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**Interim Report** **IR-04-033**

# Assessment of Energy-related Emissions of Greenhouse Gases in Russia

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**Approved by**

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13 July 2004

## Contents

## Abstract

Russia is a substantial emitter of greenhouse gas (GHG) emissions. The energy sector is responsible for the major part of this emission. Official National Communications of Russia seem to present incomplete and out of date estimates of energy-related GHG emissions. The objective of this work is to present alternative assessments of the emissions of the Kyoto GHGs from the energy sector of Russia in 1990–2000 challenging the official estimates. The work focuses on inventory of emissions of multiple GHGs from combustion of fuels using IPCC methodology and estimation of $CO_2$ emissions from regions of the Russian Federation in 1990 and 1997.

This report also gives an overview of GHG emissions in Russia and a comparison of the results from various studies in these fields.

## Acknowledgments

I would like to express my sincere thanks to Sten Nilsson, who was my supervisor during the summer of 2003, for his help and valuable advice. He also reviewed my report and helped to improve it with constructive criticism and many useful remarks.

My gratitude is extended to the members of the Forestry (FOR) Program for the many discussions and useful suggestions. I am very grateful to Shari Jandl for her editorial assistance.

I am grateful not only to the staff of the Center for Energy Efficiency (CENEf) but personally also to Inna Gritsevich for all the useful information and comments.

## About the Author

Alexander Kolesov graduated in applied mathematics and physics from Moscow Institute of Physics and Technology (MIPT) in 1991. In 1992–1995 he was a post-graduate student at the Center for Arms Control, Energy and Environmental Studies of MIPT. Later, Kolesov worked as a researcher at the Energy Research Institute of the Russian Academy of Sciences and then at the Center for Energy Efficiency (CENEf) on projects related to climate change, energy and energy efficiency. He spent the 1993–94 academic year at the Department of Engineering and Public Policy of Carnegie Mellon University and at Battelle Memorial Institute, Pacific Northwest National Laboratories where he took part in a number of international studies in the field of energy efficiency and climate change. Since 1999 he has been working on a Multi-Regional Project to Develop Monitoring and Reporting Capacity for Multiple Greenhouse Gases in Russia.

Kolesov was a participant in the 2003 Young Summer Scientist Program (YSSP) assigned to the Forestry (FOR) Program.

## Assessment of Energy-related Emissions of Greenhouse Gases in Russia

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# 1 Introduction

Detailed, accurate, methodologically transparent, and verifiable national reports on greenhouse gas (GHG) emissions and sinks are a key condition for countries to take part in flexible mechanisms under the Kyoto Protocol. This is most important for Russia, which has a considerable untapped national quota of GHG emissions and a huge energy efficiency potential. Through flexible mechanisms, Russia hopes to attract additional investments to upgrade the economy and industrial sector, and improve energy efficiency and competitiveness in the world markets. Sectoral GHG emissions inventories are an integral part of emission reduction strategies for any country, including Russia. Such inventories can also help Russia accelerate the estimation of emissions process.

This work is dedicated to the GHG inventory of Russia focusing on the energy sector, the key source of GHGs in the country.

The main objective of this paper is paid to the calculation and analysis of GHG emissions related to fuel combustion for energy needs and to fugitive emissions of non-$CO_2$ gases. The work is performed in accordance with the recommendations and classification of the Revised Intergovernmental Panel on Climate Change (IPCC) Guidelines for Greenhouse Gas Inventories, and two approaches were used in this study: (1) Reference Approach, and (2) Source Categories Approach. In the case of the Reference Approach, $CO_2$ emissions related to combustion of the majority of fossil fuels for energy needs were calculated; $NO_x$ and $CH_4$ emissions were estimated only under the Source Categories Approach. The main sources for information on fuel production and consumption used in the study are described and their compatibility with the IPCC requirements was analyzed. Trends in emission structures are also studied.

The first part of the report describes the current status of GHG inventories in Russia. The second part is dedicated to describing the main components of the IPCC methodology for the inventory of energy-related GHG emissions. The third part of the report is devoted to the inventory of GHGs in Russia. It includes a summary of sub-sections and the sector specific description of GHG emissions estimated by the Reference Approach and by Source Categories corresponding to the modules of the IPCC Guidelines.

In addition, there is an estimation of national GHG emissions in different sectors for identifying the improvement needs of inventories. This includes new estimates obtained for $CO_2$ emissions for various sectors of the economy (energy industries, manufacturing and construction, residential sector, commercial sector, agriculture, etc.). These estimates are based on 1990, 1995 and 2000 data. The data of 1998 and 1999 were influenced by the August 1998 economic and financial crisis and are not used in this case. A comparison between 1995 and 2000 with the base year of 1990 is also carried out. The analysis also includes a general overview of GHG emissions in Russia as a whole.

A national $CO_2$ emission break-down by regions of Russia in 1990 and 1997 is also presented. This includes part of the total $CO_2$ emissions including major carbon fuels combustion for energy needs in the regions; natural gas, heavy oil, diesel fuel, and gasoline. It gives a representative picture of contributions by different regions to the total GHG emissions in Russia, and reveals major regional characteristics of the source structure and changing trends. A comparative analysis of the regional structure of anthropogenic GHG emissions and sinks may be helpful in identifying priority strategies and partners for activities aiming at reduction of anthropogenic GHG emissions in the frameworks of both national policy setting and international cooperation.

The fourth part of the report gives an overview of GHG emissions in Russia and a comparison of the results with other studies in this field.

# 2 Background

## 2.1 Current Situation of GHG Inventories in Russia

One of the obligations of the Russian Federation as a Party to Annex 1 of the United Nations Framework Convention on Climate Change (UNFCCC) is to report national GHG emissions. National Communications (NC) have a three year interval and the Annual Inventory is due on 15 April of each year. The first NC was presented in 1995, the second in 1998 and the third was due in 2002, however, no Annual Inventory has yet been officially presented. The assessments for the NCs were carried out by a small group of specialists from the Institute of Global Climate and Ecology of the Russian Federal Service for Hydrometeorology and Environment Monitoring and Russian Academy of Sciences in cooperation with experts from various ministries, agencies, and institutions. The platform for the assessments was formed in 1994–1995, when the appropriate GHG inventory tasks were carried out by a Russian team within the framework of the US Country Studies Program.

In the second NC, the emissions in the energy sector are estimated according to the country's detailed fuel balance developed in 1994 by the State Committee of Russia for Statistics. On this basis, emissions from fuel combustion were calculated (including non-$CO_2$ GHG emissions), mainly using the IPCC default emission factors.

A brief overview of the details and data quality shows the following conclusions. The energy sector, and first and foremost fuel combustion, is the dominant GHG source in

Russia. The first NC comprised approximate data for 1990, whereas the second NC included data for 1994, slightly improved data for 1990 and some data for 1993–1994.

In 1998–1999 the work proceeded within the framework of the Federal Target Program "Prevention of Climate Change and Its Negative Consequences". The Program was approved in 1996, and included a subprogram on GHG inventory activities. Unfortunately, the limited funding of the Program allowed mainly approximate assessments.

In 1999–2000, some additional estimations of GHG emissions for 1995 and 1996 were made and presented to the UNFCCC Secretariat.

The third NC contains data on energy-related GHG emissions for 1997, 1998 and 1999. In spite of the fact that this NC was issued in 2002, it does not contain estimations for 2000. Similar to previous NCs the complete set of standard IPCC inventory table forms were not completed. None of the NCs contain results of the Source Categories Approach inventories of energy-related GHG emissions.

In 1998–1999, RAO "EES Rossii" conducted $CO_2$ emission inventory of 1990–1997 in compliance with IPCC methodology and recommendations. This inventory includes almost 370 large heating facilities which play a key role in the Russian power and heat supply systems and takes into account thermal properties of different fuels (various coals, natural gas, peat, heavy oil, and coke), as well as generation processes and capacities used by these facilities. In addition, RAO "EES Rossii" developed an investment portfolio for some of these facilities. Therefore, this information allows for a more comprehensive understanding of the regional emission structure and for a better identification of priority strategies and promising regions for reduction of GHG emissions.

Currently there is no *official* methodology and software to carry out GHG inventories in Russia. Work with Russian versions of software (Excel spreadsheets) and Workbook leads to mistakes and errors in completing the worksheets. That is why it is possible to work only with original English versions of the software.

## 2.2 Methodology

### *2.2.1 Main components of energy-related GHG inventory using IPCC methodology*

According to the IPCC classification the *Energy* category includes emissions of all UNFCCC GHGs originating from energy activities (fuel combustion for energy purposes, and emissions connected with leakages). The IPCC methodology for calculating energy-related emissions consists of two parts:

(A) Calculation of emissions from **Combustion of fuels**, and
(B) Estimation of **Fugitive emissions.**

**(A) Emissions from fuel combustion**

All emissions of all GHGs related to combustion of all types of fuels during any human economic activity. GHG emissions related to biomass combustion (wood, wood wastes, etc.) are calculated but not included in the total emissions number.

Emissions from the following sectors are calculated under this category:

1. Energy industries;
2. Manufacturing and construction;
3. Transport;
4. Commercial and institutional;
5. Residential;
6. Agriculture and forestry; and
7. Other mobile and stationary sources.

**(B) Fugitive emissions**

Intentional and unintentional emissions/leaks of GHG caused by human activities are taken into consideration. These emissions may originate during the production, transformation, transmission, storage and consumption of fuels and include emissions from combustion of fuels when it is not connected with energy purposes and for industrial activities (for instance, flaring of natural gas).

This section is also deals with emissions caused by leaks of natural gases during the production, storage, transportation and transformation of:

1. Solid fuels, and
2. Oil and natural gas.

***Calculations:***

***Combustion of fuels***

This part consists of two subsections:

1. Emissions of $CO_2$, and
2. Emissions of non-$CO_2$ gases.

According to IPCC methodology, there are two levels of consideration with respect to combustion of fuels:

1. *Reference Approach* — estimation of emissions based on gross amounts of fuel combustion; and
2. *Source Categories Approach* — estimation of emissions is based on the combustion of fuels in sectors of the economy enumerated above.

The Reference Approach is simpler and requires much less data than the Source Categories Approach.

***Fugitive emission of methane***

This section also consists of two parts:

1. Methane emissions from coal production; and
2. Methane emissions from oil and gas activities.

Accidental and non-accidental emissions and leakages of methane, as well as leakages during repairing and maintenance of equipment are taken into account in this section.

# 3 Inventory of GHG Emissions Related to Fuel Combustion in Russia

Fuel combustion for energy needs makes the greatest contribution to the GHG emissions in Russia. The emissions are determined by the economic activities, where the energy sector, including production, transportation and treatment of most fossil fuels such as oil, natural gas and coal, and power and heat production, plays the most significant role.

According to the Revised IPCC Guidelines for Greenhouse Gas Inventories, two approaches — as mentioned above — are used in this study: (1) Reference Approach, and (2) Source Categories Approach. In the case of the Reference Approach, $CO_2$ emissions related to combustion of the majority of fossil fuels for energy needs are calculated; $NO_x$ and $CH_4$ emissions are estimated only under the Source Categories Approach. The results of the inventory are presented electronically in MS EXCEL format with the help of software developed for Module 1 of the Workbook for the Revised IPCC Guidelines for Greenhouse Gas Inventories (IPCC, 1996).

## 3.1 Reference Approach

According to the Reference Approach, GHG emission is estimated based on the data of total consumption of different types of fossil fuels in the region (the data are not split by particular sectors and/or technologies). Average coefficients of carbon content and of the share of carbon oxidized for particular fuels are used for the conversion of energy units to tons of $CO_2$.

Annual data on production, exports and imports to the region, and on total fuel consumption in Russia were used to calculate energy-related GHG emissions. Thus, Energy Balances of Russia, as part of the USSR Energy Balance for 1990, and specific Russian Energy Balances for 1991, 1995, and 2000 were used for the calculations. Other statistical materials, data from the special statistical forms ("4-toplivo" containing data on annual consumption of specific fuels measured in physical units), etc., were used as the main sources of information to compose energy balances for 1991, 1995 and 2000. This information helps in taking into account all fuels (22 types) including all kinds of coal used in a region. Thus, the conversion to tons of coal equivalents was made based on energy characteristics of particular fuels. For this purpose, information on annual consumption of different kinds of coal in physical units (metric tons) was converted to tons of coal equivalent with the help of an energy conversion factor for each kind of coal. Due to the lack of detailed information on the specifics of coal consumption, conversion to energy units was done with the help of an average weighted conversion factor calculated based on the regional coal consumption structure. However, this factor was irrelevant for 1990 $CO_2$ emission estimates, because heat values of local fuels had been taken into account in the energy balance for that year.

Energy balances and additional statistical materials used in the study contain data on secondary fuel consumption (diesel oil, mazut,[1] etc.), categories that are somewhat different from the fuel categories used in the Revised IPCC Guidelines. Thus, fuels with similar low heat values were combined and placed in corresponding lines in the spreadsheets. For instance, "navy mazut" was added to "burner mazut"; "household furnace fuel" and "motor fuel" were added to "diesel oil".

Goskomstat and IEA data for 1992, 1993, 1994, 1996, 1997, 1998 and 1999 were used for GHG inventories for these years.

Emissions were estimated for the period 1990–2000. As illustrated in Figure 1, the total $CO_2$ emissions declined in the beginning of the period and in 2000 was 33% less compared to 1990. Solid fuel combustion related emissions (other bituminous coal) declined by 45% by 1998 and grew slightly in 1999–2000. The dynamics of emissions related to natural gas combustion are about the same: a decline of 17% in 1990–1998 followed by a slight growth in 1999–2000 back to the level of 1996 emissions. While there is a general tendency of a reduction of liquid fuels combustion-related emissions (which had declined by 51% by 1998), an increase can be identified again in 1999–2000.

