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Estimating Methane Emissions From the Russian Natural Gas Sector

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FOREWORD AND ACKNOWLEDGMENTS

Natural gas plays an important role in climate change mitigation as a substitute fuel for coal and oil. Nevertheless, this fossil fuel can produce significant radiative forcing when the methane gas of which it is composed escapes to the atmosphere, and even when burned to carbon dioxide. Because Russia produces and uses large amounts of natural gas, that country will need to carefully estimate methane emissions and undertake measures to reduce them. This task will not be easy, but it can help Russia save money by reducing losses of a valuable commodity – gas – while also implementing greenhouse gas emissions mitigation measures. This report analyzes current estimates of methane emissions from the Russian natural gas sector and describes how it is possible to improve these estimates by using international experience.

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ACRONYMS AND ABBREVIATIONS

AISU	Advanced International Studies Unit
BMP	Best Management Practices
CENEf	Center for Energy Efficiency
Country Study	Russian Climate Change Country Study
CS	Country Study
DI&M	Directed inspection and maintenance
DOE	U.S. Department of Energy
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
FCCC	United Nations Framework Convention on Climate Change
FSU	Former Soviet Union
Gas STAR Program	U.S. Natural Gas STAR Program
Gazprom	Joint Stock Company “Gazprom”
GEF	Global Environmental Facility
GHG	Greenhouse gas
Goscomecologia	Russian State Committee for Environmental Protection
GRI	U.S. Gas Research Institute
IEA	International Energy Agency
IMS	Industrial monitoring system
IPCC	Intergovernmental Panel on Climate Change
JI	Joint implementation
JSC	Joint Stock Company
LEL	Lower Explosive Limit
OECD	Organization for Economic Cooperation and Development
OEL	Open-ended line
Rosgazifikatsiya	Joint Stock Company “Rosgazifikatsiya”
SNC	Second National Communication
TVA	Toxic Vapor Analyzer
UGTS	Unified Gas Transmission System
USSEM	Unified State System for Environmental Monitoring
bbl	barrels
Bscf	Billion standard cubic feet
ppm	parts per million
Tg	Teragram
CO	Carbon monoxide
CO_2	Carbon dioxide
H_2S	Hydrogen sulfides
NO_x	Nitrogen oxides
SO_2	Sulfur dioxide

SUMMARY

Sectoral greenhouse gas (GHG) emissions inventories are an integral part of emission reduction strategies for any country, including Russia. Such inventories can also help Russia accelerate the process of estimating emissions. It is important to start with sectors that are economically active and, therefore, produce a large share of the emissions. Methane is the second most important greenhouse gas in Russia, contributing 19 percent to the total GHG emissions. The natural gas industry contributes 60 percent to total Russian emissions of methane.

The natural gas sector plays an important role in the Russian economy. It accounts for around 50 percent of total energy consumption and production in Russia. One natural gas company – Joint Stock Company (JSC) “Gazprom” (Gazprom) - dominates the sector. Gazprom is responsible for almost all gas production, transmission, and exports in Russia. In addition to Gazprom, the ITERA Group of companies is now an important player in the Russian natural gas sector. ITERA was created in 1992 as a supplier of industrial products, oil, and foodstuffs but, since 1994, natural gas business has become the main priority of ITERA. Currently, the natural gas sector covers 80% of ITERA aggregate business. In 1999, ITERA gas production was 6.6 billion m^3. ITERA also supplies natural gas from Russia and Central Asia to Armenia, Georgia, Belorussia, Lithuania, Latvia, and Moldova and exports natural gas to Turkey through Georgia (ITERA 2000).

The distribution segment of the sector is served by JSC “Rosgazifikatsiya” (Rosgazifikatsiya) that consists of regional gas distribution companies. After 1993, all regional companies became independent and today Rosgazifikatsiya is an umbrella organization that has a policy-making and lobbying role. It provides research and policy advice to regional companies on a contractual basis. Rossgazifikatsiya is independent from Gazprom.

The natural gas industry ranks among Russia’s most stable financial sectors. 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 percent methane and methane is a potent greenhouse gas. The climate change potential of methane is about 21 times higher than that of carbon dioxide. Therefore, it is important to minimize leakage and venting of natural gas if it is to maintain its priority as the *transition fuel*. Fortunately, the natural gas sector provides many such opportunities because reducing natural gas losses means reducing methane emissions. Reducing methane emissions is a profitable business as preliminary results from a Gazprom and the U.S. Environmental Protection Agency (EPA) study shows[1].

[1] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

Because natural gas produces so many opportunities to reduce losses, it is very important to carefully estimate current losses. Unfortunately, current detailed estimations are not available. It is also important that Intergovernmental Panel on Climate Change (IPCC) Guidelines do not allow estimating methane emissions accurately in Russia because regional emission and activity factors they provide are very uncertain. The paper analyzes four current studies:

1. Two governmental studies – the **Second National Communication** and the **Russian Federation Climate Change Country Study -** present estimates for the whole natural gas sector. In 1996-1997, under the U.S. 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) (Russian Federal Service for Hydrometereology and Environmental Monitoring 1997 - 1997a). 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 one and, therefore, this report describes only the SNC (Interagency Commission of the Russian Federation on Climate Change 1998).

2. A study conducted by Gazprom and EPA that provides estimates of methane emissions from compressor stations – "Methane Leak Management at Selected Natural Gas Pipelines Compressor Stations in Russia"[2].

3. A study conducted by Gazprom and Ruhrgas that provides estimates for all segments that Gazprom controls – "Estimating Methane Releases from Natural Gas Production and Transmission in Russia" (Gazprom/Rurhgas study) (Dedikov et al. 1999).

The estimates in these studies contradict each other and the results of the government studies differ by a significant factor from estimates in the Gazprom/EPA and Gazprom/Ruhrgas studies. One reason for such a difference may be that government studies include emissions from different segments in one category. Because Gazprom does not own the distribution segment, it is important to provide separate estimates for this segment. The paper also comes to the conclusion that the EPA methodology for estimating methane losses adopted by Gazprom and EPA is suitable for Russia and may be used in the future.

Because Gazprom is the company that controls the largest part of the natural gas sector, it will be responsible for monitoring emissions in the future. The paper analyses Gazprom

[2] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

experience with monitoring other substances, such as criteria pollutants. Gazprom is currently creating an Industrial Monitoring System (IMS) that has regional branches and includes information centers for processing air pollutants data. Much of this information is available from Gazprom publications. This system does not include provisions to monitor GHG emissions but could be extended to include such emissions[3].

Monitoring methane emissions is cost-effective if it produces information that results in money-saving repairs. Until the U.S. Gas Research Institute (GRI) introduced a Hi-Flow Sampler, no instruments were known that could be used to actually measure gas leaks. GRI has shown that a leak detection and repair program can be developed around the use of the Hi-Flow Sampler that can reduce leakage from U.S. compressor stations with a pay back period of less then one year[4]. Gazprom and EPA used the Hi-Flow Sampler for their measurement program in 1995 and showed it is possible to create such a leak detection program in Russia.

Although the paper mainly analyzes monitoring in the segments owned by Gazprom, it is also important to conduct more monitoring studies in the distribution segment. All distribution pipelines in Russia are old and may have large natural gas losses. None of the Russian agencies have conducted a detailed study of these losses. A Global Environmental Facility (GEF) grant to estimate emissions from segments owned by Gazprom was linked to a larger World Bank grant to estimate losses from the distribution segment. Because of poor coordination between different entities the projects were unsuccessful. Local distribution companies will monitor methane emissions, but more studies are needed to understand the capabilities of these companies to monitor emissions. Monitoring methane in the distribution segment may be physically easier than in other segments because this segment covers cities while, for example, transmission pipelines traverse remote areas that are difficult to access. At the same time, the tremendous length of the distribution sector under municipal infrastructure may be an obstacle to accurately estimating losses.

The distribution sector already consists of many companies that are independent. They will be able to get money from reducing emissions directly. At the same time, these companies are less financially strong then Gazprom. Independent companies are more vulnerable to a nonpayment problem because they get money from local population that often is not able to pay and cannot offset losses by increasing exports. Therefore, technical assistance for estimating methane emissions may be crucial for these companies.

[3] Monitoring GHG emissions, including methane, is a different task than monitoring criteria pollutants. For monitoring criteria pollutants, agencies use continuous monitoring, but in the case of methane emissions monitoring means estimating leaks through measuring leak rates at typical components and then extrapolating the results to the whole sector or to different segments. These measurements should be done periodically to update information on emission factors.

[4] Robert Lott, Gas Research Institute, May 2000. Personal communication.

INTRODUCTION

Creating sectoral inventories is very important for Russia because it allows the country to accelerate the process of estimating emissions. It is important to start with sectors that are economically active and, therefore, produce a large share of emissions. Such sectors can have a significant role in mitigating climate change and can participate in flexible mechanisms. It will be crucial to start with sectors that a small number of companies control because it will facilitate data collection. It is also useful to start with sectors that offer high potential for cost-effectively reducing emissions. Methane is the second most important greenhouse gas in Russia and contributes 19 percent to the total GHG emissions. Table 1 shows the contribution of different economic sectors to total methane emissions.

Table 1. Russian Methane Emissions from Different Sectors (1990)

Sector	**Share of emissions (%)**
Gaseous fuel	60
Domestic animals and manure	18
Solid fuel	11
Solid waste	7
Forest fires and biomass burning	3
Waste water	1
Liquid fuel	<1

Source: Russian Federal Service for Hydrometereology and Environmental Monitoring (1997a)

As is clear from Table 1, the natural gas sector is the most important source of methane emissions in Russia. Accurate estimates of these emissions can substantially help improve Russian GHG inventories. This paper examines only the natural gas sector[5], but in the future it will be important to also estimate methane emissions from other sectors.

