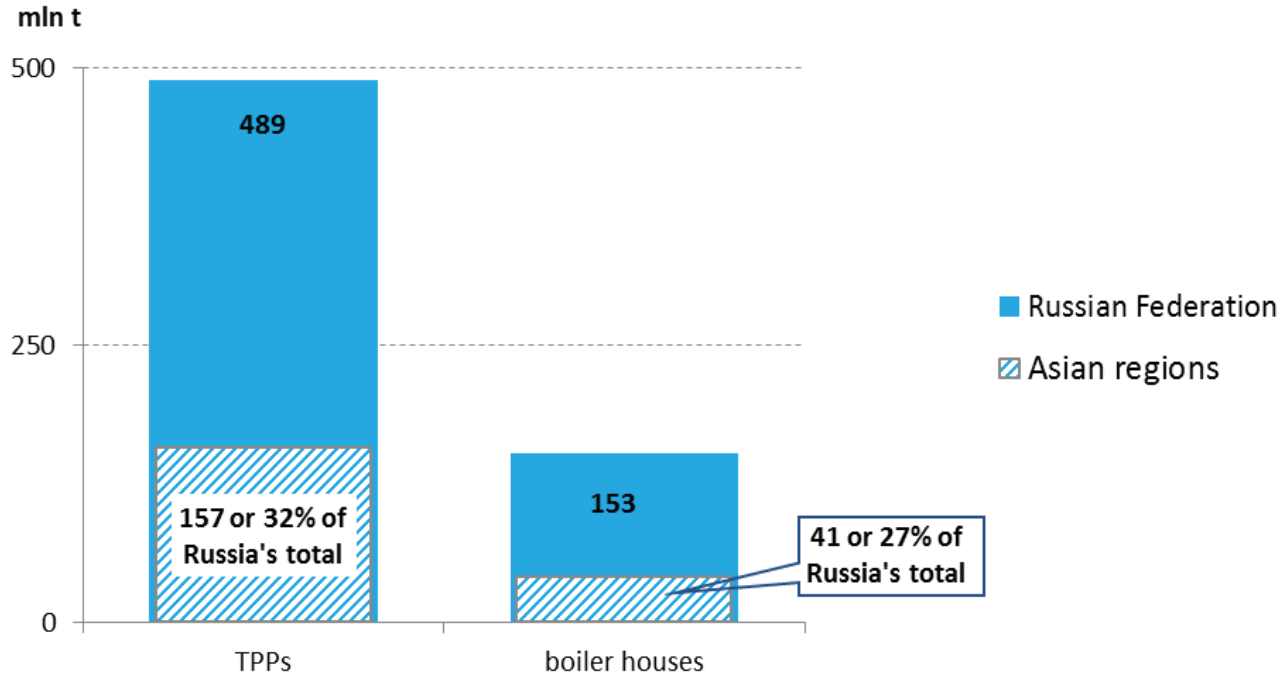

Fig. 4. Estimated amount of carbon dioxide emissions from power facilities in Russia and its Asian regions in 2020.

Table 2. Estimated carbon dioxide emissions from generation facilities in Russia, million tons (as of 2020)

Country, region	Generation facilities		Total
	TPP	boiler houses	
Russia's total, inclusive of the following:	489	153	642
Asian regions	157	41	197
European regions	333	112	445

pollutant from both TPPs and boiler houses. Depending on the type of a generation facility, a significant amount of sulfur oxides (500 thous. tons) and nitrogen oxides (460 thous. tons) came from large TPPs, see Fig. 2.

The environmental assessment performed indicated that the main sources of air pollutant emissions were coal-fired generation facilities, with a significant share of boiler houses, while the volume of coal consumption by TPPs was almost 4 times higher than by boiler houses.

This feature unique to the Asian regions of Russia is related to the considerable amounts of coal consumed by generation facilities. The coal consumed is for the most part lignites, most notably its Kansko-Achinsky, Primorsky, Kharanorsky, and Azeisky varieties. For the purposes of our calculations, their qualitative characteristics were assumed as per the data found in reference books [7–9].