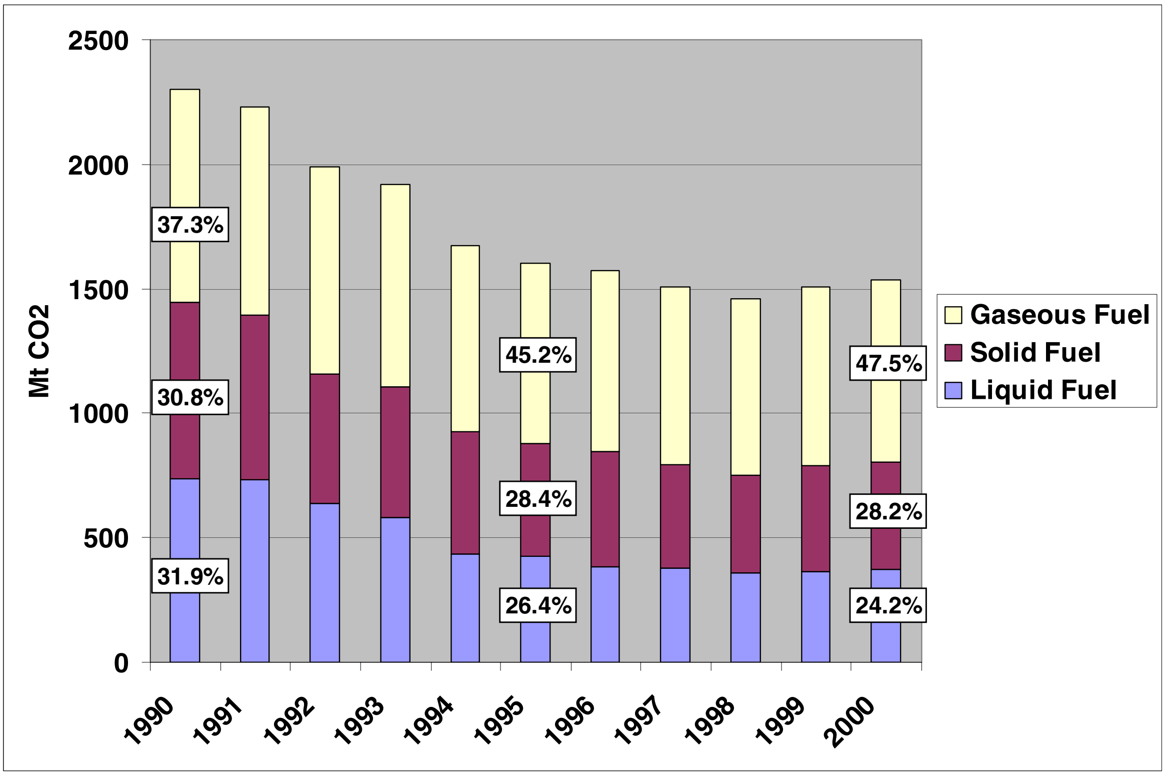


*Figure 1:* $CO_2$ emissions in Russia by types of fuels.

[1] Analog of heavy fuel oil.

Natural gas combustion makes the largest contribution to emissions (more than 47% in 2000) and its share constantly grew during the period under consideration. In 1998, it reached its maximum of 49%. At the same time, the contribution of solid fuels went down from 31% in 1990 to almost 28% in 2000, while the contribution of liquid fuels decreased from 32% to 24%.

The total picture is that the energy-related emissions declined substantially during the period 1990–1998 but the total emissions started to increase again in 1999 and 2000 but still being at a 33% lower level than in 1990.

## 3.2 Estimation of Emissions by Source Categories

### 3.2.1 $CO_2$ emissions

Emissions of greenhouse gases related to fuel combustion for energy needs of Russia were estimated by the source categories described below in compliance with recommendations and classifications proposed in the revised 1996 IPCC Guidelines and using energy balance information and fuel consumption data available from statistical reports of the Russian Federation, which were corrected to match the IEA format:

(1) ***Power and heat generation.*** This category comprises thermal power plants and co-generating plants of RAO ES Rossii, other power plants, municipal and industrial boilers that supply energy to public networks to meet heat and power demand by the country, fuel (coal, gas and oil) producers and petroleum refineries. Fuel consumption for heat and power generation for customers and internal needs, as well as fuel losses were taken into consideration.

(2) ***Industry and construction.*** This category covers the aggregate contribution of the enterprises in all industries in Russia, including ferrous and non-ferrous metallurgy, chemical and petrochemical industry, light industry, food, mechanical wood industry, secondary wood industry, pulp and paper industry, machine building, production of building materials, and construction, etc. End-use and own needs of fuel consumption of all major industrial enterprises and facilities of the enterprises (organizations) were taken into account.

(3) ***Transport*** — includes railway transport, sea and river transport, air transport, road transport and pipelines. Fuel consumption by vehicles, excluding internal transfers and companies' own transportation needs, was taken into consideration.

(4) ***Commercial and institutional sector***. Includes public services (schools hospitals, post, etc.), municipal economy, trade and services. End-use fuel combustion was taken into account.

(5) ***Residential sector.*** Fuel consumption to satisfy various household needs was taken into consideration.

(6) ***Agriculture.*** Fuel consumption by all types of organizations with various agricultural activities was taken into account. This is driven by the format of information on fuel and energy consumption in agriculture used in the statistical system of the Russian Federation.

With respect to specific coal and natural gas emission factors, the estimates are based on those of RAO EES Rossii made for inventory purposes. With respect to any other types of fuels, the estimates are based on the factors recommended by the IPCC Guidelines.

A detailed inventory was made for 1990, 1995 and 2000. These years were chosen due to the availability of a sufficient amount of systematic official information on fuel consumption in Russia. There are possibilities to make inventories for other years during the period 1991–1999. However, completeness, level of detail and reliability of these inventories are much lower due to insufficient amount of reliable data for these years.

GHG emissions related to fuel combustion to satisfy the energy needs of Russia by sources in 1990, 1995 and 2000 were estimated relying on the fuel and energy balances of the country for these years. The estimates were brought into compliance with the IEA format, which required correction of certain data for use as input in spreadsheets and calculation of emissions in conformity with IPCC methodology. Thus, the energy balance data on natural gas consumption by the fuel industry was taken into account in the section "Energy Industries" (rather than in the section "Manufacturing Industry"), because this gas was used by the fuel industry to satisfy energy needs. Balance data on gasoline consumption by private vehicles were input in the section "Transport", because this fuel could not be used for other purposes.

Fuel and energy balances of Russia do not provide information on fuel consumption in agriculture broken down by mobile and stationary users, therefore, while completing the section "Agriculture" a decision was made to account balance coal consumption data in the column "Stationary Sources", based on an assumption that no mobile agricultural mechanisms can run on coal.

In the Russian system of statistical reports, fuel consumption by municipal boilers for conversion into other types of energy is shown in the section "Housing and Public Utilities Sector" which does not comply with the IPCC format. In this context, a decision was made to adjust the data on residential fuel consumption in 1995 and 2000 to fuel consumption by municipal boilers. Fuel consumption by municipal boilers was taken into account in the section "Energy Industries".

As in the 1990 GHG emissions inventory, the data on residential gasoline and diesel fuel consumption in 1995 and 2000 were also accounted in the section "Transport", because the amounts of such fuels used for other purposes are barely noticeable.

The $CO_2$ emission estimates by source categories are presented in the IPCC electronic tables and in the summary table (Figure 2, Table 1). The table shows that fuel combustion in the energy sector is responsible for the largest $CO_2$ emissions, and its share slightly increased from 58% in 1990 to more than 60% in 2000. This is caused by the fact that emission reduction from this source was smaller (only 28% during the period 1990–2000), as compared to other sources, except for transport and residential sector.

While in 1990 the contribution of transport was third largest (almost 15%), in 2000 its contribution grew up to 17% and became second largest, whereas the contribution of the industry became third largest and its share was reduced from 18% to 15% during the same period.

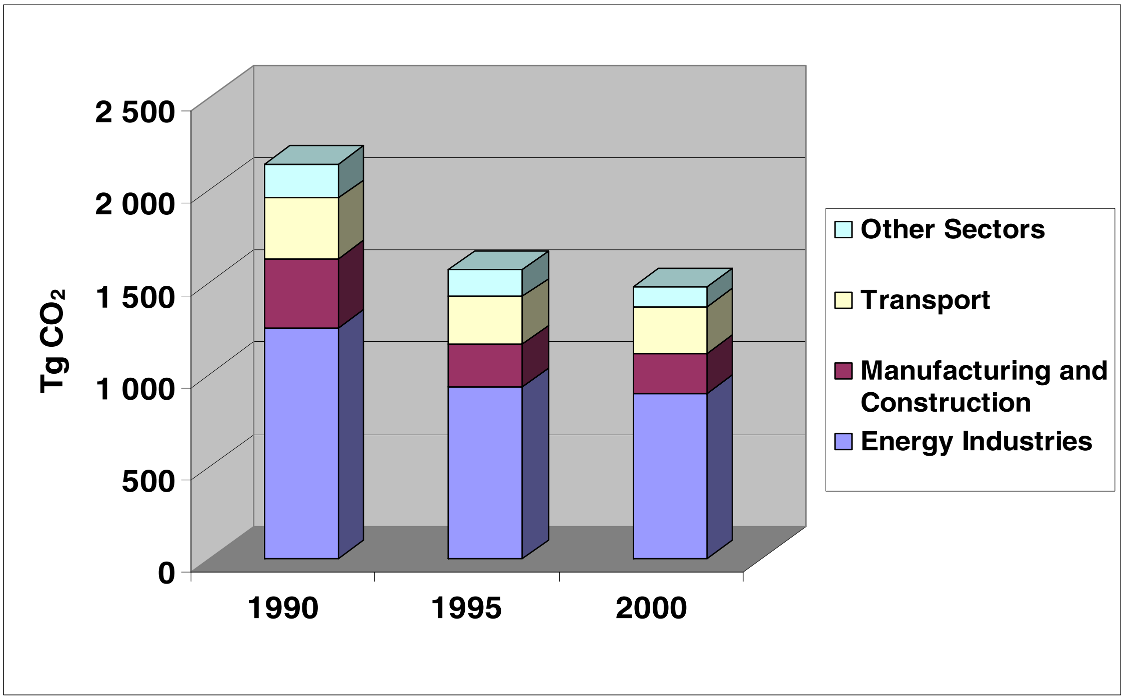


*Figure 2:* Energy-related $CO_2$ emissions in Russia by major source categories.

*Table 1:* Results of $CO_2$ Emission Estimates by Source Categories in Russia, Gg $CO_2$.

| **Source Categories** | | **1990** | **1990 % from SCA** | **1995** | **1995 % from SCA** | **2000** | **2000 % from SCA** |
|---|---|---|---|---|---|---|---|
| Energy Industries | | 1250099.6 | 58.46 | 930581.65 | 59.37 | 896772.72 | 60.84 |
| Manufacturing and Construction | | 376327.89 | 17.60 | 230332.75 | 14.69 | 216467.95 | 14.69 |
| Transport: | Domestic Aviation | 32675.12 | 1.53 | 22388.00 | 1.43 | 19978.76 | 1.36 |
| | Road Transport | 148251.15 | 6.93 | 122645.55 | 7.82 | 112533.45 | 7.63 |
| | Rail Transport | 18582.54 | 0.87 | 4635.93 | 0.30 | 18647.65 | 1.27 |
| | National Navigation | 17367.69 | 0.81 | 5896.97 | 0.38 | 9923.79 | 0.67 |
| | Pipeline Transport | 111413.95 | 5.21 | 102414.46 | 6.53 | 93002.26 | 6.31 |
| | Total Transport | 328290.45 | 15.35 | 257980.91 | 16.46 | 254085.91 | 17.24 |
| Commercial and Institutional | | 32919.07 | 1.54 | 11711.88 | 0.75 | 9226.09 | 0.63 |
| Residential | | 90682.56 | 4.24 | 88760.09 | 5.66 | 73590.85 | 4.99 |
| Agriculture: | Stationary | 14047.43 | 0.66 | 16736.05 | 1.07 | 19577.84 | 1.33 |
| | Mobile | 45851.26 | 2.14 | 31379.16 | 2.00 | 4308.54 | 0.29 |
| | Total Agriculture | 59898.69 | 2.80 | 48115.21 | 3.07 | 23886.38 | 1.62 |
| Total Source Categories | | 2138218.3 | 100.00 | 1567482.5 | 100.00 | 1474029.9 | 100.00 |
| Difference between RA and SCA | Total | 165231.07 | | 89080.83 | | 55144.06 | |
| | % from RA | 7.17 | | 5.38 | | 3.61 | |
| Total RA | | 2303449.34 | | 1656563.33 | | 1529173.96 | |

SCA = Source Categories Approach; RA = Reference Approach.

Transportation emissions decreased by 23%. At the same time, railway emissions in 2000 remained at the 1990level, while aviation emissions showed considerable reduction (more than 39%). The biggest contribution is made by emissions of road transport (over 45% of total emissions from transport) and its share remained the same in 2000 as in 1990.

The share of the commercial and institutional sector in the generation of emissions was reduced more than twice, from 1.5% to 0.6% during 1990–2000, while the share of the residential sector remained relatively the same — 4.2% in 1990 and 4.9% in 2000. In absolute figures, emissions from the commercial and institutional sector were reduced totally by 72% from 1990 to 2000. The emissions from the residential sector reduced by 19%. Such dynamics primarily results from less accountability of data on fuel consumption for heating purposes both by small businesses, which provide incomplete statistical reports due to current tax regulations for the services industry, and by the residents who live in private houses.

The quality of information on the fuel consumption in agriculture and forestry is rather low. The emission dynamics in this sector is similar to others. Precisely these emissions have decreased significantly (2.5 times) in these sectors during the period from 1990 through 2000, and primarily from mobile sources. The basic fuels still include diesel fuels — for mobile sources, and coal — for stationary sources.

The total amount of $CO_2$ emissions based on source categories were reduced from 2,138,218 Gg in 1990 to 1,474,030 Gg in 1999, i.e., by 31%.