Natural gas plays an important role in the Russian economy. Russia accounts for 23 percent of world gas production (Dedikov et al. 1997). In 1995, natural gas contributed over 50 percent to total primary energy production and 48.1 percent to total energy consumption in Russia. Oil and coal contributed 30 percent and 15 percent to total energy production and 26.4 percent and 18.4 percent to total energy consumption, respectively (Center for Energy Efficiency [CENEf] 1997). Russia is also the largest natural gas exporter with a share of 53 percent of the world trade in natural gas (Gazprom 1997b). It is also important to emphasize that, since 1980, the share of natural gas in the total energy consumption has risen more than 1.5 times. Between 1990 and 1995, natural gas consumption has dropped by 13 percent and natural gas production has dropped by 8 percent that led to a decrease in GHG emissions (CENEf 1997). This decrease in production and consumption is relatively small if we compare it with a 43 percent drop in

[5] To clearly estimate emissions from the natural gas sector, it is very important to accurately define borders of this sector. Information on how the sector is defined may be found in (EPA/GRI 1996) and (Popov 2000).

oil production, a 50 percent drop in oil consumption, a 35 percent drop in coal production, and a 36 percent drop in coal consumption in the same period and, as a result, a substantial drop in GHG emissions from the oil and coal sectors (International Energy Agency [IEA]/Organization for Economic Cooperation and Development [OECD] 1995). It is also important to note that in the future IEA predicts an increase in gas production and consumption, while oil and coal production and consumption will continue to decline (IEA/OECD 1995).

Financially, Gazprom is a very important company because it is one of the largest exporters in Russia and it brings in hard currency. In 1998 Gazprom delivered 142 billion m^3 of natural gas to foreign countries and received $9.7 billion (Anonymous 1999). Russian gas exports to foreign countries were relatively stable over the last few years. In the future, Gazprom is going to increase exports and construct new pipelines between Yamal (in Western Siberia) and Germany. Other pipelines are being built between Russia and Turkey and in Poland as a part of the Yamal pipeline. Gazprom is also proposing to construct a new pipeline between Russia and Bulgaria. Natural gas exports to countries other than those of the former Soviet Union (FSU) are the main stable source of money from the natural gas industry. In 1997, only 15 percent of Gazprom domestic customers paid for natural gas in cash (Energy Information Administration [EIA] 1998). The FSU countries also do not pay on time. In 1999, Ukraine owed Gazprom at least $1.5 billion (Lelyveld 2000).

Because natural gas is a cleaner fuel than either coal or oil in terms of criteria pollutants and also has a lower carbon content, it plays an important role for climate change mitigation. Russia considers natural gas an appropriate substitute for these fuels (Ministry for Fuel and Energy of the Russian Federation 1999). At the same time, it is important to understand that natural gas is a fossil fuel composed of methane, a potent greenhouse gas. The climate change potential of methane is 21 times higher than that of carbon dioxide. Without introduction of climate change mitigation measures in the natural gas sector, methane emissions may continue to grow. The natural gas sector also produces CO_2 emissions, mainly from burning natural gas at compressor stations. However, their share is relatively small compared to the total CO_2 emissions from fossil fuel combustion.

Fortunately, because reducing methane emissions means reducing natural gas losses, the natural gas sector may also provide opportunities to mitigate climate change and to do it in an economic way. By reducing gas losses, Gazprom has more gas to export and increase its revenues. Gazprom really needs to increase gas exports and would like to reach this goal by converting some gas fired power plants into coal fired power plants and, therefore, sell more gas abroad and increase its profits (Ivanov 1999). Although no detailed economic analysis yet exists of profitable options to reduce gas losses in Russia, preliminary studies suggest that such opportunities exist and the Russian natural gas sector has a tremendous energy saving potential. By utilizing this potential, it will be possible to prevent switching some power plants to dirtier fuels.

Most of the energy saving potential exists in the transmission segment that uses 10 percent of gas throughput for internal needs (Russian Federal Service for Hydrometereology and Environmental Monitoring 1999). The most important measures to tap this potential are:

- Replacing energy inefficient compressors with compressors of greater energy efficiency. Most existing Russian compressors have an efficiency of 25 percent, while new compressors are 36 percent efficient. This measure allows a saving of 8-9 billion m^3 of natural gas annually.

- Improving technical maintenance level.

- Replacing or repairing old leaking equipment with low or zero leaking versions. The Gazprom/EPA study found that a relatively small number of components is responsible for the largest number of leaks. Therefore, it might be profitable to replace or repair only a small number of components with the highest leak rates.

- Optimizing the transportation grid control. This measure can save 750 million m^3 of natural gas annually.

Gazprom has already begun implementing some of these measures through Joint Implementation (JI) projects. Ruhrgas and Gazprom are implementing a project to optimize a gas transportation system in the Nizhny Novgorod region through introduction of a computer modeling system. Gazprom and the Canadian company Transalta are negotiating a project to replace or repair leaking equipment at compressor stations[6].

Because the natural gas sector provides so many opportunities to reduce natural gas losses, it is very important to carefully estimate current losses.

Most studies estimate emissions using activity and emission factors (that is, Emissions = AF x EF) where an emission factor is the average leak rate from a component, piece of equipment, or facility in the system. The problem with this approach is the cost of developing, through measurements, a representative value for the emission factor. If the emission factor is not representative, the bias error can easily be as low as a factor of 3 and as high as a factor of 10 [7]. Therefore, it is very important to conduct detailed studies to better understand emission and activity factors. Such studies have been conducted only in a few countries.

[6] This project expected to start in September 2000. The current status is not clear.
[7] Robert Lott, Gas Research Institute, May 2000. Personal communication.

In Russia, unfortunately, such detailed estimations are not currently available. Only four studies exist that estimate methane emissions in the natural gas sector and all of them allow estimating methane emissions only with +/- 50 percent of uncertainty[8]:

1. Two National Communications and the Country Study present estimates for the whole natural gas sector. The National Communications do not provide detailed estimates for different segments. They use the simplest IPCC methods that do not allow for estimation of emissions carefully because emission and activity factors are not well developed for Russia. Even for the IPCC methods not enough explanations are made on how they were implemented. The uncertainty of results is very high. This paper covers only the SNC because it includes results of the first one (Interagency Commission of the Russian Federation on Climate Change 1998). The Country Study provides emission breakdown between sectors but combines transmission, storage, processing, and distribution into one category (Russian Federal Service for Hydrometereology and Environmental Monitoring 1997). Because the distribution segment does not belong to Gazprom, it is important to provide separate estimates for the distribution segment. It uses the same IPCC methods and does not provide better estimates. It is also important to note that IPCC approaches are based on a country's natural gas production and cannot provide an accurate breakdown by segment. These are the only official governmental documents presented to the United Nations Framework Convention on Climate Change (FCCC) Secretariat.

2. EPA and Gazprom conducted a number of measurements in preparation for implementing a larger project under a GEF grant. EPA and Gazprom introduced more detailed methods of estimating emissions and began developing activity and emission factors. Their measurements cover only a small number of components. At the same time, the study provides accurate component counts and clearly describes the methodology it uses. It is the most detailed study of methane emissions from the transmission segment to date. Preliminary results of the study show the EPA methodology of estimating emissions is applicable in Russia. It might be considered for monitoring emissions in the future[9].

3. Ruhrgas and Gazprom conducted measurements at compressor stations, pipelines, and gas processing plants. They extrapolated results to the whole natural gas sector (Dedikov et al. 1999). Gazprom and Ruhrgas do not provide detailed descriptions of the components covered and do not develop any activity or emission factors. Although their estimates of leaks from compressor stations are close to EPA and Gazprom estimates, more information is needed to understand how Ruhrgas and Gazprom derived these results. The uncertainty of results is also very high.

4. Results from all studies are different and show that methane emissions from the natural gas sector might be between 1 percent (measurement results from Gazprom and

[8] No studies give statistical estimates of uncertainties. More measurements should be conducted to come up with solid numbers concerning uncertainties.

[9] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

Ruhrgas) and 3.7 percent (estimates from government documents) of the natural gas production. Because the government documents include estimates of emissions from the distribution segment that is not owned by Gazprom within transmission and production segments that belong to Gazprom, such a difference may indicate big losses from distribution pipelines. No studies exist that estimate methane emissions from the distribution segment. Ultimately, methane estimates in the natural gas sector might be 1 percent. However, Gazprom should conduct more measurements and collect more statistics about a number of components to develop better activity and emission factors. EPA and Gazprom have already begun this work and their information seems to be more detailed and thus more credible than the government estimates.

Results from the Gazprom/EPA and Gazprom/Ruhrgas studies show the transmission segment is the biggest contributor to methane emissions from segments covered by measurements and, hence, it is important to start creating a monitoring system for this segment at the first place. It is also important that EPA and Gazprom have already started to develop emission and activity factors for this segment. According to the Gazprom/EPA study, the transmission segment can provide a number of cost effective mitigation options, yet another important factor to start monitoring at this segment.

Russia needs a more comprehensive monitoring system in the natural gas sector. Introduction of such a system will ultimately benefit Russia, although it will take time and effort to create it. At the same time, because Gazprom controls the transmission and production segments and uses standardized equipment throughout, this task will be easier than in other countries where many companies are responsible for gas production and transportation. After covering a rather large number of components, it will be possible to reliably extrapolate results to the entire sector. Creating reliable estimates will be also important for implementing emission trading programs and JI projects. Currently, it is not possible to transfer emission reduction units from JI projects. In the future, when it will be possible, it will be very important to get much better estimates of methane emissions. Otherwise, the system will not be credible. On the other side, implementing JI projects can help develop better estimates of methane emissions because they are implemented in smaller segments of the sector and periodically require emission estimates to verify emission reductions.

The natural gas sector is suitable for monitoring because Gazprom is the company that controls the largest part of the sector and it will be easier to collect data. Gazprom has a lot of experience in monitoring other pollutants and is creating the IMS that covers all companies and has an hierarchical structure with regional data collection centers. The IMS does not currently cover GHG emissions but Gazprom should extend it and include provisions to monitor them.

In implementing any emission reduction project, it will be important for local companies to benefit from saving more gas. On the regional level, they will be responsible for monitoring and they should have financial incentives for doing this well. Introduction of more competition into the gas sector by dividing it into production, transmission, and distribution companies (Fadeev 2000) may provide local companies with more incentives to reduce gas losses. The Russian government is currently attempting to liberalize the natural gas sector by ending the monopoly of Gazprom. On November 9, 2000, the government ordered Gazprom to allow other companies to use up to 15 percent of its pipelines (EIA 2000a). At the same time, it is crucial to preserve the current monitoring scheme and keep the IMS in place.

It is useful to look at the structure of the Russian natural gas sector and examine existing monitoring systems at Gazprom. The following sections provide this information and also discuss current estimates of methane emissions from the sector.

GAZPROM PROFILE

Gazprom controls 95 percent of Russia's natural gas production, 100 percent of its exports, and owns 100 percent of the country's natural gas transmission pipelines. In short, Gazprom dominates the Russian natural gas sector. A large number of regional and municipal gas distribution companies, most of them privatized under the umbrella of the former state distribution company Rossgazifikatsia, carry out gas distribution. The Russian government owns 60 percent of Rossgazifikatsia and distribution companies own 40 percent (IEA/OECD 1995). Gazprom sells gas directly to some industrial consumers but mostly it sells to local distribution companies that resell gas to end users.