The estimated amount of coal ash generated in Russia as a whole was estimated at 16.6 million tons, of which almost 11 million tons (or 66%) were produced in the Asian regions of the country. The largest contributor was large power facilities – TPPs (Fig. 3) that capture a significant amount of fly ash (as was assumed in the calculations, with the efficiency value being 92%).

The calculated amount of coal ash at TPPs in the Asian regions of the country was almost 2 times higher than their production at TPPs in European Russia and 3.4 times higher, when making a similar comparison, at boiler houses. The resulting environmental assessment for coal ash also characterized the regions of the Asian part of Russia as facing great environmental challenges and highlighted the significant amount of coal used for generation needs.

Based on the amount of fuel used by generation facilities in Russia in 2020, the amount of CO_2 was estimated at 642 million tons, with the Asian regions of the country accounting or 197 million tons of the total amount. In terms of power generation facilities, the mix of carbon dioxide emissions sources was dominated by TPPs in both Russia and the Asian part of the country (Fig. 4).

The contribution of the Asian regions to Russia's total carbon dioxide emissions can be reduced by about half through large-scale gasification of power facilities.

In general, the calculations of CO_2 emissions showed that in the European regions of Russia the share of TPPs was quite high (up to 75%), but this contribution was formed by the consumption of significant amounts of natural gas (94% of all gas in Russia), while in the Asian regions the large contribution of TPPs to carbon dioxide emissions (up to 79%) originated from coal-fired generation, see Table 2.

To analyze the data obtained, it is advisable to compare the specific carbon dioxide emission figures for Asian and European parts of Russia. Taking into account the amount of fuel burned at the power facilities of Russia in 2020, we can see that the specific emission of carbon dioxide in the Asian regions was 2.5 tons of CO_2 / tce, and in the European regions – 1.7 tons of CO_2 / tce. In fact, there were 1.5 times more carbon dioxide emissions per ton of coal equivalent used by power facilities in the Asian regions than in the European regions of the Russian Federation.

Thus, the main causes of greenhouse gas emissions from generation facilities in the Asian regions of the Russian Federation are as follows:

- high share of coal in the fuel and energy balance of the areas in question;
- lack of technology to capture and use greenhouse gases;
- insufficient energy and fuel conservation measures;
- high degree of wear and tear of the generating equipment.

IV. Conclusion

Environmental assessment of the operation of generation facilities in the Asian regions of Russia allowed us to identify their key environment-related features. First of all, it is the predominance of coal in the fuel balance, which generates a significant amount of pollutants (63% of emissions from power facilities in Russia) and carbon dioxide (31% of CO_2 emissions from power facilities in Russia) emitted into the atmosphere. Furthermore, about 60% of all coal ash in Russia is produced there.

Numerous coal-fired boiler houses operating in the Asian regions of the country make a significant contribution to emissions. At the same time, environmental protection equipment at boiler houses is often missing or does not operate properly, thus accounting for almost half of the contribution to total emissions from power generation facilities. In fact, the use of treatment devices at thermal power houses offsets the emissions from four times the fuel consumption compared to boiler houses.

Thus, the environmental features unique to the energy industry of the Asian regions of Russia should also include:

- low level of gasification of boiler houses and power houses;
- high wear and tear of energy equipment and the use of obsolete equipment;
- lack of measures to process the coal before combustion (including thermal processing and gasification of coal);
- lack of ash capturing equipment at boiler houses and gas treatment equipment at large thermal power houses. Given the new challenges posed by

the climate agenda for generation facilities, it is necessary to provide for the following:

- equipment of the facilities with greenhouse gas capture systems;
- burial or re-purposing of carbon dioxide;
- introduction of automated boiler houses;
- increase in the share of energy facilities that run on renewable energy sources;
- implementation of energy-saving measures at all stages of energy production;
- continuous monitoring of the effluence of both pollutants and carbon dioxide into the environment.

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