$CO_2$ inventories by Source Categories in 1990, 1995, and 2000 cover 93%, 95% and 94%, respectively, of emissions assessed by the Reference Approach, which can be considered a good correlation compared to the Reference Approach.

### *3.2.2 Non-$CO_2$ emissions*

Emissions of $CH_4$, $N_2O$, $NO_x$ and CO result from fuel combustion in all sectors, as well as methane emissions related to production, processing and transportation of coal, petroleum and natural gas.

All emissions were estimated in full compliance with the IPCC methodology to cover the same years and using the same sources of information as in the $CO_2$ emissions estimation.

Methane emissions related to the combustion of fuel in Russia decreased almost 1.5 times in 2000, compared to 1990. In 1990, coal combustion by residential sector was responsible for the largest emission of methane. The contribution of fire wood combustion to methane emissions was the second largest due to a relatively large scale of fire wood consumption in the residential sector. In 2000, coal — which was mainly used in power generation industry — accounted for almost 50% of the emissions. Combustion of coal for power and heat generation was the main source of $N_2O$ and $NO_x$ emissions, which were reduced by approximately 35% during the period 1990–2000.

In Russia, coal is mined in open pits and underground mines. The structure of coal mining has not changed very much: in 1990 55% of coal was mined in open pits, and by 2000 the share of coal that was mined in open pits grew to 65%. As a result, methane emissions related to mining coal remained relatively stable.

Russia is one of the biggest oil and natural gas producers in the world. Transportation of natural gas in pipelines and its leakage is the third largest source of methane emissions. Fugitive emissions of GHGs from oil and natural gas activities were estimated in full compliance with the IPCC methodology using default country-specific emission factors. The inventory covers all emissions from the production, processing, transport and use of oil and natural gas. Emissions of GHGs from non-productive combustion (gas flaring) were not calculated because of the lack of information on these types of activity in open sources of information and absence of local emission factors for Russia.

Goskomstat sources of information were used to obtain data on volumes of oil and gas production and transportation, as well as on lengths of pipelines. The volume of oil production and transportation changed insignificantly during this period of time, whereas the volume of petroleum refining decreased since 1990 but remained too insignificant to generate considerable methane emissions. Methane emissions caused by leakage remained relatively stable over the period 1990–2000 as volumes of natural gas transportation by pipelines changed insignificantly.

Information on fuel consumption and gas transportation is quite reliable and accessible, but the information on country-specific emission factors is very contradictive and not uniform. So the quality of estimation of non-$CO_2$ emissions related to fuel consumption and transportation is rather low. In the case of coal mining, problems of obtaining data on coal bed methane emission factors for coal fields in Russia are substantial. The experts from Skochinski Institute of Mining and Institute of Coal and Coal Chemistry of the Siberian branch of the Russian Academy of Sciences provided estimates of this information. Estimated methane emission factors for underground and surface mines used in this study are presented in Table 2.

*Table 2:* Estimated methane emission factors for different methods of coal production, $m^3$ $CH_4$/t of coal produced.

| | | **Emission Factor** |
|---|---|---|
| ***Underground Mines*** | Mining | 10 |
| | Post-Mining | 2.5 |
| ***Surface Mines*** | Mining | 8.5 |
| | Post-Mining | 0.1 |

Energy-related nitrous oxide emissions originate from fossil fuel combustion from both stationary and mobile sources. The volumes of $N_2O$ emissions from combustion of fuels were calculated based on volumes of fuel combusted by various sectors and default $N_2O$ emission factors for Russia. The energy industries sector is responsible for 64% of nitrous oxide emissions in Russia.

Nitrogen oxides ($NO_x$) are indirect GHGs. They have been the target of environmental policies for their role in forming ozone ($O_3$), as well for their direct acidification effects. Fuel combustion activities are the most significant anthropogenic source of $NO_x$ in Russia. Within fuel combustion, the most important sources are the energy industries and mobile sources. These sources were responsible for 50% and 35% of total $NO_x$ emissions in Russia in 2000 respectively.

Carbon monoxide is an indirect GHG. The majority of CO emissions from fuel combustion come from motor vehicles. Another large contributor is the residential sector with small combustion equipment. Emissions of CO from transport accounted for 78% of the total CO emissions in 2000. CO emissions were reduced by approximately 36% during the period 1990–2000.

Summary information on energy-related GHG emissions is presented in Figure 3 and Table 3.

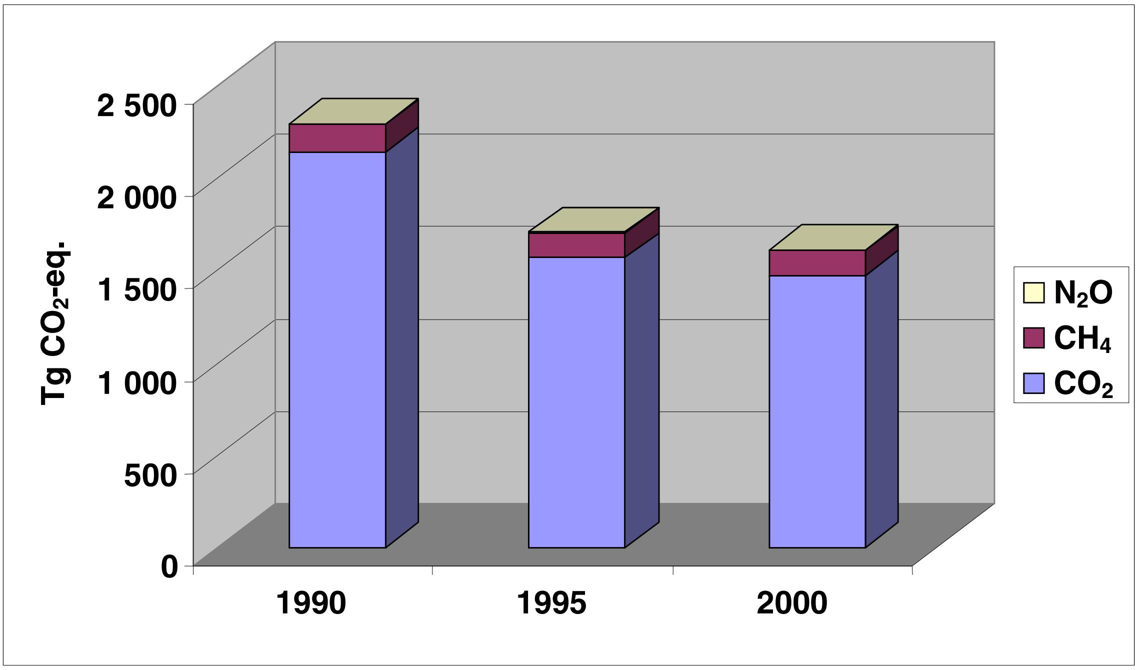


*Figure 3:* Summary data on energy related GHG emissions in Russia.

*Table 3:* Summary data on energy related GHG emissions in Russia, Gg per year.

| Year | GHG Source Categories | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO |
|---|---|---|---|---|---|---|
| **1990** | **Emissions, total** | **2138218** | **7156** | **17** | **7559** | **16093** |
| | **(A)** Fuel Combustion (Sectoral Approach) | 2138218 | 342 | 17 | 7559 | 16093 |
| | (1) Energy Industries | 1250100 | 26 | 10 | 3526 | 414 |
| | (2) Manufacturing Industries and Construction | 376328 | 28 | 3 | 1006 | 346 |
| | (3) Transport | 328290 | 32 | 2 | 2199 | 11651 |
| | (4) Other Sectors | 183500 | 257 | 3 | 828 | 3682 |
| | **(B)** Fugitive Emissions from Fuels | 0 | 6814 | 0 | 0 | 0 |
| | (1) Solid Fuels | 0 | 1779 | 0 | 0 | 0 |
| | (2) Oil and Natural Gas | 0 | 5035 | 0 | 0 | 0 |
| **1995** | **Emissions, total** | **1567483** | **6445** | **13** | **5108** | **11955** |
| | **(A)** Fuel Combustion (Sectoral Approach) | 1567483 | 279 | 13 | 5 108 | 11955 |
| | (1) Energy Industries | 930582 | 23 | 7 | 2 650 | 459 |
| | (2) Manufacturing Industries and Construction | 230333 | 20 | 2 | 634 | 287 |
| | (3) Transport | 257981 | 25 | 1 | 1467 | 8921 |
| | (4) Other Sectors | 148587 | 212 | 2 | 357 | 2287 |
| | **(B)** Fugitive Emissions from Fuels | 0 | 6166 | 0 | 0 | 0 |
| | (1) Solid Fuels | 0 | 1803 | 0 | 0 | 0 |
| | (2) Oil and Natural Gas | 0 | 4363 | 0 | 0 | 0 |
| **2000** | **Emissions, total** | **1474030** | **6265** | **11** | **4867** | **10339** |
| | **(A)** Fuel Combustion (Sectoral Approach) | 1474030 | 233 | 11 | 4867 | 10339 |
| | (1) Energy Industries | 896773 | 19 | 7 | 2462 | 405 |
| | (2) Manufacturing Industries and Construction | 216468 | 18 | 2 | 598 | 266 |
| | (3) Transport | 254086 | 23 | 1 | 1682 | 8049 |
| | (4) Other Sectors | 106703 | 172 | 1 | 125 | 1620 |
| | **(B)** Fugitive Emissions from Fuels | 0 | 6032 | 0 | 0 | 0 |
| | (1) Solid Fuels | 0 | 1720 | 0 | 0 | 0 |
| | (2) Oil and Natural Gas | 0 | 4312 | 0 | 0 | 0 |

# 4 Regional Structure of GHG Emissions in Russia

## 4.1 Introduction

This analysis attempted to assess and analyze the regional structure of GHG emissions in Russia. This attempt could be an important step in improving anthropogenic GHG emissions and sinks inventory in Russia, and bringing it in line with the IPCC methodology and requirements to Annex I countries' national reports on GHG emissions and sinks.

It is important to point out that accurately transparent methodologically and verifiable national reports on GHG emissions and sinks are a key condition for countries to take part in flexible mechanisms under the Kyoto Protocol. This is most important for Russia, which has a considerable untapped national quota of GHG emissions and huge energy efficiency potentials. Through flexible mechanisms, Russia hopes to attract additional investments to upgrade the economy and industrial sector, improve energy efficiency and competitiveness in world markets.

There is a need to analyze the regional structure of GHG emissions because, above all, Russia has a two-level statistical reporting system. The major part of primary information is collected and analyzed on the regional level. On the federal level, information from the regions is analyzed, in particular, to get average, as well as global data for the whole country. Therefore, the quality of national information on anthropogenic GHG emissions and sinks is determined, in the first place, by the quality of regional inventories.

As a country, Russia is based on federal principles. It unites 89 "subjects of the Federation" (including nine autonomous counties, which in this paper will be considered parts of corresponding regions, rather than separate entities), which differ a lot in many characteristics, such as geographical location, size of territory, population, climate, availability of natural resources and raw materials, economic structure and conditions, etc. In accordance with the Federal Constitution, subjects of the Federation have a certain degree of freedom in setting priorities and implementation of, social, economic, and environmental policies. Therefore, a comparative analysis of the regional structure of anthropogenic GHG emissions and sinks may be helpful in identifying priority strategies and good partners for actions aiming at reduction of anthropogenic emissions and both in the framework of national policy setting and international cooperation.

## 4.2 Information Sources

At this point, there is not satisfactory information for regional inventories of anthropogenic GHG emissions and sinks, therefore the assessments in this study are approximate. The inventories include parts of $CO_2$ emissions from major carbon fuels combustion in the regions, including natural gas, heavy oil, diesel fuel, and gasoline. A comparison of contributions by various fuels may be useful while assessing emission reduction measures, for example in Joint Implementation fuel switch projects.

The limitation to only these parts of emissions in the analysis does not cause any significant distortions to the regional structure. The reason for this is that over the last decade $CO_2$ emissions accounted, at a stable level, for around 78% of the total GHG emissions in Russia. Over 98% of these were caused by fuel combustion of the energy sector.

Major information sources for the analysis were Goskomstat data on regional fuel consumption (formats 4T and 11-TER); data by "Kortes" information and analysis center; reference books by Goskomstat, Gazprom, Infotech, etc. Thus, many information sources were used, because none of the above individual sources contains all the necessary data, and in some cases the data provided by different sources do not coincide and have to be recalculated and verified.

## 4.3 Regional Structure of 1997 $CO_2$ Emissions

The regional structure of $CO_2$ emissions was assessed for 1997, because there is enough information available for this year, and the economic situation in Russia in 1998 and 1999 was highly unstable due to the financial crisis of 1998 as well as to price fluctuations in the world oil market.

Figure 4 shows the volume-ordered regional structure of $CO_2$ emissions in 1997. Contributions by separate fuels to the total emission are shown in different colors. The cumulative curve reflects progressive total regional contributions (percent) to the total emission. The figure also shows that the biggest emission in 1997 was in Sverdlovsk Region and in Moscow (around 76 and 74 million tons $CO_2$, respectively). However, the structure of sources is absolutely different: in Sverdlovsk Region, 50% of the emissions are caused by coal combustion, whereas in Moscow natural gas combustion is responsible for over 80% of the emissions. Importantly, 15 regions with the highest annual emission (30–76 million tons $CO_2$) are responsible for more than 50% of the total emissions of the country, whereas 32 regions with the lowest emission levels add only 10%. The reason for this is that heat sector emitters contribute by about 30% to the total regional emissions, except for Chelyabinsk Oblast (26%), where large energy intensive industrial enterprises (steel plants) are also big heat and power producers and suppliers.

Geographically, regions with the highest $CO_2$ emission levels are spread all over the country: from Moscow to Primorsky Krai (Russian Far East). However, while analyzing $CO_2$ emissions from natural gas and coal combustion, locations may be identified more specifically.