Gazprom was created in 1993 by a presidential decree. It is a joint stock company with 40 percent of the shares owned by the government, 50 percent owned by Gazprom employees or the population of the regions where Gazprom has its operations, and the remaining 10 percent is owned by Gazprom with permission to sell 9 percent to foreign investors (Gazprom 1997b). As of 1998, the biggest foreign shareholder was Ruhrgas that bought 4 percent of shares. In the future, Gazprom would like to sell up to 20 percent of its shares to foreign investors (Nikolsky 2000). Currently, the Russian government is planning to break up Gazprom into the production and transmission segments to make it more competitive.

Production segment

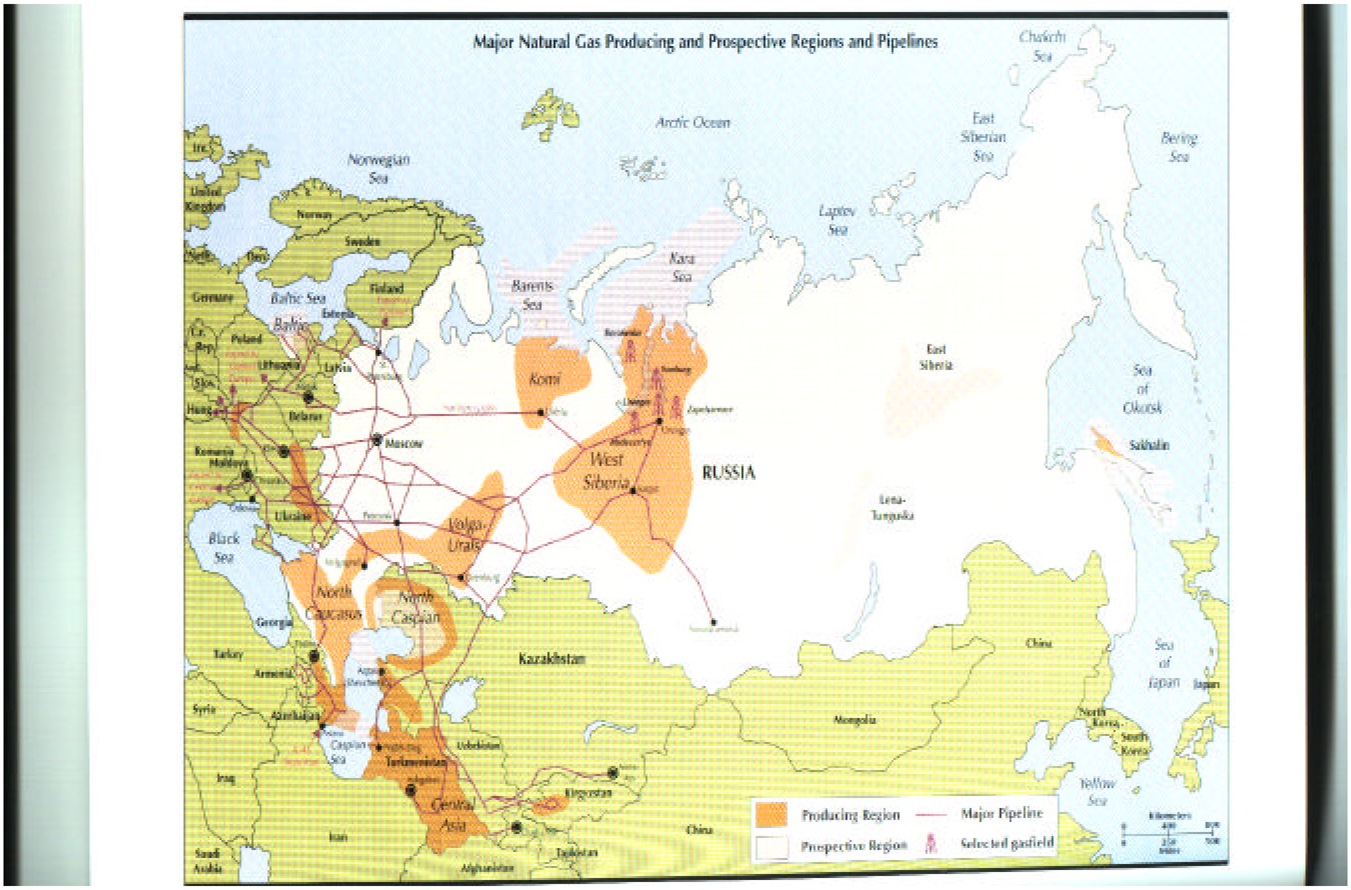
Gazprom consists of eight production associations. The largest production companies are Urengoygazprom (around the Urengoy field), Yamburggazdobycha (Yamburg field) and Nadymgazprom (Medvezye field). These companies produce 86 percent of Russia's gas. About 97 percent of the production comes from 21 very large fields (gas volumes more than 500 billion m^3) and 118 large fields (gas capacity between 30 and 500 billion m^3) (Gazprom 1997). The main gas production regions are Siberia (92 percent of the total gas production) and the Orenburg region (5 percent of the total gas production) (IEA/OECD 1995). The remaining 3 percent is distributed among numerous regions. Table 2 shows gas production by companies and regions in 1994 and, where data is available, 1999. In addition to Gazprom, several oil companies and ITERA also produce gas but their share is only 6 percent of the total gas production. For monitoring purposes, such a high concentration of production fields in one region may help to facilitate data collection. Figure 1 shows major gas producing fields and pipelines in 1995.

One of the main goals of Gazprom in the production segment is to discover or begin to develop more gas fields because production from all gas fields, except Yamburg, is declining. Gazprom predicts that production from the Yamburg field will begin to decline in 2002 (Gazprom 1997b). Several gas fields have been discovered during the last 10 years, but most of them are in remote areas (Far East, Arctic Coast, and Eastern Siberia) and their development will require substantial investments. The most promising gas field is Kovyktinskoye near Lake Baikal that was discovered in 1987 and has around 1.3 trillion m^3 of gas condensate and 600 million barrels (bbl) of oil (Keun-Wook Paik 1997), but it has not been developed yet. Gazprom estimates potential gas reserves at 212 trillion m^3 but the proven reserve base is about 49 trillion m^3 (IEA/OECD 1995). Only 42 percent of this amount is currently under development (Gazprom 1997b). These numbers suggest that in the future Gazprom will probably be the biggest gas exporter in the world and the natural gas sector in Russia will grow. This growth will lead to construction of new pipelines and therefore may lead to the increase of methane emissions through leaks. It will be important to undertake measures to reduce gas losses. In addition, increasing gas production will also lead to increased methane emissions from the production and processing segment, although the share of emissions from this segment is smaller than the transmission segment.

Table 2. Gas Production by Region and Company in Russia

Region/Companies	**Gas Production (billion m^3)**		**Percent of the Total Russian Production**	
	1994	**1999**	**1994**	**1999**
Russia	606.8	590.7	100	100
Gazprom	570.6	545.6	94	92
Siberia	529.1		87	
Nadymgazprom	64.3		10.5	
Yamburggazdobycha	179.3		29.5	
Urengoygazprom	249.4		41	
Surgutgazprom	36.1		6	
Outside Siberia	41.5		7	
Orenburggazprom	32.6		5	
Severgazprom	3.4		0.5	
Astrakhangazprom	3.3		0.5	
Oil companies	36.2	29.4	6	5
ITERA		6.6		1

Source: IEA/OECD (1995), Ministry for Energy (2000), and ITERA (2000). Percentages calculated by author.



Source: IEA/OECD (1995)

Figure 1. Russian Gas Producing Regions and Pipelines (1995)

Transmission segment

Gazprom consists of 16 gas transmission companies that are responsible for gas transmission from gas fields and for storage of gas. The most important companies are Tyumentransgas[10] that ships gas from Siberian fields and Uraltransgaz, Permtransgaz, Volgotransgaz, Lentrasgas, and Mostransgaz that transport gas throughout the country (IEA/OECD 1995).

Gazprom transports all gas through the Unified Gas Transmission System (UGTS) that was constructed between 1975 and 1990. Because almost all gas comes from remote regions, the average gas transmission distance to end user consumers is about 2500 kilometers. Table 3 presents the main characteristics of the UGTS. The system is getting old and needs extensive maintenance. The average age of pipelines is about 22 years, 85 percent of pipelines have been in operation between 10 and 30 years, and 14 percent are more than 30 years old (Gazprom 1999). The average lifetime of a pipeline is about 30 years. Compressor prime movers have a lifetime about 15-17 years and in 8-10 years Gazprom will need to replace half of them. Installed compressors have efficiency of about 25 percent that is low in comparison with the efficiency of modern compressors (Gazprom 1997b). Therefore, Gazprom needs to modernize the UGTS. Gazprom identified a list of improvements and began to implement some measures. Because of financial problems, Gazprom was not able to implement all of them. For example in 1995, out of 53 compressor stations proposed for modernization Gazprom started work at only 38; out of 3000 kilometers of pipelines proposed for reconstruction, Gazprom actually repaired only 1400 kilometers. Probably, the natural gas transportation sector is the most important segment for implementing climate change mitigation projects because it offers many profitable ways to reduce emissions. Currently, all JI projects in the natural gas sector are being implemented in this segment and several more have been proposed for implementation by Japan (Russian Federal Service for Hydrometereology and Environmental Monitoring 1999).

Table 3. Main Parameters of the Russian Transmission Sector (1998)

Pipeline length (thousand kilometers)	149
Number of compressors	4042
Installed capacity (million kWt)	42
Number of compressor stations	251
Length between stations (kilometers)	120
Gas transported (billion m^3)	560
Average length of transportation (kilometers)	2500
Gas consumption for internal needs (%)	10

Source: Gazprom (1999)

[10] "Transgas" is a Russian abbreviation for "transmission company".

GAZPROM EXPERIENCE WITH MONITORING

Currently, Gazprom does not have a comprehensive system to monitor GHG emissions. At the same time, Gazprom has experience in monitoring other substances and since 1995 has been creating the sophisticated automatic IMS. This system is already in place at several gas production facilities and processing plants. Gazprom would like to include GHG into this system in the future. It is useful to have a closer look on this system.