The largest $CO_2$ emissions from coal combustion are in coal extraction and neighboring regions, for example, in Kuzbass. Kemerovskaya Oblast, where coal is extracted and ferrous metallurgy is located, comes first (over 12%). Nine regions of the Urals, Siberia, and Far East are responsible for 60% of the total $CO_2$ emissions from coal combustion. The analysis shows that 64 regions add only 10% to this amount; in particular, coal is practically unused in Moscow (only 0.28% of the total emissions in that region).

Locations of the largest natural gas consumers largely depend, to a large extent, on access to the gas supply system. Two regions — Moscow and Tyumen Oblast — stand out against the other regions, as they are responsible for over 18% of the emissions from natural gas combustion. At the same time, 14 regions, including practically the whole of East Siberia and Russian Far East, have no access to the natural gas supply whatsoever (for some of them, propane is supplied for residential needs).

In all regions, other fuels' contribution to the $CO_2$ emissions is much less, than the contributions of natural gas and coal. Only in some regions (Murmanskaya and Kamchatskaya Oblasts, Karelia Republic, and Bashkortostan), mazut makes a substantial contribution in relation to total emissions. This is determined by a number of specific features of these regions.

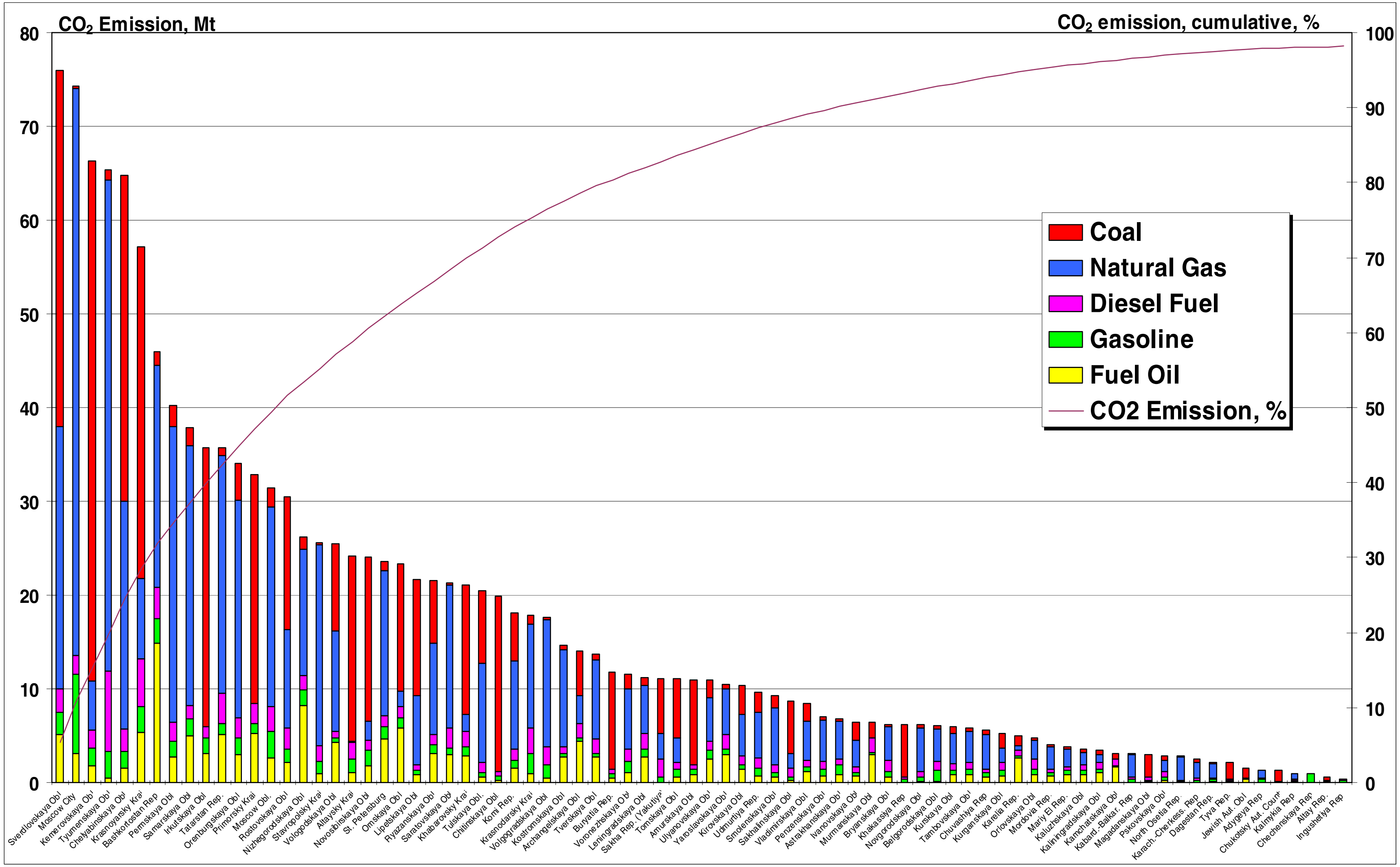


*Figure 4:* Regional structure of $CO_2$ emissions in the Russian Federation in 1997.

As mentioned above, Russia's regions significantly differ in many characteristics; therefore, it makes sense to consider specific $CO_2$ per capita emissions and emissions per unit of Gross Regional Product (GRP[2]) for a correct understanding of the emission ratio between the regions. This is illustrated in Figure 5. The diagram is structured over GRP per capita in the region. It is clear from the figure that the emission factor per unit of Gross Regional Product in Moscow is the lowest in the country: 232 tons $CO_2$/billion rubles (1997 prices); and in Kostroma Oblast are the highest: 1,653 tons $CO_2$/billion rubles. In half of the regions (39 regions) the emission factor per unit of GRP varies between 300 and 600 tons $CO_2$/billion rubles (1997 prices). At the same time, only in three of twenty regions with the highest GRP per capita the emission exceeded 800 tons $CO_2$/billion rubles, which is in line with global trends.

Dispersion of per capita emission is also pretty big: from 1.01 tons $CO_2$ (Dagestan Republic) to 21.9 tons (Kemerovskaya Oblast). In 42 regions per capita emissions vary between 4 and 10 tons $CO_2$. In general, it seems like the bigger per capita GRP, the bigger per capita emission. The biggest per capita emissions are in Kemerovskaya and Tyumenskaya Oblasts, which is determined by the economic structure in these regions dominated by energy intensive industries, namely coal mining, natural gas extraction, ferrous metallurgy, and oil and gas refinery.

Emissions per capita GRP is highest in Tyumenskaya and Kemerovskaya Oblasts, of which the former oblast has the highest per capita GRP in the country. In the group of regions, where per capita GRP is close to Russia's average value — 10–16 million rubles in 1997 prices, — seven regions, including Kemerovskaya Oblast, must be pointed out for their high per capita emissions (over 15.5 tons of $CO_2$). Large energy sector facilities are located in three of these regions (Gusino-Ozerskaya, Kostromskaya, and Ryazanskaya hydro power plants), and in the rest of these regions large steel plants are located (Lipetskaya, Chelyabinskaya, Vologodskaya, and Kemerovskaya Oblasts).

### 4.4 Regional Structure of $CO_2$ Emissions in 1990 Versus 1997

In accordance with the Climate Convention and the Kyoto Protocol, 1990 emissions were taken as the baseline for GHG emissions in Russia. Therefore, a similar methodology was used to assess $CO_2$ regional emission structure for 1990 both by regions and by RAO EES Rossii facilities. These assessments may be used as baselines for the analyses of regional emission dynamics for identification of potential regional quotas for emission trade and JI projects.

To obtain some ideas of the regional dynamics this analysis focused on the comparison of regional $CO_2$ emission structure in 1990 versus 1997.

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[2] Information on GRP was obtained from the Russian Statistical Yearbook (1998-2001) published by State Committee of Russia for Statistics.

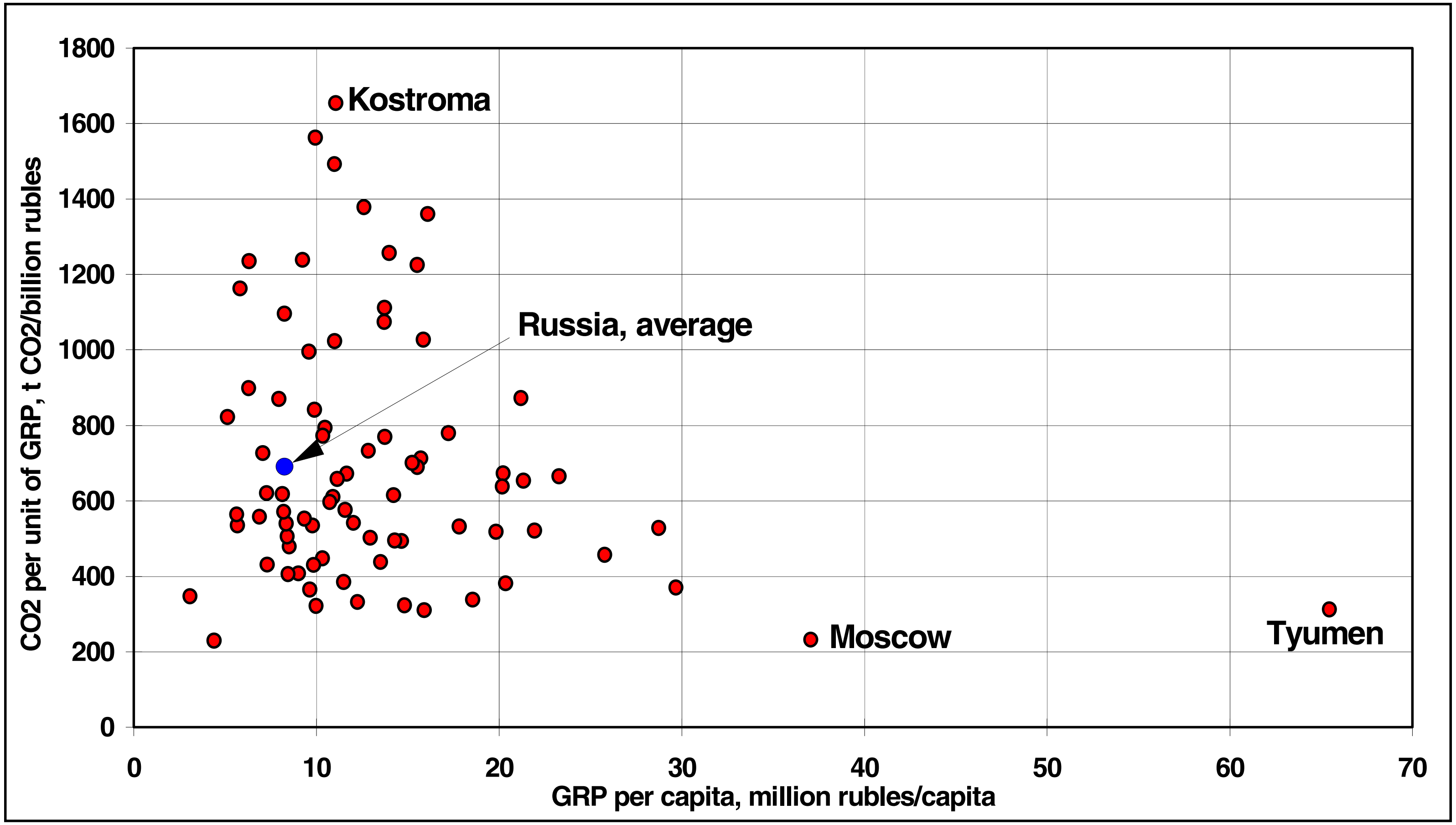


*Figure 5:* Specific $CO_2$ emissions per unit of GRP as a function of GRP per capita in the regions of the Russian Federation in 1997.

Regional structure of $CO_2$ emissions in 1990, ordered by total regional emissions, is shown in Figure 6. As in 1997, 15 regions were responsible for 50% of the total $CO_2$ emissions, while 30 regions with least emissions were responsible for only 10%. At the same time, while many of the regions in these two groups changed position, the regional structure of the groups altered only insignificantly: only two regions left their positions in the group of 15 biggest emitters of 1990 in 1997.

Sverdlovskaya Oblast was the biggest emitter in 1990; however, its emissions were 24.5 million tons higher than in 1997. The same pattern applies for most regions, with the exception of Moscow, Chitinskaya Oblast, and Karachayevo-Cherkessiya. Moscow stands out in this respect, because its emissions grew by more than 16 million tons (27%) from 1990 through 1997, primarily due to a bigger share of natural gas consumption in the municipal energy supply system, but also due to the growth of gasoline combustion by a bigger automobile stock. All these factors brought Moscow from 8$^{th}$ to 2$^{nd}$ place in the list of Russia's biggest emitters in 1997.

Dispersion of regions by their $CO_2$ emissions of coal combustion did not change much, neither in terms of concentration, nor in terms of volume. This may be explained by their geographical links to coal mines and metallurgical plants.

At the same time, the regional structure of natural gas combustion $CO_2$ emissions was more dynamic. This may be explained by aggressive gasification of regions that took place during this period. In 1990, Tyumenskaya Oblast was the biggest emitter (its emission was 1.5 times that of Moscow, which came second). However, while Moscow increased its natural gas consumption, Tyumenskaya Oblast was reducing it, and by 1997 these two regions changed positions. In 1990, 16 regions were not gasified. Apart from this, emissions structure altered insignificantly.

In 1990, there was a big dispersion of specific per capita emission: the lowest emissions was in Dagestan and Karachayevo-Cherkessiya (2.84 and 2.57 tons of $CO_2$, respectively), while the highest levels were in Kemerovskaya and Vologodskaya Oblasts (31.32 and 31.35 tons, respectively). The average regional level equaled 13.44 tons of $CO_2$. In half of the regions, emissions varied between 4 and 12 tons of $CO_2$ per capita. In three regions, namely, Moscow, Chitinskaya Oblast and Karachayevo-Cherkessiya, the per capita consumption had grown by 1997, in the rest of regions per capita emissions reduced, which results from a considerable decrease in production.

The analysis demonstrate considerable differences between regions with respect to emissions of total amounts; contributions by sources (types of fuel and directions of fuel use); and by specific emissions.

A comparison of 1990 and 1997 regional structures of $CO_2$ emissions helped obtain an idea of the alterations that occurred due to different economic tendencies in regions during the restructuring of Russia's economy.

Detailed information on regional structure of $CO_2$ emissions in the Russian Federation in 1990 and 19997 is presented in Tables A1 and A2 in the Appendix.

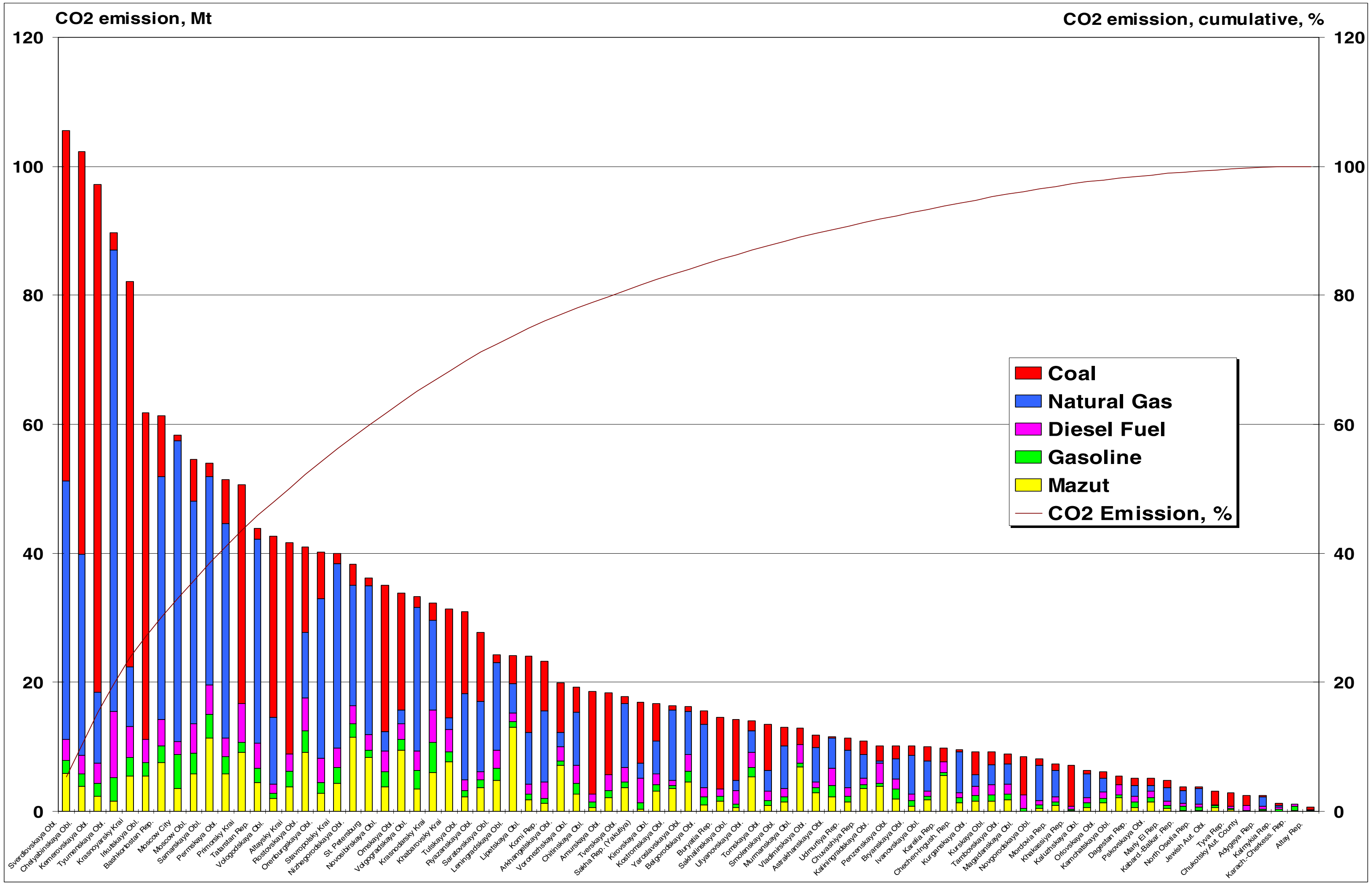


*Figure 6:* Regional structure of $CO_2$ emissions in the Russian Federation in 1990.

# 5 Overview of GHG Emissions in Russia and Comparison of Results

## 5.1 Energy Related $CO_2$ Emissions

An attempt to compare the results of inventory assessments based on different sources of statistical information was undertaken. For this purpose Goskomstat and IEA data for 1990–2000 were used for conducting Reference Approach inventories. Figure 7 illustrates the results of this calculation. The Third National Communication of Russia was included.

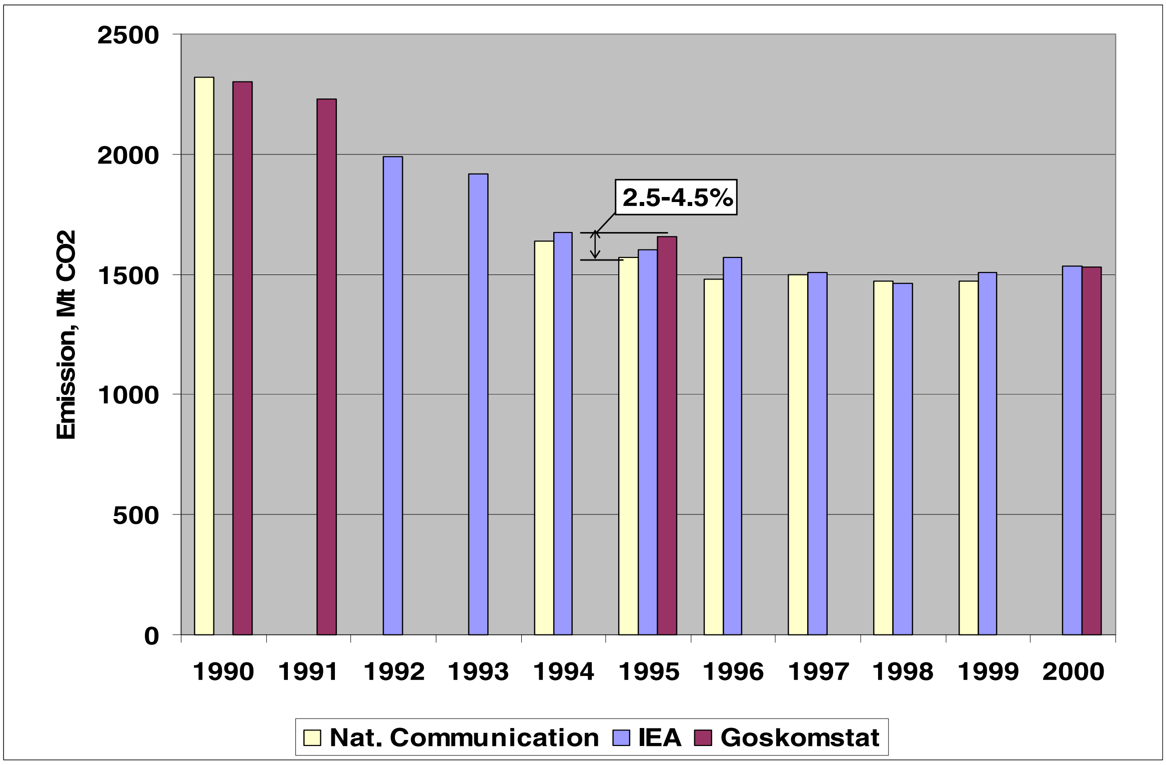


*Figure 7:* Results of Reference Approach inventory of $CO_2$ emissions from the Russian energy sector.

Analysis of the results shows that the difference between estimated volumes of $CO_2$ emissions calculated based on various sources of information is not high — 2.5-4.5%. This could be explained by the fact that Goskomstat data were used as a basis both for the compilation of IEA Russia's energy balances and for the Russian National Communication.

## 5.2 Energy Related Methane Emissions

Methane ($CH_4$) is the second largest contributor to global warming among anthropogenic GHGs, after carbon dioxide. It is estimated to be 21 times more effective at trapping heat in the atmosphere. Methane is emitted from both natural and anthropogenic sources, with the major anthropogenic sources including waste, energy, and the agricultural sector. Energy related methane emissions originate from:

- Natural gas and oil systems; and
- Coal mining activities.

This chapter of the report presents a summary and analyses of the results from various studies dedicated to estimations of energy-related methane emissions.

### *5.2.1 Methane emissions from the natural gas/oil sector*

The natural gas sector plays an important role in the Russian economy. It accounts for around 50% of total energy consumption and production in Russia. One natural gas company — Joint Stock Company (JSC) "Gazprom" — dominates the sector. Gazprom is responsible for almost all gas production, transmission, and exports in Russia.

Russia is the largest natural gas exporter in the world and plans to further increase its gas exports. Natural gas is also important for climate change mitigation because it emits less carbon dioxide ($CO_2$) per unit of energy produced than either coal or oil and may be a substitute for these fuels. However, natural gas is approximately 95% methane and methane is an important GHG. Therefore, it is important to minimize leakage and venting of natural gas if it is to maintain its priority as a transition fuel. The present work analyzes four studies:

Three governmental studies — the **Second** and the **Third National Communication** and the **Russian Federation Climate Change Country Study —** present estimates for the whole natural gas sector. In 1996–1997, under the US Country Studies Program and with assistance from the United States, Russia prepared a 6-volume report about Russia's climate change mitigation and adaptation policies — the "Russian Federation Climate Change Country Study" (Country Study) (RFSHEM, 1997). The Country Study also provides information about GHG emissions, including methane emissions from the natural gas sector. The Country Study is the foundation for all government documents about climate change mitigation policies in Russia. Most of the information for the National Communications was collected under the Country Study. Because of budget constraints, the same small group of experts participated in preparing the Country Study and the National Communications. The Second National Communication (SNC) repeats the results of the First Communication; therefore, the discussion in this paper describes only the SNC (ICRFCCP, 1998).

A study conducted by Gazprom and Ruhrgas provides estimates for all segments that Gazprom controls (Dedikov *et al.*, 1999).

#### *5.2.1.1 National Communications (NC)*

The SNC provides data for methane emissions for the years 1990 and 1994 (ICRFCCP, 1998). It classifies methane emissions from the natural gas sector as fugitive (or emissions that are not associated with fossil fuel combustion). This category includes technological discharges and leaking of natural gas from various components. The SNC does not define gaseous and liquid fuels. According to the SNC, methane emissions were 16.0 million tons of methane in 1990 and in 1994 dropped to 11.5 million tons of methane. The SNC supplemented data on methane emissions for the years 1997, 1998 and 1999.

Data on fugitive methane emissions in 1994 were obtained from Gazprom. According to Gazprom data, technological emissions were 1.45 million tons of methane and gas losses or leakages were 6.59 million tons of methane. The document does not clearly explain that Gazprom does not own the distribution segment and its data, probably, do not include emissions from this segment.

It is also important to note that the 11.5 million tons of methane estimate for 1994 may be not a realistic number because it means that between 1990 and 1994 emissions dropped by 28%, whereas gas consumption dropped only by 5.2% for the same period (Gazprom, 1997). At the same time, because emission estimates are uncertain, within ±50%, it is impossible to determine the accuracy of this number. At the least, this number contradicts estimates from the Country Study that gives 15.2 million tons for 1990.

National Communications use coefficients recommended by the IPCC for methane emission calculations, but it is not clear how the coefficients were implemented. The range of uncertainty of calculations is given to ±30–40%, but the SNC does not explain how this uncertainty was defined.

National Communications also provide information about the distribution of emissions between sectors. The 81% of methane emissions in $CO_2$ equivalent are from oil and gas production and transportation, but the documents do not give numbers for oil and gas separately, nor do the NCs explain how the above share was calculated.

#### *5.2.1.2 Russian Federation climate change country study*

The Country Study provides estimations of methane emissions for 1990 and 1994 (RFSHEM, 1997). For all calculations, the Country Study uses the Standard Tier 1 IPCC Reference method. Again, it is not clear how the method was applied. Unlike NCs, it is clear how the Country Study calculates fugitive emissions specifically from the natural gas sector. In addition, the Country Study also estimates the distribution of emissions between different technological processes. The document emphasizes a large range of uncertainty in calculating methane emissions because of the lack of reliable statistical data and the large uncertainty of emission factors.

Total 1990 emissions are 19.1 million tons of methane with an uncertainty range of ±50% (or 11.8–26.5 million tons). The Country Study recommends using 16 million tons as a conservative estimate.

The Country Study does not provide estimates for transportation, processing, and distribution separately. Excluding consumption, the estimate of total emissions is 9.3–21.1 million tons of methane or 15.2 million tons of methane with the uncertainty range of ±50%, which is very close to the conservative estimate of 16 million tons of methane.

The Country Study also uses an alternative method of calculating emissions by using data from Gazprom. According to Gazprom, in 1991 it used 9.3% of extracted gas for technological purposes at the pipelines. Converted to methane, this amount equals 46.1 million tons of methane. At the same time, the estimation of gas consumption by the gas storage and transportation system equipment, taking into account its capacity factor, results in an estimation of actual consumption for technological purposes to be 15.5 million tons of methane. The rest are emissions to the atmosphere and illegal gas consumption. Taking into account that it is impossible to estimate how much gas is consumed illegally, the upper level of methane emissions is estimated to be 30.6 million tons. Based on these estimates, the Country Study calculates the share of methane emissions from the natural gas sector as 60% of all methane emissions from anthropogenic sources.

The Country Study also estimates emissions from the natural gas sector for 1994 as 15.2 million tons of methane. The Country Study does not explain if this estimate includes leaks from industrial and residential sectors. This estimate contradicts the SNC estimate of 11.5 million tons. If 15.2 million tons is a correct estimate, methane emissions from the natural gas sector dropped by 5% since 1990 and that corresponds to the decrease of gas consumption by 5.2% for the same period (Gazprom, 1997).