Although Gazprom does not have a GHG monitoring system, it has some experience with monitoring methane emissions and has conducted several projects to begin developing better estimates of methane emissions. At the same time, a larger effort to estimating emissions in the gas sector has recently failed. In 1995, the Global Environmental Facility initiated a big project to estimate CO_2 and methane emissions from the Russian natural gas sector and the increase of natural gas use in all economic sectors. Gazprom was responsible for carrying out estimates of methane emissions from all the transmission and production segments. Unfortunately, this project failed. It is useful to understand why.

This section provides descriptions of both the IMS and Gazprom experience with GHG monitoring. It is important that a GHG monitoring system not be created from scratch, but rather be included as a component into the existing system. This process can save time and money. The same Gazprom entities that now conduct monitoring should continue monitoring methane emissions.

Gazprom Industrial Monitoring System

Gazprom launched the IMS in 1995 by adopting a decree about monitoring and creating a feasibility study. The main reasons for creating a new system were to better collect information about pollution from different Gazprom facilities and to facilitate the exchange of information between local companies and Gazprom. It was also important to collect more reliable information by introducing new equipment for monitoring air pollutants and saving money/labor by introducing automatic monitoring equipment. The creation of the IMS was initiated by a decree from the Ministry for Fuel and Energy[11] that required all facilities burning fossil fuel to monitor all sources of pollution and discharges into water and the atmosphere. Although Gazprom is an independent company, it still reports all information about pollution to the Ministry for Energy. In addition, all local companies are required by Russian law to report environmental information to local branches of the State Committee for Environmental Protection (Goscomecologia).

The IMS includes monitoring of all sources of pollution and discharges into the atmosphere and water. It has a hierarchical structure with the main monitoring center in Moscow, three regional monitoring centers, and monitoring centers at Gazprom facilities. The system includes electronic exchange of data between centers, and it will be compatible with a Unified State System for Environmental Monitoring (USSEM) that was created by Goscomecologia to monitor criteria pollutants (Yarygin 1998). Unfortunately, because of a major government reorganization that took place in May 2000, the current status of the

[11] In 2000, Ministry for Fuel and Energy was renamed to the Ministry for Energy of the Russian Federation.

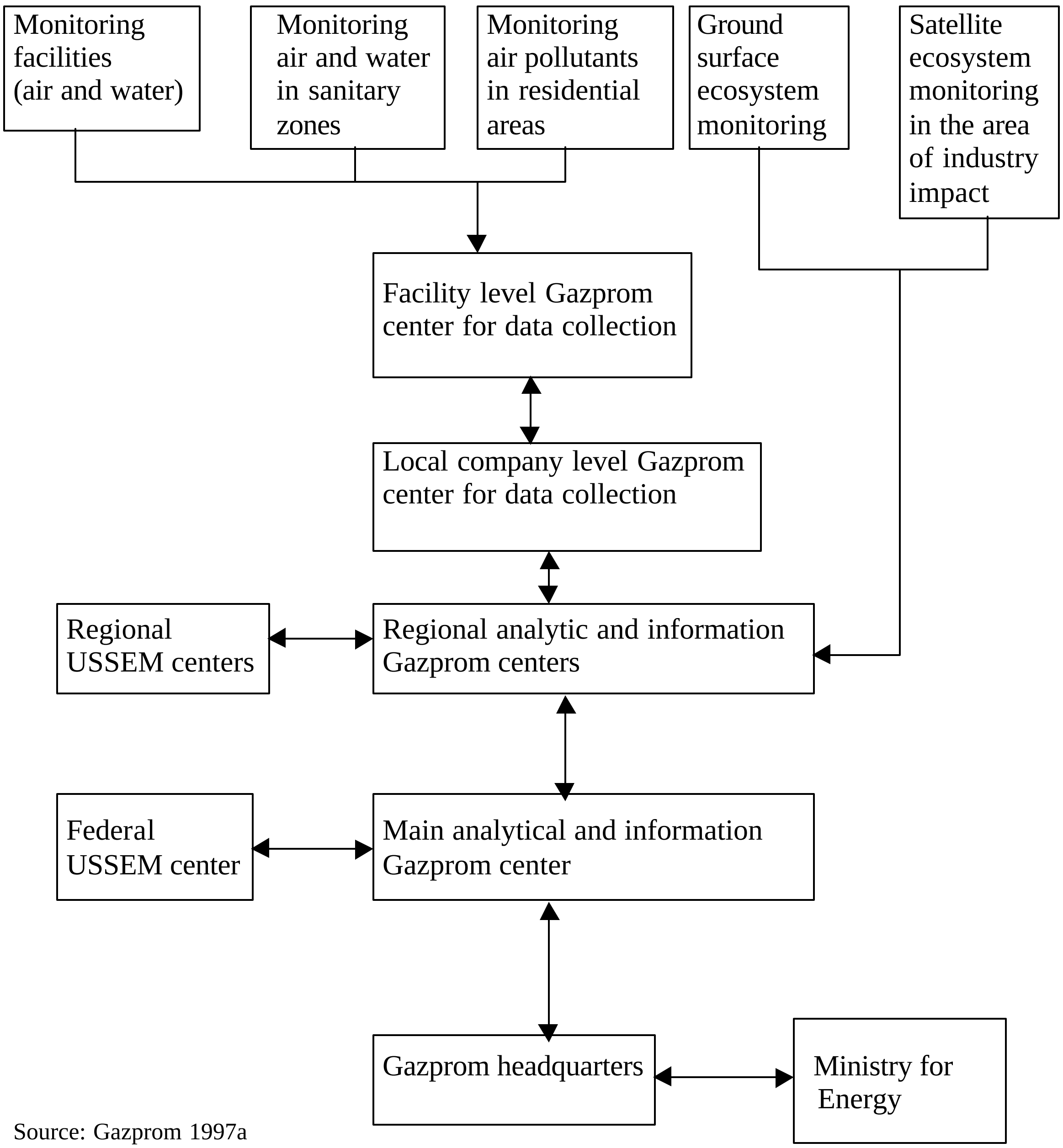
USSEM is not clear. In particular, under this reorganization Goscomecologia was disbanded and its functions transferred to the Ministry for Natural Resources. More information about the USSEM can be found in "Monitoring Greenhouse Gas Emissions in Russia: a Foundation for Climate Accountability" (Popov 1999). Gazprom decided to create the IMS on the basis of environmental laboratories that exist at each facility. Currently, all local transmission companies and gas production and processing facilities have either environmental labs or environment protection departments that are responsible for monitoring. All these monitoring entities are overseen by the Department of New Technologies and Ecology that designs methodologies to monitor pollutants and collects information from these entities. Gazprom appointed this department to be in charge of coordinating the work of entities responsible for designing the IMS. Gazprom also decided to use standard monitoring equipment everywhere and to finance the IMS centrally.

The first stage of designing the IMS took place from 1997 to 2000. During this stage, Gazprom decided to provide all environmental labs with modern monitoring equipment, design the uniform monitoring procedures, and create, test, and certify equipment (Gazprom 1997a).

In 1996 and 1997, this system was introduced at an Astrakhan gas processing plant. It allows users to automatically measure sulfur dioxide (SO_2), hydrogen sulfides (H_2S), and hydrocarbons and includes a computer center to process and store the data (Koltypin and Petrulevich 1997). Gazprom is also planning to create a monitoring system at compressor stations that will allow them to monitor carbon monoxide (CO) and nitrogen oxides (NO_x) emissions (Akopova and Solovyova 1998). In addition to the Astrakhan gas processing plant, Gazprom recently introduced the system at several other facilities. At a Nadym gas production facility, a regional information and analytical computer center was created as a first step in creating an IMS branch. It will allow users to electronically collect and process data (Novikov 1998).

Several challenges arose in creating the IMS, some of them stemming from the central design of the system. Creating standard equipment and introducing standardized monitoring procedures ultimately provides better and more comparable information. Central financing of all work can help local companies save money, but some problems come with this financing method. Because of financial problems, introduction of the IMS is not as fast as was expected. For example, at one production facility in the Orenburg region, financial problems stalled introduction of the system (Gafarov and Panteleev 1998). In creating a GHG monitoring system, it will be very important that local companies have access to the money from saving and selling more natural gas. If Gazprom chooses to collect all money, local companies will not have any incentive to conduct monitoring. If flexible mechanisms allow transferring credits, local companies should be able to receive some of them. Probably, local companies will sign an agreement with Gazprom about credit distribution.

In addition to financial problems, some facilities also experienced a lack of documentation in choosing appropriate monitoring equipment. For example, no list of equipment that is recommended to a facility for monitoring is found in any documents about the IMS. Some equipment that is listed is not suitable for some areas. At the same time, local companies cannot design their own equipment because it contradicts the principles of using standardized equipment at all facilities (Kobychev and Kabakov 1998). For monitoring GHG emissions, it will be important that local companies use standardized equipment throughout, because that makes monitoring faster and less expensive. Companies may use money they save from reducing natural gas to buy equipment. Figure 2 shows the structure of the IMS and the parameters it can monitor.



Source: Gazprom 1997a

Figure 2. Structure of the Industrial Monitoring System at Gazprom

Monitoring greenhouse gas emissions

Natural gas is mainly methane and reducing methane emissions means reducing losses. Monitoring GHG emissions in the natural gas sector is very important because it is closely related to the estimates for natural gas losses. Therefore, implementing climate change mitigation policies will be beneficial for the natural gas sector. The experience of American natural gas companies, that estimate methane emissions and then implement policies to reduce them, shows it is a profitable business. It is useful to look at Gazprom experience in accounting for natural gas losses.

Until Russia ratified the FCCC in 1994, it was not necessary to monitor GHG emissions and none of the official documents required industries to collect information about most GHG. However, there were some exceptions. Gazprom has a system to account for natural gas losses and because natural gas is mainly methane, intentional methane emissions are covered by different regulations. For example, in 1994, Gazprom adopted a document called the "Technological Requirements for Designing and Constructing Compressor Stations" (Gazprom 1994). This document sets up rules for monitoring criteria pollutants such as SO_2, NO_x, and CO. In addition to these pollutants, this document requires all compressor stations to account for natural gas discharges due to engine start up and stop operations and to compressor station blowdown[12]. The document defines formulas to calculate such discharges and gives an example of calculations at one compressor station. It is not clear how many compressor stations have conducted such calculations, but Gazprom and Ruhrgas were able to find this information during their measurement program (Dedikov et al. 1999). It will be important for Gazprom to carefully collect this information from all compressor stations. Local transmission companies also might have it. By analyzing this information, it will be possible to cover a substantial part of emissions from the transmission segment. These calculations may give better results than measurement estimates of technological emissions because they are based on technological data and engineering parameters defined by manufacturers after substantial research.