#### *5.2.1.3 Gazprom/Ruhrgas study*

Gazprom and Rurhgas estimated methane emissions from the whole Russian natural gas sector in 1997 (Dedikov *et al*., 1999). The main purpose of the Gazprom/Ruhrgas study was to obtain a more reliable estimate of methane emissions than previous studies have estimated. The study provides a table of estimates from studies conducted by either international agencies (IEA) or Russian and Western experts in the period 1989–1994. These studies show that methane emissions from the Russian natural gas sector might be in the range of 2–10% of the total gas production. Gazprom and Ruhrgas based their estimates on measurements they did at two compressor stations, two pipeline sections, and three production and processing facilities. After Ruhrgas and Gazprom conducted measurements, they extrapolated results to the entire natural gas sector. The Gazprom/Ruhrgas study provides results of estimates and extrapolation methods, but it contains no detailed description of component counts and no estimation of activity and emission factors.

Ruhrgas and Gazprom categorized emissions from compressor stations as intentional and fugitive emissions. Intentional emissions included emissions due to repair work, start up and depressurization of compressor units and incomplete combustion of methane. The study estimated intentional emissions by using technical data. Fugitive emissions included leaks from equipment and were identified and measured by flame ionization detectors. The measurements covered a large number of components but the study does not provide a detailed description of components studied. The highest emissions appeared due to leaks from vents. The study does provide a description of measurement techniques.

In addition to compressor stations, Gazprom and Ruhrgas also measured emissions from pipelines. The study showed the largest leaks occur when pipeline sections are vented for repair purposes.

After conducting measurements at all segments, Ruhrgas and Gazprom extrapolated results for the whole natural gas sector. The study extrapolated emissions for each compressor station by adding emissions from each component. Ruhrgas and Gazprom related the emissions calculated in this way to installed compressor capacity of the stations, producing a number in $m^3$/yr/Mw. Then the study multiplied this number by the installed capacity of Tyumentransgaz and Gazprom compressor stations.

Table 4 provides estimates from the whole sector for the four studies mentioned earlier. For all cases, the range of uncertainty is ±50%. However, EPA and Gazprom do not provide estimates of uncertainties, but they do note that results are very preliminary and more measurements should be done.

*Table 4:* Methane emissions from the Russian natural gas/oil sector.

| | **Study** | **Emissions (Mt of $CH_4$)** | **Emissions (bln $m^3$)** | **Gas production (bln $m^3$)** | **% from gas production** |
|---|---|---|---|---|---|
| **1990** | Second and Third NC | 16.0 | 21.6 | 589.5 | 3.7 |
| | EPA/CS | 16.0 | 21.6 | 589.5 | 3.7 |
| | This study | 5.0 | 6.8 | 640.3 | 1.1 |
| **1994** | Second NC | 15.2 | 20.5 | 570.5 | 3.6 |
| | Third NC (EPA/CS) | 11.5 | 15.5 | 570.5 | 2.7 |
| **1995** | EPA/CS | 16.0 | 21.6 | 589.5 | 3.7 |
| | This study | 4.4 | 5.9 | 595.6 | 1.0 |
| **1997** | Third NC | 7.9 | 10.7 | 573.0 | 1.9 |
| | Ruhrgas/Gazprom | 4.0 | 5.4 | 540.0 | 1.0 |
| **2000** | EPA/CS[a] | 17.2 | 23.2 | 583.7 | 4.0 |
| | This study | 4.3 | 5.8 | 583.7 | 1.0 |

[a] Projection. The Country Study reports disaggregate fugitive emissions for 1990. The 1990 estimates were scaled to the consumption of natural gas fuel use in Russia for 1995 and projected use through 2010.

Table 4 provides data not only in million tons of methane but also in billion $m^3$ of natural gas. In addition, the percentage of emissions from total gas production is calculated. This way of presenting data helps to better explain the uncertainties in the calculations. For the distribution segment, it is more correct to estimate emissions in percentage of the natural gas volume delivered for sale by Gazprom.

To estimate emissions in common units a correlation factor between $m^3$ and tons of methane (1 million tons of methane emissions approximately equals 1.35 billion $m^3$ of gas production) was used. Respectively, 1 billion $m^3$ approximately equals 0.74 million tons of methane. These coefficients are from Dedikov *et al.* (1999) who estimate emissions in 1997 as 5.4 billion $m^3$ or 4 million tons of methane. Data about gas production is from (Gazprom, 1997) for 1990–1994 and from Dedikov *et al.* (1999) for 1997. The latter paper considers only gas produced by Gazprom. In addition, three other companies produce natural gas in Russia, but their share is small.

Analysis of the data reveals several important differences. Information about emissions is scarce and contradictory. Because emissions from different segments are included into one category, there are difficulties in comparing data. There are also difficulties in comparing data with emission estimates from other countries. The government documents provide only aggregated information and do not show a detailed description of the way emissions were calculated. Only the Country Study has estimates of emissions from different segments of the sector, but these estimates are also uncertain. In addition, the methods recommended by the IPCC do not allow for reliable estimations of methane emissions because emission and activity factors are not well-defined for Russia. Studies that used more rigorous approaches do not cover enough components and, therefore, estimate emissions with a very high degree of uncertainty. Only Gazprom and EPA have estimated emission and activities factors that in the future might help to develop better estimates. Measurements done by Ruhrgas and Gazprom are probably correct, but more information about the components covered should be provided for the results to be credible. Although the Ruhrgas and Gazprom estimate of intentional emissions from compressor stations is the same as EPA, more data is needed to understand how this estimate was derived. Only a few years are covered by estimates and the last estimates were done in 1997.

Estimates from official documents are several times higher than estimates produced by Ruhrgas and Gazprom. Such a difference can be explained by the fact that the official documents include emissions from the distribution segment while studies conducted by Ruhrgas, and Gazprom do not. EPA and Gazprom data are the most transparent and it is absolutely clear how they arrived at the estimates. However, Ruhrgas and Gazprom do not provide enough information on their measurements.

Only a few segments are covered by detailed measurements. According to Gazprom data, Russia had 148,800 kilometers of transmission pipeline with 251 compressor stations in 1999 (Gazprom, 1999). Only six transmission compressor stations and 2000 kilometers of pipelines were actually measured. More measurements at different compressor stations are needed. It is also important that technological or unintentional emissions from compressor stations might be calculated by using technological parameters and technical data. Each compressor station in Russia has technical documentation that can be used to calculate the amounts of gas flared or vented. If this information is collected, data on technological emissions, probably, will be less uncertain than data on leakage.

### 5.2.2 Methane emissions from Russian coal mining activities

Two governmental studies — the Second and Third National Communications and the Russian Coal Bed EPA Study (2000) were analyzed. A summary of the results of these reports is presented in Table 5.

The Third National Communication presents data on methane emissions for 1990, 1997, 1998 and 2000. This document does not describe the methodologies used for the generated numbers, but in most cases it seems to be consistent with the Revised 1996 IPCC Guidelines. Unfortunately, the Third National Communication does not present any information on emission factors used for inventory.

*Table 5:* Methane emissions from the Russian coal mining activities.

| | Study | Emissions (Mt of $CH_4$) | Emissions (bln $m^3$) |
|---|---|---|---|
| **1990** | Second and Third NC | 2.9 | 3.9 |
| | EPA/CS | 2.5 | 3.4 |
| | This study | 1.8 | 2.4 |
| **1994** | Second and Third NC | 1.8 | 2.4 |
| **1995** | EPA/CS | 1.8 | 2.5 |
| | This study | 1.8 | 2.4 |
| **1999** | Third NC | 1.4 | 1.9 |
| **2000** | EPA[a] | 1.5 | 2.1 |
| | This study | 1.7 | 2.3 |

[a] Projection.

The EPA study focuses exclusively on historical and future coal mining methane emission in Russia. For the majority of underground mines, the methodology was consistent with the IPCC Tier 3 methodology, using measurement data collected by the individual mines. For the remaining underground mines and for surface and post mining, the IPCC Tier 2 methodology was used.

Analysis of results shows that the difference between estimated volumes of methane emission presented in these studies is not high. This could be explained by the fact that all the studies used a similar methodology, similar data and emission factors for the calculations.

## 5.3 Nitrous Oxide Emissions

Nitrous oxide ($N_2O$) is emitted from a variety of natural and anthropogenic sources. It is produced from many natural sources, as well as from human-related activities. Nitrous oxide is estimated to be 310 times more effective at trapping heat in the atmosphere than carbon dioxide.

Energy-related nitrous oxide emissions originate from fossil fuel combustion both stationary and mobile sources.

Two governmental studies — the Second and the Third National Communication and Russian EPA Study (2001) were analyzed. A summary of the results of these reports is presented in Table 6.

The Third National Communication presents data on nitrous oxide emission for 1990, 1997, 1998 and 2000. As was the case with methane emissions estimations, this document does not describe the methodologies used for generated numbers on $N_2O$ emissions. The Russian Third NC does not present separate data on nitrous oxide emissions from stationary and mobile fossil fuel combustion but it could be assumed that emissions were calculated based on Revised 1996 IPCC Guidelines and default emission factors.

*Table 6:* $N_2O$ emissions from combustion of fossil fuel in Russia.

| | Study | Emissions (Thou.t. $N_2O$) |
|---|---|---|
| **1990** | Second and Third NC | 17.4 |
| | EPA | 24.3 |
| | Author | 17.0 |
| **1994** | Second and Third NC | 11.1 |
| **1995** | EPA | 17.8 |
| | Author | 13.0 |
| **1999** | Third NC | 10.1 |
| **2000** | EPA[a] | 20.1 |
| | Author | 11.0 |

[a] Projection.

To report $N_2O$ emissions from stationary fossil fuel combustion, EPA developed methods of estimating both emissions and projections for Russia. For nitrous oxide from mobile fossil fuel combustion EPA used a basic approach for estimating fuel consumption in Russia by assigning fuel consumption for different classes or categories of vehicles, and then apply the updated emission factors at a disaggregated level.

Analysis of results shows that the difference between estimated volumes of $N_2O$ emissions presented in these studies lies between 25–30%, which is not high for estimations of emissions of this gas. This could be explained by the fact that all the studies used a similar methodology, similar data and emission factors for the calculations. Some difference of emission coefficients might influence the results of these studies. The 50% difference in results for 2000 was not taken into consideration because the number for 2000 was obtained as a result of a forecast.

## 6 Conclusions and Recommendations

The first general conclusion is that it is quite feasible to perform full energy-related GHG inventory in Russia in full compliance with IPCC methodology.

Energy (or fuel combustion for energy needs according to the definition of IPCC Guidelines) is a major GHG source in Russia. The future success of GHG inventory accounting in Russia will depend on detailization and accuracy of fuel-use accounting. The Russian energy statistics contain more or less the data required for Reference and Source categories according to IPCC approaches, and more specialized reports have to be used only for Tier 2 emission estimates for transport information.

Energy balances have been completed, in particular, balances in the International Energy Agency format for 1995 and 2000. It is one of the necessary conditions for "good practice" inventories in Russia.

Emission of $CO_2$ from regions of the Russian Federation was calculated and its structure was analyzed. This analysis could be an important step in improving anthropogenic GHG emissions inventory in Russia, and bringing it in line with the IPCC methodology and requirements to Annex I countries' national reports on GHG emissions and sinks.

A comparison of inventory results from various studies was made. The data were analyzed and the reasons for their discrepancy were described.

Analysis of results has showed that all Russian National Communications do not contain all the information required by IPCC methodology. None of Russian NCs provide a Source Categories Approach inventory of GHG energy-related emissions as well as a regional break-down of emissions.

Taking into account the first main conclusion of the above, the main obstacle for GHG inventory accounting in Russia is an institutional problem. Currently, all climate issues are nominally under the responsibility of the Russian Federal Service for Hydrometeorology and Environment Monitoring. However, this agency has no capacity to collect and analyze data, no funds, no prestige or influence on regional and federal bodies to enforce them to send data for GHG emissions estimation. The Ministry of Energy, regional administrations (energy and economic departments), have data and they are ready to conduct inventories, if official responsibility would be transferred to the ministry and/or regions and some minimum funds were available for this work. The Ministry of Natural Resources (actually Russian Ministry of Environment) and related institutes are ready to finalize and adopt the official methodology and conduct inventories.

Improving national GHG emissions inventory is a precondition for Russia's compliance with the UNFCCC, and its participation in flexible mechanisms under the Kyoto Protocol. The regional level of the accounting system plays a crucial role in achieving this objective.

Energy related non-$CO_2$ emissions from all source categories listed by the IPCC Revised Guidelines and Good Practice Methodologies are considered under the study among other problems. The analysis of sources of information on energy production and consumption existing in Russia showed that they contain enough data for accurate and complete inventories of $CO_2$ emissions, but for correct country specific estimates of non-$CO_2$ emissions from coal mining, oil and gas supply system, etc., experts' estimates have to be used. Additional analysis is needed to develop an efficient inventorying system for the Russian oil and gas sector.

Detailed, accurate, methodologically transparent, and verifiable national reports on GHG emissions and sinks are a key condition for countries to take part in the flexible mechanisms under the Kyoto Protocol. This is a very important issue for Russia.