Information about methane emissions from unintentional equipment leaks is less available because environmental laws did not require measuring or estimating these emissions. Although Russian government agencies have set a maximum permissible level and Gazprom requires local companies to measure methane concentrations once a year in residential districts (Gazprom 1994), such measurements do not estimate emissions accurately and do not provide information about leaks. The IMS has a provision to include GHG in the future and design remote methods to measure methane emissions from different segments of the natural gas sector (Decision N 12-98 1998). Currently, Gazprom does not have a comprehensive system to estimate methane leaks.

Gazprom began designing remote methods to detect natural gas leaks from pipelines. Because the Russian pipeline system is extensive and the biggest gas fields are in remote areas in northern Russia, remote methods help to find methane leaks more effectively. Recently, Gazprom designed and tested two systems. One is a helicopter laser and

[12] Blowdown means intentional discharge of gas from a compressor station when a company shuts it down for a repair or because of an accident.

thermovisual system that detects gas leaks (Zhuchenko et al. 1998). Another system is a vehicle-based radiolocation system to detect leaks from gas pipelines (Asanov et al. 1998).

Monitoring methane emissions will be a different task than monitoring other pollutants. Because unintentional methane emissions are measured and numerous leaking components exist in the gas sector, it will be difficult to measure them all. Instead, it will be important to measure emissions at several components at different segments (for example, compressor stations) and then calculate emission factors. It is also important to develop activity factors by collecting statistics about the number of components from different sectors. After emission and activity factors are collected for a rather large number of components, it will be possible to reliably extrapolate them to the entire sector. Because Gazprom controls almost all transmission and production companies and uses standardized equipment in all segments, this task will be not as difficult as in other countries where many independent companies are responsible for gas production and transmission. Local Gazprom subsidiaries will be responsible for conducting measurements. Local IMS branches should serve as depositories of emission and activities factors on a local level; the main analytical Gazprom center may serve as a depository for aggregated information about emission and activity factors.

Unfortunately, attempts to create a GHG monitoring system in Gazprom have not been successful as yet. The GEF and the World Bank have attempted to initiate a larger effort of estimating GHG emissions from all segments of the natural gas sector, including natural gas losses from industrial and residential sectors in Russia. The main goal of this effort was to help Russia define cost-effective methods to reduce natural gas losses and to start preparing proposals for profitable climate change mitigation projects in the natural gas sector. Unfortunately, the GEF and World Bank project did not work out because of a lack of coordination between participants.

In 1995, the GEF decided to give Russia $3.2 million to estimate emissions of methane emissions into the atmosphere from the natural gas sector and propose methods to reduce these emissions. Another goal of the project was to identify and appraise projects to decrease CO_2 emissions by increasing the efficiency of natural gas use. This project was closely linked to a $106 million World Bank project of to rehabilitate the gas distribution system in the Volgograd region and identify sources of gas leaks in the residential and industrial sectors. Together these projects had the following components (GEF 1995):

- Identification of GHG emission sources (including CO_2 and methane) and methods of emission reductions from associated and non-associated gas production and the gas transmission segment (pipelines and compressor stations).

- Identification of GHG emission sources and methods of emission reductions in the distribution segment.

- Identification of GHG sources in the residential and industrial sectors, including electricity and heat production. Based on these assessments, development of emission reduction projects.

The GEF part covered only the first component and the emissions from natural gas use in the third component, with the rest of the money coming from the World Bank. The same agencies coordinated the implementation of both projects. Because the GEF and the World Bank do not directly lend money to private entities, the Ministry for Fuel and Energy was responsible for coordinating the projects. The ministry created a Coordinating Committee that included representatives from Gazprom, Rossgazifikatsia, and the Ministry of Environment and Natural Resources[13]. Because of the lack of the coordination between different players, the project failed. The only report that was prepared under the GEF component was the EPA and Gazprom measurement program[14]. It was the first attempt in Russia to introduce rigorous methods of estimating methane emissions and create a high quality inventory in the natural gas sector.

This negative experience has important implications for designing a monitoring system in the natural gas sector. It is important to work with Gazprom directly, possibly under supervision from an agency that will be responsible for GHG monitoring. It is important to use the Gazprom entities responsible for monitoring. The Department of New Technologies and Ecology could be a choice.

[13] This organization became the State Committee on Environmental Protection (Goscomecologia). However, Goscomecologia was disbanded by a presidential decree in May 2000 and its functions were transferred to the Ministry for Natural Resources.

[14] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

METHANE EMISSIONS FROM THE RUSSIAN NATURAL GAS SECTOR

Three government documents provide overall estimates of methane emissions from the Russian natural gas sector. In 1994 and 1998, Russia compiled and submitted the First and Second National Communications to the FCCC Secretariat. The communications have special sections on estimating methane emissions from all anthropogenic sources, including the natural gas sector. The Country Study also provides information about GHG emissions, including methane emissions from the natural gas sector.

Currently, these three documents are the only ones that provide official information about methane emissions from the entire natural gas sector. These estimates are very uncertain because they are based on unreliable emission factors and very aggregated sectoral statistics. None of the documents provides a detailed description of the methodology that was used. They only mention that they use IPCC Tier 1 Reference approach and IPCC coefficients for calculations. This method is the simplest one for calculating methane emissions from the natural gas sector. It is a means of calculating emissions with a very high degree of uncertainty because emission factors are not well-defined for Russia. The IPCC recommends using local emission and activity factors. Although the Country Study provides information about distribution of emissions between different segments of the gas sector, it uses the same approach as the National Communications and, therefore, does not improve the estimates. Emission estimates for 1994 from the Country Study contradict emission estimates from the SNC for the same year. It is difficult to explain the difference in estimates, but one reason may be that Russia prepared the SNC more recently. The last estimates the documents provide are for 1995.

In developing a regional inventory for the Novgorod region, the same Tier 1 Reference method was used for estimating methane emissions, but a team compiling the inventory emphasized that more precise methods might provide better results. Implementation of such methods was beyond the scope of the project because of time constraints. The Novgorod region is also a minor source of methane emissions in Russia because it does not have big compressor stations and gas production facilities (Novgorod 1999).

In addition to the above-mentioned government documents, other recent attempts were made to improve information about methane emissions and to develop a better methodology to estimate emissions by implementing more rigorous emission estimation approaches.

In 1995, EPA and Gazprom conducted a joint measurement program at four compressor stations in the Saratov and Moscow regions. The main goal of this program was to start improving methane emission estimates from the transmission segment and test the applicability of the EPA emission estimating methodologies in Russian conditions. Another goal was to identify profitable ways to reduce natural gas losses. Under the program, preliminary estimates of compressor methane emissions were developed. EPA and Gazprom estimated emissions in billion m^3 of methane only for Russian compressor stations. Their total estimate is 2.1 billion m^3. It does not cover compressor exhaust or engine start and stop emissions and, therefore, total emissions may be higher. EPA and

Gazprom provided a detailed report of their project, including component counts, as well as calculated preliminary emission and activity factors for many compressor station components.

In 1996 and 1997, Gazprom and Ruhrgas conducted measurements on two pipelines and two compressor stations in the Tyumen and Volgograd regions, and three gas processing plants in the Tyumen region and then extrapolated the results to the whole sector. They provide estimates for different segments of the sector, as well as an estimate for the whole sector. These estimates are available in several articles, but no single publication provides detailed information on the number of components covered by measurements in each segment or the number of measurements conducted. Gazprom and Ruhrgas estimated emissions from compressor stations as 3.1-3.7 billion m^3 of which leaks comprised 2.1 billion m^3 and intentional emissions comprised 1-1.6 billion m^3. For pipelines and gas processing facilities these estimates were 1.15 and 0.1 billion m^3 respectively. Gazprom and Ruhrgas included information about the extrapolation methodology they used, but did not estimate any emission and activity factors. They also did not provide any statistical information about the number of components in the natural gas sector. The uncertainty of estimates is +/- 50 percent, but the report does not explain how this was calculated.

Both studies covered only a small percentage of the sector and their results are quite preliminary. At the same time, these studies for the first time introduced more rigorous emission estimation techniques and showed more precise distribution of emissions between sectors. They also provide more up-to-date information than the official documents.

This section provides estimates from the government documents and estimates from the Gazprom/Rurhgas and Gazprom/EPA studies. The latter estimates are very preliminary and provided only for comparison. To get estimates in commonly used units, emissions from these studies are converted into million tons of methane. The most important goal of these studies is to begin developing better approaches to estimating methane emissions in Russia.

Second National Communication

The SNC provides data for methane emissions for the years 1990 and 1994 (Interagency Commission of the Russian Federation on Climate Change 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.

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 percent, whereas gas consumption dropped only by 5.2 percent for the same period (Gazprom 1997b). At the same time, because emission estimates are uncertain within +/- 50 percent, 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 (Russian Federal Service for Hydrometereology and Environmental Monitoring 1997).

The SNC uses coefficients recommended by the IPCC for methane emission calculations, but it is not clear how it implements them. The range of uncertainty of calculations is not less than ± 30-40 percent, but the SNC does not explain how this uncertainty was defined.

The SNC also provides information about the distribution of emissions between sectors. The 81 percent of methane emissions in CO_2 equivalent are from oil and gas production and transportation, but the document does not give numbers for oil and gas separately, nor does it explain how it calculated this share.

Russian Federation Climate Change Country Study

The Country Study provides estimations of methane emissions for 1990 and 1994 (Russian Federal Service for Hydrometereology and Environmental Monitoring 1997). For all calculations, the Country Study uses the Standard Tier 1 IPCC Reference method. Again, it is not clear how it applied this method. Unlike the SNC, it is clear 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. Table 4 shows estimates from the Country Study.

Table 4. Methane Emission Estimates for Russia (1990)

Segment	Emissions (million tons of methane)
Production (routine maintenance)	4.9 (3.0-6.8)
Production (venting and flaring)	0.4 (0.1-0.7)
Production (total)	5.3 (3.1-7.5)
Transport, storage, processing, distribution	9.9 (6.2-13.6)
Consumption (leaks from power stations and industrial facilities)	3.8 (2.4-5.2)
Consumption (leaks in the residential and commercial sectors)	0.17 (0.10-0.23)
Total	11.8-26.5

Source: Russian Federal Service for Hydrometereology and Environmental Monitoring (1997a)

Total 1990 emissions are 19.1 million tons of methane with an uncertainty range of +/- 50 percent (or 11.8-26.5 million tons). The Country Study recommends using 16 million tons as a conservative estimate. It seems more logical to pick the midpoint or 19.1 million tons of methane as the Country Study does initially.