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# Appendix

*Table A1:* Regional structure of $CO_2$ emission in the Russian Federation in 1990.

| No | Region | mazut thou.tons | gasoline thou.tons | diesel fuel thou.tons | natural gas thou.tons | coal thou.tons | thou.tons | % | cumulative total, % |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Sverdlovskaya Oblast | 5853.8 | 2082.0 | 3238.8 | 40012.8 | 54321.5 | 105508.9 | 5.3 | 5.3 |
| 2 | Chelyabinskaya Oblast | 3923.5 | 1867.2 | 2842.2 | 31179.4 | 62436.4 | 102248.7 | 5.1 | 10.4 |
| 3 | Kemerovskaya Oblast | 2288.2 | 2079.0 | 3043.7 | 11094.4 | 78649.1 | 97154.4 | 4.9 | 15.3 |
| 4 | Tyumenskaya Oblast | 1585.1 | 3682.9 | 10191.7 | 71578.5 | 2658.5 | 89696.8 | 4.5 | 19.8 |
| 5 | Krasnoyarsky Krai | 5492.8 | 2884.0 | 4743.3 | 9245.7 | 59785.5 | 82151.4 | 4.1 | 24.0 |
| 6 | Irkutskaya Oblast | 5430.1 | 2103.2 | 3594.5 | 0.0 | 50613.3 | 61741.1 | 3.1 | 27.1 |
| 7 | Bashkortostan Republic | 7599.0 | 2475.4 | 4126.4 | 37725.8 | 9414.6 | 61341.3 | 3.1 | 30.2 |
| 8 | Moscow City | 3584.5 | 5250.5 | 1995.5 | 46638.7 | 862.6 | 58331.9 | 2.9 | 33.1 |
| 9 | Moscow Oblast | 5769.1 | 3204.8 | 4582.8 | 34573.7 | 6406.8 | 54537.2 | 2.7 | 35.8 |
| 10 | Samarskaya Oblast | 11312.1 | 3707.1 | 4551.3 | 32357.0 | 2013.5 | 53941.1 | 2.7 | 38.5 |
| 11 | Permskaya Oblast | 5831.8 | 2620.7 | 2883.1 | 33253.7 | 6889.7 | 51479.0 | 2.6 | 41.1 |
| 12 | Primorsky Krai | 9089.9 | 1619.0 | 5948.8 | 0.0 | 34009.4 | 50667.1 | 2.5 | 43.7 |
| 13 | Tatarstan Republic | 4410.0 | 2221.2 | 3987.9 | 31536.2 | 1704.3 | 43859.6 | 2.2 | 45.9 |
| 14 | Vologodskaya Oblast | 2030.8 | 750.5 | 1435.3 | 10356.8 | 28032.0 | 42605.3 | 2.1 | 48.0 |
| 15 | Altaysky Krai | 3807.3 | 2466.4 | 2587.3 | 0.0 | 32784.1 | 41645.1 | 2.1 | 50.1 |
| 16 | Rostovskaya Oblast | 9165.2 | 3331.9 | 5127.3 | 10107.2 | 13203.0 | 40934.6 | 2.1 | 52.2 |
| 17 | Orenburgskaya Oblast | 2790.4 | 1715.9 | 3714.1 | 24736.4 | 7261.8 | 40218.6 | 2.0 | 54.2 |
| 18 | Stavropolsky Krai | 4331.5 | 2436.1 | 3068.9 | 28544.9 | 1553.5 | 39934.9 | 2.0 | 56.2 |
| 19 | Nizhegorodskaya Oblast | 11519.3 | 2085.1 | 2706.9 | 18742.8 | 3229.2 | 38283.2 | 1.9 | 58.1 |
| 20 | St. Petersburg | 8302.0 | 1201.4 | 2392.1 | 23087.3 | 1211.9 | 36194.8 | 1.8 | 59.9 |
| 21 | Novosibirskaya Oblast | 3838.7 | 2263.6 | 3216.8 | 3091.1 | 22632.8 | 35043.1 | 1.8 | 61.7 |
| 22 | Omskaya Oblast | 9450.8 | 1703.8 | 2401.6 | 2135.3 | 18113.5 | 33805.0 | 1.7 | 63.4 |
| 23 | Volgogradskaya Oblast | 3452.6 | 2917.3 | 2952.4 | 22277.6 | 1654.7 | 33254.6 | 1.7 | 65.1 |
| 24 | Krasnodarsky Krai | 5966.8 | 4717.9 | 4970.0 | 13908.2 | 2691.0 | 32253.9 | 1.6 | 66.7 |
| 25 | Khabarovsky Krai | 7699.4 | 1516.1 | 3462.3 | 1784.1 | 16880.6 | 31342.5 | 1.6 | 68.3 |
| 26 | Tulskaya Oblast | 2241.1 | 986.5 | 1617.8 | 13385.0 | 12695.3 | 30925.8 | 1.6 | 69.8 |
| 27 | Ryazanskaya Oblast | 3672.4 | 1195.4 | 1199.2 | 11009.4 | 10691.4 | 27767.7 | 1.4 | 71.2 |
| 28 | Saratovskaya Oblast | 4833.7 | 1809.7 | 2873.7 | 13507.1 | 1242.4 | 24266.6 | 1.2 | 72.4 |
| 29 | Leningradskaya Oblast | 13016.5 | 865.5 | 1353.4 | 4618.2 | 4341.8 | 24195.5 | 1.2 | 73.7 |
| 30 | Lipetskaya Oblast | 1726.3 | 968.4 | 1526.6 | 8077.2 | 11731.5 | 24030.0 | 1.2 | 74.9 |
| 31 | Komi Republic | 1233.5 | 820.1 | 2455.1 | 11074.1 | 7689.3 | 23272.1 | 1.2 | 76.0 |
| 32 | Arkhangelskaya Oblast | 7087.3 | 732.3 | 2203.3 | 2233.3 | 7618.7 | 19875.0 | 1.0 | 77.0 |
| 33 | Voronezhskaya Oblast | 2699.3 | 1670.5 | 2744.7 | 8221.4 | 3971.6 | 19307.5 | 1.0 | 78.0 |
| 34 | Chitinskaya Oblast | 546.1 | 886.7 | 1249.6 | 0.0 | 15914.9 | 18597.3 | 0.9 | 78.9 |
| 35 | Amurskaya Oblast | 2090.4 | 1098.5 | 2502.3 | 0.0 | 12691.5 | 18382.7 | 0.9 | 79.9 |
| 36 | Tverskaya Oblast | 3625.3 | 941.2 | 2247.3 | 9850.2 | 1099.3 | 17763.3 | 0.9 | 80.8 |
| 37 | Sakha Republic (Yakutiya) | 367.2 | 941.2 | 3795.9 | 2405.2 | 9391.7 | 16901.3 | 0.8 | 81.6 |
| 38 | Kirovskaya Oblast | 3148.2 | 926.0 | 1687.1 | 5165.4 | 5788.5 | 16715.2 | 0.8 | 82.4 |
| 39 | Kostromskaya Oblast | 3521.7 | 505.4 | 812.1 | 10874.4 | 622.2 | 16335.7 | 0.8 | 83.3 |
| 40 | Yaroslavskaya Oblast | 4610.9 | 1606.9 | 2596.7 | 6618.6 | 767.2 | 16200.3 | 0.8 | 84.1 |
| 41 | Belgorodskaya Oblast | 1042.1 | 1183.3 | 1495.1 | 9794.7 | 2091.7 | 15606.9 | 0.8 | 84.9 |
| 42 | Buryatia Republic | 1538.0 | 777.7 | 1167.7 | 0.0 | 11090.3 | 14573.7 | 0.7 | 85.6 |
| 43 | Sakhalinskaya Oblast | 568.1 | 517.5 | 2108.9 | 1626.9 | 9479.5 | 14300.9 | 0.7 | 86.3 |
| 44 | Ulyanovskaya Oblast | 5335.9 | 1498.0 | 2256.8 | 3344.4 | 1540.2 | 13975.2 | 0.7 | 87.0 |
| 45 | Tomskaya Oblast | 916.5 | 759.6 | 1413.2 | 3263.1 | 7074.8 | 13427.2 | 0.7 | 87.7 |
| 46 | Smolenskaya Oblast | 1487.8 | 717.2 | 1378.6 | 6494.7 | 2984.9 | 13063.2 | 0.7 | 88.4 |
| 47 | Murmanskaya Oblast | 6924.1 | 572.0 | 2902.0 | 0.0 | 2542.1 | 12940.2 | 0.7 | 89.0 |
| 48 | Vladimirskaya Oblast | 2906.5 | 814.1 | 859.3 | 5328.1 | 1881.8 | 11789.7 | 0.6 | 89.6 |
| 49 | Astrakhanskaya Oblast | 2200.3 | 1800.6 | 2700.6 | 4636.7 | 265.3 | 11603.4 | 0.6 | 90.2 |
| 50 | Udmurtiya Republic | 1415.6 | 913.9 | 1322.0 | 5781.1 | 1900.9 | 11333.4 | 0.6 | 90.8 |
| 51 | Chuvashiya Republic | 3534.3 | 635.5 | 938.0 | 3727.1 | 2065.0 | 10899.8 | 0.5 | 91.3 |
| 52 | Kaliningradskaya Oblast | 3854.4 | 535.6 | 3046.8 | 390.1 | 2328.4 | 10155.3 | 0.5 | 91.8 |
| 53 | Penzenskaya Oblast | 1858.2 | 1609.9 | 1526.6 | 3146.6 | 1975.3 | 10116.5 | 0.5 | 92.3 |
| 54 | Bryanskaya Oblast | 816.1 | 862.5 | 1007.2 | 5988.1 | 1421.8 | 10095.7 | 0.5 | 92.8 |
| 55 | Ivanovskaya Oblast | 1776.5 | 575.0 | 752.3 | 4699.6 | 2194.8 | 9998.1 | 0.5 | 93.3 |
| 56 | Karelia Republic | 5521.1 | 505.4 | 1696.5 | 0.0 | 2097.4 | 9820.4 | 0.5 | 93.8 |

*Table A1:* continued.

| No | Region | mazut thou.tons | gasoline thou.tons | diesel fuel thou.tons | natural gas thou.tons | coal thou.tons | thou.tons | % | cumulative total, % |
|---|---|---|---|---|---|---|---|---|---|
| 57 | Chechen-Ingushetiya Rep. | 1305.7 | 789.8 | 808.9 | 6282.1 | 435.1 | 9621.7 | 0.5 | 94.3 |
| 58 | Kurganskaya Oblast | 1597.6 | 889.7 | 1353.4 | 1822.9 | 3622.3 | 9286.0 | 0.5 | 94.8 |
| 59 | Kurskaya Oblast | 1569.4 | 1004.7 | 1510.8 | 3192.8 | 1929.5 | 9207.2 | 0.5 | 95.2 |
| 60 | Tambovskaya Oblast | 1833.0 | 889.7 | 1554.9 | 3096.7 | 1551.6 | 8925.9 | 0.4 | 95.7 |
| 61 | Magadanskaya Oblast | 0.0 | 460.0 | 2049.0 | 0.0 | 5996.5 | 8505.5 | 0.4 | 96.1 |
| 62 | Novgorodskaya Oblast | 430.0 | 538.7 | 727.1 | 5481.6 | 946.6 | 8124.0 | 0.4 | 96.5 |
| 63 | Mordovia Republic | 925.9 | 511.4 | 780.6 | 4128.3 | 1053.5 | 7399.7 | 0.4 | 96.9 |
| 64 | Khakassiya Republic | 119.3 | 242.1 | 472.1 | 0.0 | 6284.7 | 7118.2 | 0.4 | 97.2 |
| 65 | Kaluzhskaya Oblast | 605.8 | 699.1 | 755.4 | 3721.6 | 616.4 | 6398.3 | 0.3 | 97.6 |
| 66 | Orlovskaya Oblast | 1312.0 | 714.2 | 1032.4 | 2031.8 | 1047.8 | 6138.1 | 0.3 | 97.9 |
| 67 | Kamchatskaya Oblast | 2165.8 | 378.3 | 1576.9 | 0.0 | 1337.9 | 5458.8 | 0.3 | 98.2 |
| 68 | Dagestan Republic | 505.3 | 932.1 | 875.0 | 1654.6 | 1204.3 | 5171.3 | 0.3 | 98.4 |
| 69 | Pskovskaya Oblast | 1497.2 | 626.4 | 1023.0 | 830.1 | 1185.2 | 5161.8 | 0.3 | 98.7 |
| 70 | Mariy El Republic | 436.3 | 447.9 | 670.4 | 2118.7 | 1156.5 | 4829.8 | 0.2 | 98.9 |
| 71 | Kabardino-Balkarskaya Rep. | 128.7 | 635.5 | 494.2 | 2000.4 | 540.1 | 3798.8 | 0.2 | 99.1 |
| 72 | North Osetia Republic | 147.5 | 559.8 | 437.5 | 2433.0 | 219.5 | 3797.3 | 0.2 | 99.3 |
| 73 | Jewish Aut. Oblast | 565.0 | 287.5 | 198.3 | 0.0 | 2108.9 | 3159.7 | 0.2 | 99.5 |
| 74 | Tyva Republic | 244.8 | 245.1 | 336.8 | 0.0 | 2044.0 | 2870.7 | 0.1 | 99.6 |
| 75 | Chukotsky Aut. County | 0.0 | 93.8 | 843.5 | 0.0 | 1530.6 | 2468.0 | 0.1 | 99.7 |
| 76 | Adygeya Republic | 94.2 | 290.5 | 374.6 | 1442.0 | 202.3 | 2403.6 | 0.1 | 99.8 |
| 77 | Kalmykia Republic | 15.7 | 293.5 | 365.1 | 258.8 | 339.7 | 1272.9 | 0.1 | 99.9 |
| 78 | Karachayevo-Cherkessiya Rep. | 119.3 | 680.9 | 283.3 | 0.0 | 0.0 | 1083.5 | 0.1 | 100.0 |
| 79 | Altay Republic | 22.0 | 112.0 | 135.3 | 0.0 | 446.6 | 715.9 | 0.0 | 100.0 |
| | *Russian Federation* | *256280.5* | *105457.5* | *169860.1* | *743723.9* | *714004.5* | *1989326.5* | *100.0* | *100.0* |

Rep. = Republic; Aut. = Autonomous.