The Country Study does not provide estimates for transportation, processing, and distribution separately. Leaks from industrial and residential sectors probably should not be attributed to the natural gas sector, according to the IPCC methodology. Excluding the 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 percent, very close to a conservative estimate of 16 million tons of methane. The first table in the Data Summary section gives ranges of estimates from Table 4 for total production and transport, storage, processing, and distribution. The next table in that same section gives a total estimate of 16 million tons of methane, as accepted for the entire sector.

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 percent 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 as 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 30.6 million tons. Based on these estimates, the Country Study calculates the share of methane emissions from the natural gas sector as 60 percent 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 percent and that corresponds to the decrease of gas consumption by 5.2 percent for the same period (Gazprom 1997b). The Country Study also provides information about the distribution of emissions between regions (see Table 5). It is not clear how the authors estimated these shares.

Table 5. Distribution of Methane Emissions Between Russian Regions

Region	**Share of methane emissions (%) from gas transportation (1993)**	**Share of methane emissions (%) from gas distribution and consumption (1990)**
Western Siberia	24	15
Ural	15	22
Central	17	21
North Caucasus	8	14
Volga	10	8
Central Chernozem	4	6
Volga Vyatka	8	4
North-West	5	4
North	6	4
East Siberia	2	1
Far East	1	1

Source: Russian Federal Service for Hydrometereology and Environmental Monitoring (1997b)

Gazprom/EPA Study

In 1995, EPA and Gazprom conducted one of the most detailed studies of methane emissions from the natural gas sector. The study involved measurements at four compressor stations[15]. The purpose of the Gazprom/EPA study was to begin developing better estimates of methane emissions from the whole sector. Another goal was to start identifying profitable options for reducing natural gas losses in Russia. EPA recommends this study as the first step in developing emission and activity factors for the Russian natural gas sector and identifying a number of options to reduce natural gas losses cost effectively. EPA and Gazprom conducted the study in the framework of the U.S./Gazprom Working Group, a joint initiative between Gazprom, EPA, and the U.S. Department of Energy (DOE). The Gore-Chernomyrdin Commission Energy Policy Committee established this group in 1995 to develop projects in the Russian natural gas sector. The U.S./Gazprom Working Group was also responsible for coordinating two GEF and World Bank projects in the natural gas sector. The Working Group still exists, but has not met since 1996. It is likely that the Working Group will still be in place because the President Bush is going to reconsider assistance programs to Russia. The main reason for this may be a failure of both the GEF and World Bank projects. Because EPA and Gazprom included only small number of components and they intended to broaden their measurements, the results of the study are very preliminary. At the same time, the study helps to understand sources of emissions from compressor stations and tests the applicability of the EPA methodology of estimating emissions. The study also produced estimates for all Russian compressor stations with a breakdown into components.

[15] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

EPA and Gazprom covered four compressor stations. Two – Petrovsk and Storojovka – are located in the Saratov region and operated by Yugtransgas. Two others – Pervomayskaya and Chaplygin – are located in the Moscow region and operated by Mostrangas. Because of time constraints, EPA and Gazprom measured only a subset of components at each site. In total, they screened 1800 components for leaks and measured 348 of these components. The study focused mainly on vents and valves attached to them that are supposed to have large leaks. The study also does not include estimations of technological emissions (for example, engine start and stop or compressor exhaust emissions) and, therefore, total estimates might be higher. The Gazprom/Ruhrgas study showed that intentional emissions comprise one third of the total methane emissions from compressor stations (Dedikov et al. 1999). Table 6 provides a brief description of the components measured at each station.

As is clear from Table 6, EPA and Gazprom measured only a small portion of the components at each station. At only one station did they measure emissions from compressors. It is also important that types of components measured at each station vary and this fact limits our ability to develop accurate emission factors for all components.

After EPA and Gazprom screened all the components for leaks, they quantified the leaks by using the Hi-Flow Sampler developed by GRI and an American company called Indaco. All measured components were categorized and recorded at each compressor station. These component counts were used to calculate emission factors for each component category. EPA and Gazprom produced detailed reports for each compressor station and extrapolated results for all compressor stations in Russia.

Table 6. Components Covered at Russian Compressor Stations by the Gazprom/EPA Study[16]

Compressor station	Components measured
Chaplygin	Blowdown/unit valve vents, fuel gas vents, starter gas vents, and cooler blowdown vents
Pervomayskaya	Field and yard valve components, scrubbers, and components outside compressor building. Not compressors themselves.
Petrovsk	Field and valve yard and blowdown/unit valve vents. Not compressors themselves.
Storojovka	Field and valve yard. Not compressors themselves.

EPA and Gazprom used an extrapolation technique that included following steps:

1. Calculating average emission factors for all of the component categories covered at four compressor stations.

[16] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

2. Estimating the number of components for the entire Gazprom transmission system. These estimates are based on Gazprom data for the number of compressor stations and the number of components per compressor station.

3. Defining an activity factor (percent of time a component leaks) for each component. It was necessary to do this to account for the fact that some components leak only when a compressor is running and some leak only when a compressor is not in operation. For most components, the activity factor was 1.0 meaning they may leak all the time regardless if a compressor station is running or not. Compressor unit valves and compressor blowdown vents leak only when a compressor station is not running. EPA and Gazprom suggested it happens only half of the time and the activity factor for these two components is 0.5.

4. Multiplying emission and activity factors to get an estimate of total emissions from compressor stations.

Using these three steps, the study estimated total emissions for all compressor stations and produced estimates of what percentage each component contributes to total emissions. In addition, the study provides a cross-station comparison and identifies components with the highest emission factors.

The total emission estimate is 2 billion m^3. Three components – compressor unit valve vents, station blowdown vents, and ball valve vents – contribute 85 percent. Across all compressor stations covered, the unit valve vents, station blowdown vents, recycle vents, fuel gas vents, and start gas vents are the components with highest emission factors. All results are very preliminary and more measurements should be done to get a better picture. It is also important to continue collecting activity factors. In addition, these estimates do not include technological emissions like, for example, compressor exhaust emissions so the final results will be higher. At the same time, this number is very similar to the Gazprom estimates from the joint Ruhrgas and Gazprom study conducted in 1997 that showed maximum leaks may be 2.1 billion m^3.

The study also took a first step toward proving cost-effectiveness of emission reduction projects. The study shows that a small number of components is responsible for the largest percentage of leaks and it might be very cost-effective to repair these components. Again, more studies should be done to prove this theory.

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 and prove that real emissions are lower 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 percent. 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.

The Gazprom and Ruhrgas chose two compressor stations for measurements: Kazym and Upper Kazym, located in the Tyumen region and operated by Tyumentransgas. Tyumentransgas is responsible for transporting gas from three gas production fields and is the largest of the Gazprom transmission companies in Russia. It operates over 27,000 km of pipelines with 33 compressor stations. Ruhrgas and Gazprom suggested that Kazym and Upper Kazym represent the range of typical compressor stations in Russia because Kazym is one of the oldest compressor stations in Russia (built from 1971-1977). Upper Kazym is relatively new and has been upgraded recently. In addition, both stations use standard equipment that accounts for 70 percent of all units in operation.

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. About 2000 kilometers of pipeline at Tyumentransgas were examined by air patrol using methane detectors. In addition, approximately 630 kilometers of pipeline with more than 350 valves at the Volgotransgas transmission company were examined by foot patrol using methane leak detectors. The study showed the largest leaks occur when pipeline sections are vented for repair purposes.

Gazprom and Ruhrgas checked for emissions at three out of eight processing facilities of the Yamburggazdobycha production company and representative group of wells and gathering lines. The study does not explain what wells and gathering lines are representative, nor does it provide the number of wells measured. The study chose the oldest and newest processing plants for measurements, as well as one gas condensate plant. These measurements included valves, pipelines, buildings, and vents. It is important to note EPA, in accordance with the GRI approach, considers production and processing segments separately and provides estimates for each of the segments.

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 [17]. Then the study multiplied this number by the installed capacity of Tyumentransgaz and Gazprom compressor stations. Table 7 presents the measurement results.

Table 7. Emissions from Russian Compressor Stations (1997)

Source	**Emissions (billion m^3)**
Intentional	1-1.6
Maximum leaks	2.1
Total	3.1-3.7

Source: Dedikov et al. (1999)

Considering that the volume of gas produced in 1997 was 540 billion m^3, emissions from compressor stations would equal 0.57 - 0.69 percent of total gas production.

For pipelines, the study related total emissions from Volgotransgaz to the length of examined pipeline and then multiplied this value by the total length of Russian pipelines (140,700 km in 1997). Table 8 presents emission estimates from pipelines.

Table 8. Methane Emissions from Volgotransgaz Pipelines, 1997

Source	**Emissions (m^3/km)**
Leaks	2,700
Repairs	4,800
Ruptures	700
Total	8,200

Source: Dedikov et al. (1999)

This table means that in 1997 emissions from transmission pipelines for the entire sector were 8200 m^3/km/ x 140,700 km or 1.15 billion m^3 that is equivalent to 0.21 percent of total gas production in Russia.

Gazprom and Ruhrgas estimated emissions from gas production and processing facilities as 0.06 percent of the total output of Yamburggazdobycha (176 billion m^3) or 0.1 billion m^3. The study divides these emissions into leaks (0.02 percent) and intentional emissions caused by venting, depressurization, and repair work on wells (0.04 percent). It is not clear how the study extrapolated emissions due to leaks at processing plants to the entire Yamburggazdobycha region or how it estimated technological emissions. Gazprom and Ruhrgas decided that because other production sites are located in the same climate conditions, these emissions are representative for the whole gas production segment. The value of 0.06 percent from both production and processing segments seems too small. For example, the EPA estimates of methane emissions from these segments in the U.S equal estimates of methane emissions from the transmission segment (EPA 1998) and comprise

[17] Other activity factors may be used. For example, in the U.S. GRI has found that for compressor stations with reciprocating equipment a number of engines in a facility is best (Robert Lott, Gas Research Institute, May 2000. Personal communication).

0.6 percent. Table 9 shows 1996 methane emissions from the U.S. production, transmission, and distribution segments as percentages of the U.S. natural gas production. To calculate emissions in cubic feet, the paper uses a correlation factor between billion standard cubic feet (Bscf) and teragrams (Tg) of methane (1 Bscf approximately equals 0.019 Tg) (EPA/GRI 1996). Respectively, 1 Tg of methane equals approximately 52 Bsfc.