*Table A2:* Regional structure of $CO_2$ emission in the Russian Federation in 1997.

| No | Region | mazut thou.tons | gasoline thou.tons | diesel fuel thou.tons | natural gas thou.tons | coal thou.tons | thou.tons | % | cumulative total, % |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Sverdlovskaya Oblast | 5157.0 | 2372.6 | 2514.9 | 27921.9 | 37998.1 | 75964.4 | 5.4 | 5.4 |
| 2 | Moscow City | 3091.7 | 8425.0 | 2055.3 | 60495.2 | 211.8 | 74279.1 | 5.3 | 10.6 |
| 3 | Kemerovskaya Oblast | 1829.9 | 1824.8 | 1986.1 | 5158.0 | 55537.2 | 66336.1 | 4.7 | 15.4 |
| 4 | Tyumenskaya Oblast | 521.0 | 2799.2 | 8555.0 | 52403.2 | 1068.8 | 65347.2 | 4.6 | 20.0 |
| 5 | Chelyabinskaya Oblast | 1607.1 | 1785.5 | 2297.7 | 24316.8 | 34696.4 | 64703.4 | 4.6 | 24.6 |
| 6 | Krasnoyarsky Krai | 5310.8 | 2802.3 | 5124.2 | 8504.3 | 35421.7 | 57163.3 | 4.1 | 28.6 |
| 7 | Bashkortostan Rep. | 14890.3 | 2563.2 | 3358.4 | 23671.6 | 1505.8 | 45989.3 | 3.3 | 31.9 |
| 8 | Permskaya Oblast | 2762.1 | 1679.5 | 2005.0 | 31510.3 | 2236.8 | 40193.7 | 2.8 | 34.7 |
| 9 | Samarskaya Oblast | 4990.6 | 1821.8 | 1410.1 | 27694.5 | 1937.1 | 37854.1 | 2.7 | 37.4 |
| 10 | Irkutskaya Oblast | 3094.8 | 1694.7 | 1196.1 | 0.0 | 29772.5 | 35758.1 | 2.5 | 39.9 |
| 11 | Tatarstan Republic | 5062.8 | 1304.3 | 3100.3 | 25357.6 | 900.8 | 35725.9 | 2.5 | 42.5 |
| 12 | Orenburgskaya Oblast | 3025.8 | 1764.3 | 2146.6 | 23131.7 | 3931.5 | 33999.9 | 2.4 | 44.9 |
| 13 | Primorsky Krai | 5232.3 | 1028.9 | 2140.3 | 0.0 | 24409.7 | 32811.2 | 2.3 | 47.2 |
| 14 | Moscow Oblast | 2589.5 | 2829.5 | 2659.7 | 21336.6 | 2061.2 | 31476.4 | 2.2 | 49.4 |
| 15 | Rostovskaya Oblast | 2103.0 | 1479.8 | 2206.4 | 10482.5 | 14218.3 | 30490.0 | 2.2 | 51.6 |
| 16 | Nizhegorodskaya Oblast | 8236.1 | 1682.6 | 1491.9 | 13453.4 | 1316.9 | 26180.9 | 1.9 | 53.5 |
| 17 | Stavropolsky Krai | 954.2 | 1355.7 | 1564.3 | 21451.2 | 221.4 | 25546.8 | 1.8 | 55.3 |
| 18 | Vologodskaya Oblast | 4240.5 | 508.4 | 730.2 | 10722.8 | 9284.8 | 25486.8 | 1.8 | 57.1 |
| 19 | Altaysky Krai | 1120.5 | 1392.1 | 1765.8 | 170.1 | 19726.2 | 24174.7 | 1.7 | 58.8 |
| 20 | Novosibirskaya Oblast | 1826.8 | 1570.6 | 1123.7 | 1981.9 | 17525.7 | 24028.6 | 1.7 | 60.5 |
| 21 | St. Petersburg | 4657.9 | 1331.5 | 1183.5 | 15448.3 | 897.0 | 23518.2 | 1.7 | 62.2 |
| 22 | Omskaya Oblast | 5791.0 | 1113.6 | 1158.3 | 1656.5 | 13596.1 | 23315.6 | 1.7 | 63.8 |
| 23 | Lipetskaya Oblast | 885.1 | 381.3 | 667.3 | 7321.1 | 12443.4 | 21698.2 | 1.5 | 65.4 |
| 24 | Ryazanskaya Oblast | 3050.9 | 938.1 | 1170.9 | 9780.0 | 6557.6 | 21497.4 | 1.5 | 66.9 |
| 25 | Saratovskaya Oblast | 3032.1 | 683.9 | 2090.0 | 15300.4 | 248.1 | 21354.4 | 1.5 | 68.4 |
| 26 | Khabarovsky Krai | 2824.9 | 974.4 | 1702.8 | 1793.3 | 13806.1 | 21101.5 | 1.5 | 69.9 |
| 27 | Tulskaya Oblast | 646.6 | 426.7 | 1026.1 | 10608.2 | 7824.8 | 20532.4 | 1.5 | 71.3 |
| 28 | Chitinskaya Oblast | 273.1 | 405.5 | 535.1 | 0.0 | 18691.8 | 19905.5 | 1.4 | 72.8 |

*Table A2:* continued.

| No | Region | mazut thou.tons | gasoline thou.tons | diesel fuel thou.tons | natural gas thou.tons | coal thou.tons | thou.tons | % | cumulative total, % |
|---|---|---|---|---|---|---|---|---|---|
| 29 | Komi Republic | 1512.9 | 811.0 | 1274.8 | 9428.7 | 5048.0 | 18075.3 | 1.3 | 74.0 |
| 30 | Krasnodarsky Krai | 985.6 | 2139.5 | 2757.2 | 11048.2 | 927.5 | 17858.1 | 1.3 | 75.3 |
| 31 | Volgogradskaya Oblast | 426.9 | 1495.0 | 1857.0 | 13658.7 | 162.2 | 17599.7 | 1.2 | 76.6 |
| 32 | Kostromskaya Oblast | 2752.7 | 323.8 | 720.8 | 10319.8 | 494.3 | 14611.4 | 1.0 | 77.6 |
| 33 | Archangelskaya Oblast | 4369.2 | 426.7 | 1561.2 | 2958.0 | 4784.6 | 14099.7 | 1.0 | 78.6 |
| 34 | Tverskaya Oblast | 2743.3 | 384.3 | 1551.7 | 8463.6 | 503.8 | 13646.8 | 1.0 | 79.6 |
| 35 | Buryatia Republic | 470.8 | 526.6 | 431.2 | 0.0 | 10382.2 | 11810.8 | 0.8 | 80.4 |
| 36 | Voronezhskaya Oblast | 1092.3 | 1165.1 | 1293.6 | 6411.5 | 1553.5 | 11516.0 | 0.8 | 81.2 |
| 37 | Leningradskaya Oblast | 2793.5 | 771.7 | 1680.8 | 5169.1 | 797.8 | 11212.9 | 0.8 | 82.0 |
| 38 | Sakha Republic (Yakutiya) | 40.8 | 544.7 | 1973.5 | 2630.8 | 5899.2 | 11089.0 | 0.8 | 82.8 |
| 39 | Tomskaya Oblast | 552.4 | 916.9 | 711.3 | 2597.5 | 6252.2 | 11030.5 | 0.8 | 83.6 |
| 40 | Amurskaya Oblast | 850.6 | 529.6 | 531.9 | 0.0 | 9065.4 | 10977.5 | 0.8 | 84.3 |
| 41 | Ulyanovskaya Oblast | 2442.0 | 1001.7 | 938.0 | 4699.6 | 1813.1 | 10894.2 | 0.8 | 85.1 |
| 42 | Yaroslavskaya Oblast | 3016.4 | 599.2 | 1551.7 | 4884.4 | 368.3 | 10420.1 | 0.7 | 85.9 |
| 43 | Kirovskaya Oblast | 1390.5 | 484.2 | 928.5 | 4496.2 | 3065.0 | 10364.4 | 0.7 | 86.6 |
| 44 | Udmurtiya Republic | 759.6 | 841.3 | 975.7 | 4975.0 | 2141.3 | 9693.0 | 0.7 | 87.3 |
| 45 | Smolenskaya Oblast | 568.1 | 450.9 | 831.0 | 6180.4 | 1259.6 | 9290.0 | 0.7 | 87.9 |
| 46 | Sakhalinskaya Oblast | 291.9 | 357.1 | 890.8 | 1516.0 | 5677.8 | 8733.5 | 0.6 | 88.6 |
| 47 | Vladimirskaya Oblast | 1186.5 | 478.1 | 727.1 | 4100.6 | 1946.7 | 8438.9 | 0.6 | 89.2 |
| 48 | Penzenskaya Oblast | 696.8 | 741.4 | 824.7 | 4376.0 | 356.9 | 6995.8 | 0.5 | 89.7 |
| 49 | Astrakhanskaya Oblast | 847.5 | 1107.6 | 563.4 | 4061.7 | 263.4 | 6843.6 | 0.5 | 90.1 |
| 50 | Ivanovskaya Oblast | 759.6 | 290.5 | 572.9 | 2958.0 | 1845.5 | 6426.5 | 0.5 | 90.6 |
| 51 | Murmanskaya Oblast | 2934.7 | 290.5 | 1495.1 | 0.0 | 1704.3 | 6424.6 | 0.5 | 91.0 |
| 52 | Bryanskaya Oblast | 543.0 | 656.7 | 1233.8 | 3571.8 | 238.6 | 6243.9 | 0.4 | 91.5 |
| 53 | Khakassiya Republic | 37.7 | 275.4 | 236.1 | 0.0 | 5630.1 | 6179.2 | 0.4 | 91.9 |
| 54 | Novgorodskaya Oblast | 141.2 | 472.1 | 623.2 | 4570.1 | 328.3 | 6134.9 | 0.4 | 92.4 |
| 55 | Belgorodskaya Oblast | 156.9 | 1183.3 | 960.0 | 3451.6 | 271.0 | 6022.8 | 0.4 | 92.8 |
| 56 | Kurskaya Oblast | 806.7 | 493.3 | 708.2 | 3263.1 | 654.6 | 5925.8 | 0.4 | 93.2 |
| 57 | Tambovskaya Oblast | 878.9 | 568.9 | 689.3 | 3298.2 | 419.9 | 5855.2 | 0.4 | 93.6 |
| 58 | Chuvashiya Republic | 543.0 | 478.1 | 437.5 | 3717.9 | 362.6 | 5539.1 | 0.4 | 94.0 |
| 59 | Kurganskaya Oblast | 769.0 | 484.2 | 834.1 | 1614.0 | 1488.6 | 5189.9 | 0.4 | 94.4 |
| 60 | Karelia Republic | 2573.8 | 308.7 | 623.2 | 443.7 | 1108.8 | 5058.2 | 0.4 | 94.7 |
| 61 | Orlovskaya Oblast | 828.6 | 568.9 | 1063.9 | 2052.1 | 234.7 | 4748.3 | 0.3 | 95.1 |
| 62 | Mordovia Republic | 690.5 | 323.8 | 365.1 | 2372.0 | 263.4 | 4014.8 | 0.3 | 95.4 |
| 63 | Mariy El Republic | 838.1 | 490.2 | 333.6 | 1961.5 | 219.5 | 3843.0 | 0.3 | 95.6 |
| 64 | Kaluzhskaya Oblast | 844.3 | 514.5 | 497.3 | 1406.9 | 251.9 | 3514.9 | 0.2 | 95.9 |
| 65 | Kaliningradskaya Oblast | 1020.1 | 381.3 | 692.5 | 824.5 | 530.6 | 3449.0 | 0.2 | 96.1 |
| 66 | Kamchatskaya Oblast | 1673.0 | 169.5 | 692.5 | 0.0 | 576.4 | 3111.3 | 0.2 | 96.4 |
| 67 | Kabardino-Balkarskaya Rep. | 31.4 | 320.8 | 261.2 | 2303.6 | 120.2 | 3037.2 | 0.2 | 96.6 |
| 68 | Magadanskaya Oblast | 62.8 | 118.0 | 355.7 | 0.0 | 2391.3 | 2927.8 | 0.2 | 96.8 |
| 69 | Pskovskaya Oblast | 260.5 | 287.5 | 692.5 | 1177.7 | 404.6 | 2822.7 | 0.2 | 97.0 |
| 70 | North Osetia Republic | 3.1 | 112.0 | 103.9 | 2573.5 | 7.6 | 2800.1 | 0.2 | 97.2 |
| 71 | Karachayevo-Cherkessiya Rep. | 47.1 | 239.1 | 188.9 | 1675.0 | 318.7 | 2468.7 | 0.2 | 97.3 |
| 72 | Dagestan Republic | 69.1 | 245.1 | 179.4 | 1516.0 | 89.7 | 2099.3 | 0.1 | 97.5 |
| 73 | Tyva Republic | 65.9 | 163.4 | 110.2 | 0.0 | 1757.7 | 2097.2 | 0.1 | 97.6 |
| 74 | Jewish Autonomous Oblast | 301.3 | 90.8 | 66.1 | 0.0 | 1147.0 | 1605.2 | 0.1 | 97.8 |
| 75 | Adygeya Republic | 9.4 | 302.6 | 188.9 | 822.7 | 43.9 | 1367.5 | 0.1 | 97.9 |
| 76 | Chukotsky Aut. County | 9.4 | 54.5 | 0.0 | 0.0 | 1198.5 | 1262.4 | 0.1 | 97.9 |
| 77 | Kalmykia Republic | 62.8 | 169.5 | 157.4 | 556.5 | 63.0 | 1009.1 | 0.1 | 98.0 |
| 78 | Chechenskaya Republic | 0.0 | 968.4 | 0.0 | 0.0 | 0.0 | 968.4 | 0.1 | 98.1 |
| 79 | Altay Republic | 31.4 | 81.7 | 94.4 | 0.0 | 429.4 | 636.9 | 0.0 | 98.1 |
| 80 | Ingushetiya Republic | 3.1 | 272.4 | 31.5 | 24.0 | 0.0 | 331.0 | 0.0 | 98.2 |
| | *Russian Federation* | *133921.9* | *76578.4* | *96472.1* | *623175.3* | *480631.7* | *1410779.3* | *100.0* | *100.0* |