Table 9. Methane Emissions from the U.S. Natural Gas Sector (1996)

	Production	**Processing**	**Transmission Storage**	**Distribution**
Emissions (Tg of methane)	1.5	0.7	2.2	1.6
Emissions (Bscf)	78	36.4	114.4	83.2
Gas production (Bsfc)	19,812			
% of production	0.4	0.2	0.6	0.4

Source: Compiled by author from EIA (2000b) and EPA (1998)

Ruhrgas and Gazprom calculated the uncertainty of their estimates as +/- 50 percent. Such high uncertainty is due to errors in extrapolation methods because the study covered only small numbers of compressor stations and processing plants.

Data summary

It is useful to summarize in two tables the data from the four studies mentioned in the previous section. Table 10 provides estimates from the whole sector. Table 11 provides estimates from different segments of the sector. It is necessary to have two tables because different studies provide information at different levels of detail. For example, detailed estimates only exist for 1990 and 1997. Table 11 gives only a single estimate from each study for emissions from the whole sector. It does not include estimates from the Gazprom/EPA study because it covers only one segment. For all cases, the range of uncertainty is +/- 50 percent. Table 10 provides a range of estimates (the highest and the lowest) when these estimates are available. 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.

Tables provide 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. However, because none of the government documents provides estimates separately for this segment, it is not possible to do this. Emissions from the residential and industrial sectors are not included because they cannot be attributed to the natural gas sector. To estimate emissions in common units the paper introduces a correlation factor between m^3 and tons of methane (1 million tons of methane approximately equals 1.35 billion m^3). Respectively, 1 billion m^3 approximately equals 0.74 million tons of methane. These coefficients are from (Dedikov et al. 1999) that estimates emissions in 1997 as 5.4 billion m^3 or 4 million tons of methane. Data about gas production is from (Gazprom 1997b) for 1990-1994 and from (Dedikov et al. 1999) for

1997. The paper considers only gas produced by Gazprom. In addition, three other companies produce natural gas in Russia, but their share is small.

Table 10. Methane Emission Estimates From Different Segments of the Russian Natural Gas Sector

	1990 Country Study		**1995 Gazprom/EPA**[18]	**1997 Gazprom/Ruhrgas**			
	Production (includes maintenance and flaring)	**Processing Storage Transmission Distribution**	**Transmission Compressor stations Leaks Only**	**Production and processing**	**Transmission**		
					Pipe-lines	**Compressor stations**	
						Intent-ional	**Leaks Max**
Emissions (million tons of methane)	3.1 7.5	6.2 13.6	1.48	0.22	0.85	0.74 1.2	1.6
Emissions (billion m^3)	4.19 10.13	8.37 18.36	2	0.3	1.15	1 1.6	2.1
Gas production (billion m^3)	589.5		559.5	540			
% from production	0.71 1.72	1.42 3.11	0.36	0.06	0.21	0.57-069	

Source: Compiled by author from Russian Federal Service for Hydrometereology and Environmental Monitoring (1997b); Dedikov et al. (1999)

Table 11. Methane Emissions From the Whole Russian Sector

	1990		**1994**		**1997**
	SNC	**CS**	**SNC**	**CS**	**Ruhrgas/ Gazprom**
Emissions (million tons of methane)	16.0	16.0	15.2	11.5	4
Emissions (billion m^3)	21.6	21.6	20.5	15.5	5.4
Gas production (billion m^3)	589.5	589.5	570.5	570.5	540
% from gas production	3.7	3.7	3.6	2.7	1

SNC – The Second National Communication; CS – Country Study

Source: compiled by author. Based on data from Interagency Commission of the Russian Federation on Climate Change (1998); Russian Federal Service for Hydrometereology and Environmental Monitoring (1997b); and Dedikov et al. (1999).

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, it is difficult to compare data. It is also difficult to compare 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,

[18] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

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 begun estimating 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 components covered should be provided for the results to be credible. Although their estimate of intentional emissions from compressor stations is the same as EPA and Gazprom estimates, 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 EPA, 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 EPA, Ruhrgas, and Gazprom do not. EPA and Gazprom data are the most transparent and it is absolutely clear how they arrived at such estimates. However, Ruhrgas and Gazprom do not provide enough information on their measurements. Their data on methane emissions from the production and processing seem too low because estimates of the U.S. emissions show that production and processing contribute the same percentage as transmission. For comparison, in 1996 the U.S. methane emissions from field production and processing were 2.2 Tg and emissions from transmission were also 2.2 Tg (EPA 1998). It may be possible for the final estimate of emissions to be lower than previously estimated, but more measurements are needed to prove this. Estimates must be provided separately for each segment, type of facility, and different types of equipment. They are needed in order to better understand how emissions can be reduced cost-effectively. EPA and GRI divide the natural gas sector into four segments – production, processing, transmission, and distribution – and estimate emissions separately for each segment. Such division helps to better identify measures to reduce gas losses.

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 6 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.

Analysis of Table 10 may help to identify segments that produce the largest share of methane emissions. As is evident from this table, the transmission segment and especially compressor stations produce the largest share. Distribution may also produce a large share of emissions because distribution pipelines are old; however, no studies are available to prove this. Although the ultimate goal should be to estimate emissions from the whole sector, this will take time. It will be easier to start with the transmission sector and finish estimating emissions from compressor stations.

U.S. NATURAL GAS STAR PROGRAM AND ITS APPLICABILITY IN RUSSIA

An important feature of a future Russian methane monitoring system should be its relative cost-effectiveness. It will be important for companies to identify and then reduce emissions to improve their net profit. Otherwise, they will not be interested in conducting methane measurements. One good example of reducing methane emissions cost-effectively is the U.S. Natural Gas STAR Program (Gas STAR Program). The measurement program conducted by EPA and Gazprom in 1995 in Russia showed the methodology adopted in the GAS STAR program could be directly applied to Russia. The EPA program indicated the inspection and maintenance procedures of the Gas STAR Program would be cost effective in Russia.

Design of the Gas STAR Program

The Gas STAR Program was launched as a voluntary partnership between EPA and the natural gas industry in 1993 as a response to the 1993 U.S. Climate Change Action Plan outlining activities the U.S. should undertake to reduce greenhouse emissions. The first stage of the program covered the transmission and distribution segments of the sector. A new program for producers began in 1995. Currently, the Gas STAR Program in the distribution and transmission segments covers 68 percent of transmission pipelines and 36 percent of distribution service connectors (EPA 2000).

Under the Gas STAR Program, companies are encouraged to implement cost-effective best management practices (BMP) that reduce natural gas losses. EPA and industry jointly identify these practices, but companies are asked to implement only measures that are economically profitable for them. Industry responsibilities include the following (EPA 2000):

- Determining and implementing appropriate BMP by submitting an implementation plan within the year from the moment it joins the program and implementing it within three years. Companies implement the BMP when the value of gas saved is higher or equals the cost of reducing leaks.

- Documenting progress annually.

- Cooperating with EPA in publicizing the Gas STAR Program.

In turn, EPA is responsible for the following:

- Assisting partners with program implementation by analyzing best technologies and developing training courses.

- Providing partners with public recognition.

• Recognizing partners for efforts prior to 1990 that are consistent with the program.

As the 1995 measurement program in Russia covered only compressor stations at transmission pipelines and used methods the Gas STAR Program adopted for this segment, a closer look at the Gas STAR Program is useful for compressor stations at the transmission and distribution segments. The following sections provide information about direct inspection and maintenance techniques adopted for these segments. They also discuss measurement methods adopted by the Gas STAR Program for identifying methane leaks.

Directed Inspection and Maintenance at Compressor Stations

Directed inspection and maintenance (DI&M) is a cost-effective method of identifying and reducing leaks. Companies implementing DI&M programs collect screening and measuring data through frequent surveys during the first year to identify components with the highest leak rates. The information obtained from the initial survey is used to direct further surveys and leak repair efforts in subsequent years. DI&M consists of four steps that follow (EPA 1997):

Step 1. Conduct screening and measurements. In this step, a Gas STAR Program Partner screens or surveys compressor station components to identify leaks and then measure leak rates. Several methods are used to screen and measure leaks, and as they all were implemented in Russia, it is useful to give a brief description of them.

Three screening techniques are widely used:

1. Soap screening. A soap solution is sprayed on facility components. Leaks cause the soap solution to bubble. Technical personnel can test about 100 components per hour. This method was used in the EPA and Gazprom measurement program for leak identification. Although it is a reliable and inexpensive (the cost of a soap screener is about $10-15), the screening technique cannot be used for flanges with deep crevices or for hot or moving parts[19]. For these components, EPA recommends using electronic screening or toxic vapor analyzers.

2. Electronic screening. Companies use this technique to test components with large gaps or holes. Electronic screeners are small devices that are generally convenient and accurate. Readings of the lower explosive limit (LEL) that are one percent or higher indicate a leaking component. EPA and Gazprom used electronic screening to measure open-ended lines (OEL) and flanges. In 1997, Ruhrgas and Gazprom also used electronic screening for their project.

3. Toxic Vapor Analyzer (TVA). TVA is a flame ionization device that companies use for identifying and measuring leaks. It measures methane concentrations in parts per million (ppm) in the area around the leak. These concentrations are converted to volume estimates by applying correlation equations. It is slower than soap screening (40 components

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[19] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

measured per hour), requires frequent re-calibration, and can cause a *flame out* of the hydrogen flame within the instrument. *Flame out* is a nuisance and increases the time required to screen a facility. The concentration can easily be converted to leak rate using the correlation equation, but the results are very inaccurate. Because the scatter in the data is 3 to 4 orders of magnitude, it is not possible to make a cost-effective decision on whether or not to repair a leak. However, the instrument is cheaper and more widely available than high-flow samplers. Gazprom and Ruhrgas used the TVA in their measurement program for identifying leaks and for estimating emissions.

After leaks are identified, they are tagged. In the EPA and Gazprom study, all components that showed leaks of more than 500 ppm were tagged. Tags had a leak number and a leak location.

After leaks are identified through soap and electronic screening, they are quantified by using the following devices:

Hi-Flow Sampler. This device uses a high volume flow of air to completely capture all methane coming from a leak and take a direct volumetric measurement. It provides much more accuracy than TVA. Two operators can measure up to 30 components per hour. It can measure all components; however, it has an upper limit of approximately 10 cubic feet of methane. This limit has never been exceeded by a leak from standard equipment. Currently, the Hi-Flow Sampler is the most accurate equipment designed for measuring methane emissions. EPA and Gazprom used it widely in their study and although relatively few components were measured, first results showed that it is cost-effective to use the Hi-Flow Sampler in Russia. One disadvantage of using the Hi-Flow Sampler is that it is rather expensive (the cost of the Hi-Flow Sampler is in the range $15,000 – 18,000) and it is available on a limited basis. Ultimately, it will become cheaper and more available and might be used in Russia more often.

Rotameter. Companies use this device to measure extremely large leaks from open-ended lines at vent stacks. Rotameters channel gas flow from a leak source through a calibrated tube. EPA and Gazprom used rotameters for quantifying 10 leaks.

Step 2. Evaluate results. In this step, components are grouped according to leak rates. Gas STAR Program partners noticed that some components leak more often than others. They found that components with the highest leak rates are pressure relief valves and blowdown valves at the end of vent stacks that release natural gas into the atmosphere. Preliminary results in Russia show this holds true for Russian compressor stations as well[20].

Step 3. Prioritize and repair leaks. After data is evaluated, it is important to select leaks that should be repaired. EPA and GRI studies in the U.S. showed that 20 percent of leaking components accounts for 95 percent of total leak volumes. Results of the measurement

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[20] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

program in Russia show a similar pattern. The top 10 percent of leaks account for 40-60 percent of all measured gas leaks[21].

Step 4. Develop survey plan. DI&M programs use leak measurements data collected during initial surveys to design future surveys. An important component of the survey plan is creating a list of component classes (for example, valves) and group descriptions. EPA and Gazprom used this method in their program. They classified all components into several categories that were used to calculate emission factors[22].

DI&M programs proved to be cost-effective in the U.S and led to a decrease of methane emissions. For example, during the first year of the program, Gas STAR Program partners reduced methane emissions by 1.6 billion cubic feet and saved approximately $3.2 million.

Applicability of the Gas STAR Program to Russia

The methodology recommended by the Gas STAR Program might be very useful for Russia and could lay a foundation for creating a comprehensive and cost-effective methane monitoring system. Although more studies should be conducted in Russia, preliminary results show that Gas STAR Program principles are applicable to Russia.

The GAS STAR methodology for identifying and measuring leaks was successfully tested in Russia. EPA and Gazprom conducted the measuring program at four compressor stations by using soap screening techniques and quantifying emissions with the Hi-Flow Sampler. EPA and Gazprom fund that a relatively small number of components is responsible for the largest number of leaks. The program also concluded that unit valve vents and station blowdown vents are the biggest sources of emissions at a compressor station. It is necessary to continue measuring emissions and cover more components because relatively few measurements were done.

It is very likely that DI&M at Russian compressor stations will be profitable, although more studies are necessary to understand how profitable and in which cases.

The Gas STAR Program also recommends that local companies have incentives to estimate emissions because they can profit from selling more gas. In the U.S., local transmission companies are independent. In case of Gazprom, it will be very important that local companies receive money from implementing DI&M and saving more gas. Because local transmission companies will be actively involved in any monitoring activities, Gazprom and local companies should agree in advance about sharing responsibilities and possible profits. As has been noted, one JI project in the natural gas sector has been suspended because local companies could not receive profits from reducing leaks (Russian Federal Service for Hydrometereology and Environmental Monitoring 1999).

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[21] Ibid.

[22] Gazprom/EPA 1996. Methane Leak Measurements at Selected Natural Pipeline Compressor Stations in Russia (Draft). Moscow.

POLICY RECOMMENDATIONS

Creating a GHG monitoring system in the natural gas sector in Russia will not be an easy task. It will require time and effort. At the same time, Russia has already gained some experience in measuring methane emissions and several agencies have conducted studies to estimate such emissions. Creating a monitoring system will help Russia to better understand sources of gas losses in the natural gas sector and ultimately help to identify cost-effective measures to reduce such losses. Several recommendations, both institutional and technical, might be useful for Russia and Gazprom in designing a system:

1. **Estimate emissions separately for different categories**. All government studies estimate emissions from transmission, processing, storage, and distribution under one category. Separating these categories will help to better identify segments that produce the largest share of emissions and to compare data from different studies. Because the distribution segment does not belong to Gazprom and distribution companies have not conducted any studies about losses from this segment, it will be important to study this in the future.

2. Make Gazprom responsible for monitoring segments that belong to the company. Gazprom should be responsible for monitoring methane emissions and obtaining direct assistance from international agencies. A JI project between Gazprom and Ruhrgas is successful because Gazprom gets money directly. Gazprom already has experience with monitoring and has created a regionally based monitoring system. An agency, responsible for coordinating climate change mitigation policies and preparing inventories, should certify all monitoring activities. The Gazprom Department of New Technologies and Ecology that is already responsible for monitoring other substances is a logical candidate for coordinating methane monitoring activities.

Local distribution companies will be responsible for conducting monitoring in the distribution sector. It will be important to collect information about the ability of these companies to monitor. The World Bank project, that unfortunately failed, identified a few distribution companies that can take part in future projects. Rossgazifikatsiya can help these companies set up a monitoring structure. It is also worth mentioning that some industrial consumers also use natural gas as a fuel. These consumers will be responsible for monitoring. Again, more studies are needed to estimate losses from such facilities and their ability to monitor methane emissions.

3. Create incentives for local companies to monitor. Local companies should be responsible for monitoring emissions from their facilities. The economic benefits from these efforts should flow to the local companies. The Gazprom/EPA study clearly shows that emission reduction projects at compressor stations are profitable. In the U.S., local companies are independent and retain all profits that result from emission reductions. In Russia, all local transmission companies belong to Gazprom. It is important for the local transmission companies to be rewarded by profit sharing in the projects. The Rusagas project has been suspended for more than a year because regional companies could not receive money for participating in the project and its future is not clear. All regional

Gazprom companies have environmental laboratories or departments that conduct monitoring of criteria pollutants.

4. **Start with segments that produce the biggest share of emissions.** Although the ultimate goal of monitoring is to cover the entire sector, introducing monitoring in segments with the largest share of emissions in the first place will help to save money for monitoring and will create the system faster. Preliminary studies show the transmission sector, and compressor stations in particular, is a good place to start because they produce the biggest share of emissions from the whole sector. Existing studies already covered several compressor stations.

5. **Collect more statistics to better estimate activity factors.** Availability of good statistics is important for designing activity factors. Only a few statistics have been collected by recent studies. It is necessary to create a survey that lists questions about what kind of data is already available and distribute this survey between regional companies. For example, for compressor stations, it is important to know installed capacity, number of compressors and, so on. Some of this information may be available from transmission companies and should be collected it in one place. EPA and Gazprom already have classified components for compressor stations.

6. **Conduct more measurements to better understand emission factors.** EPA, Gazprom, and Ruhrgas conducted only a few measurements during their studies. It is important that future studies measure more components and produce more emission factors. EPA and Gazprom covered different subsets of components at each station. It would be better to choose two or three stations and measure all components.

7. **Use existing monitoring systems and extend them to include GHG emissions.** Using existing systems can help save money and speed up the process of creating a comprehensive GHG monitoring system. Gazprom has just created the IMS. Several Gazprom companies already have IMS branches and Gazprom is planning to create more. The IMS includes data collection centers that can be used to store information about methane emissions. The IMS already uses standard methodologies and equipment to monitor criteria pollutants, and it will be important to include GHG emissions into this system. Choosing standard measurement techniques and creating a data acquisition center that can be set up in the Department of New Technologies and Ecology will also help in obtaining comparable data about GHG emissions from different companies. The Gas STAR Program methodology has already been tested in Russia and preliminary results show that it provides users with accurate information about methane emissions. It may be adopted for monitoring methane emissions.

8. **Use common methodologies and reporting.** Currently, only EPA and Gazprom have produced a report that clearly describes how many components were measured and identifies emission and activity factors. Although Ruhrgas and Gazprom also estimated methane emissions through rigorous measurement methods, they did not produce a detailed report and it is difficult to say if their data is entirely credible. EPA and Gazprom also showed that EPA methodology adopted for the Gas STAR Program is suitable for

Russia. It is important to continue this work and publish information about measurements. Ultimately a list of activity and emission factors for all components will be important. Creating a database that lists all activity and emission factors for different components is necessary to better characterize emissions. After each measurement program, more activity and emission factors will be available and the database will grow. The IMS Regional Analytic and Information Center can serve for storing local information and the Main Analytic Center will be a depositary for system wide emission and activity centers.

The EPA methodology will also be suitable for monitoring the distribution segment. In this case, Rosgazifikatsiya may collect all emission and activity factors.

CONCLUSIONS

The natural gas sector plays an important role in Russia. Natural gas contributes around 50 percent to the total energy production and consumption. Russia is the biggest gas exporter in the world and is planning to increase gas exports in the future. Natural gas is a cleaner fuel than either oil or coal and Russia considers it a substitute for these fuels. At the same time, natural gas is a fossil fuel and produces methane emissions. It is crucial to implement climate change mitigation policies in the natural gas sector because otherwise emissions from the sector will continue to grow.

Fortunately, because reducing methane emissions means reducing natural gas losses, the natural gas industry has the opportunity to increase earnings while mitigating climate change. As preliminary results from the EPA and Gazprom study show, only a relatively few leaks are responsible for 80 to 90 percent of methane emissions. By fixing these leaks Gazprom can substantially reduce gas losses.

Before introducing any measures to reduce leaks, it is important to estimate them carefully. As this paper shows, it is a difficult but manageable task. Currently, only a few studies exist that estimate methane emissions. Government studies use the IPCC methodology and estimate emissions with a high degree of uncertainty. New studies conducted by Ruhrgas and Gazprom and by Gazprom and EPA introduce more rigorous methods of estimating methane emissions. EPA and Gazprom clearly describe how they develop activity and emission factors. Unfortunately, their estimates cover only a small number of components. It will be necessary to continue the efforts and conduct more measurements.

One company – Gazprom – dominates the natural gas sector. It owns several regional transmission companies. Gazprom has experience in monitoring and is creating a sophisticated industrial monitoring system with regional branches. This system allows monitoring criteria pollutants and is connected to the USSEM. This system should be extended and include provision to monitor GHG emissions. Although Gazprom will be responsible for monitoring and collecting all data, local companies are able to receive monetary benefits from reducing natural gas losses.

The distribution segment may be a big contributor of methane emissions. It will be important to conduct estimates of methane emissions from this segment in the future.

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