METHANE EMISSION IN THE GAS INDUSTRY OF RUSSIA

ÉMISSIONS DE MÉTHANE DANS L'INDUSTRIE GAZIÈRE DE LA RUSSIE

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ABSTRACT

The paper presents the methodology of methane emission estimation and the strategy of the gas industry of Russia in the limitation of natural gas emission into the atmosphere. Special attention is paid to the problem of relationship between natural gas and climate change. The results of actual leakage and technological natural gas emission measurement, methods and control means are given. Design options on methane emission reduction under different processes, gas leakage and accidents.

RESUME

Cet exposé présente la méthodologie d'évaluation des émissions de méthane et la stratégie mise en oeuvre par l'industrie gazière de la Russie afin de limiter les rejets de gaz naturel dans l'atmosphère.
L'accent est mis sur la relation entre le gaz naturel et les changements climatiques.
L'exposé fournit les résultats de mesures des émissions de gaz naturel liées à l'industrie et des fuites, ainsi que des méthodes et moyens de contrôle.
Les choix techniques visant à la réduction des émissions de méthane liées aux différents procédés, aux fuites des gaz et aux accidents sont alors discutés.

1. INTRODUCTION

Methane as a main component of natural gas belongs to greenhouse gases the emission of which is under the limitation of 1997 Kyoto Protocol of International Framework Convention of the global climate change.

The idea that the increase in CO_2, methane and other greenhouse gases in the atmosphere should inevitably lead to a noticeable warming of the global climate was dominated in the second half of the 20 century.

In spite of the sufficient progress in the problem of climate change during the last decade there is no enough knowledge for reliable prediction of a future evolution of the global climate with regard to separation of man-caused environmental impacts. The problem lies in the fact that there is no simple answer what reasons cause considerable climatic variation on the Earth.

A specific though principle for Russia problem is the establishing of the origin of the increased concentration of methane in Western Siberia and estimation of emission volume in towns. Considering that Western Siberia contains around 35 % of the total proven reserves of natural gas, analysis of gas emission estimates in the oil and gas industry of Russia should be carefully done.

According to the latest data, global both natural and man-caused emission of methane into the atmosphere amounts to 470 Mt per year. Of this volume, 30 – 110 Mt/y are related to the emission that occurs during production, transportation, processing and consumption of gas and oil. It should be noted that the share of West Europe, USA and Canada in this volume is only 10 Mt/y. Thus the main portion of the global methane emission falls at East Europe and the FSU. A wide dispersion in CH4 emission estimates (30 – 110 Mt/y) is explained by the most western specialists by unsound equipment and technology being used in Russia. However, the main reason lies in the absent of reliable data on a volume and distribution of natural and antropogenic sources of methane in Russia.

The paper deals with the gas industry in Russia. The methodology of annual methane emission estimation is given along with and the ecological strategy of Gazprom in reducing methane emission by the year of 2000 to a level of 1990 with its further reduction.

2. METHANE EMISSION ESTIMATION

Gazprom is one of the leading world-wide gas companies with 94 % of Russian and 25 % of the world natural gas production.

Being the largest company in the fuel and power complex of Russia, Gazprom influences, to a certain extent, on environment. The dynamics of indices of Gazprom's environmental impacts are given in Table 1. Gas emission into the atmosphere contains a wide range of climatic active components (methane, CO_2, organic compounds, etc.). The main volumes fall at CO_2 and CH_4, Fig. 1.

Table 1

Indices Join-Stock Company GAZPROM facilities harmful impact

Indices	Years			
	1995	1996	1997	1998
1. Volume of harmful substances entering atmosphere, 10^3 tone	2425,0	2563,1	2345,2	2455,2
2. Volume of water consumption, 10^6 m^3	164,0	299,5	239,3	197,9
3. Volume of sewage waters discharge	7,43	8,9	19,2	19,37
4. Ground recultivation, 10^3 hectares	7,35	8,9	5,2	2,5
5. Industrial and domestic wastes, 10^3 tone	13,3	15,0	10,8	48,8

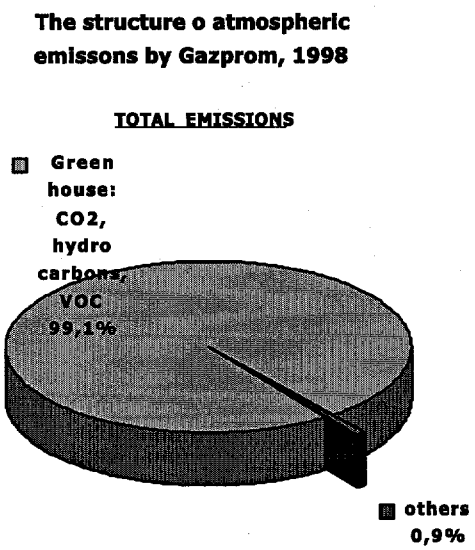

Fig.1

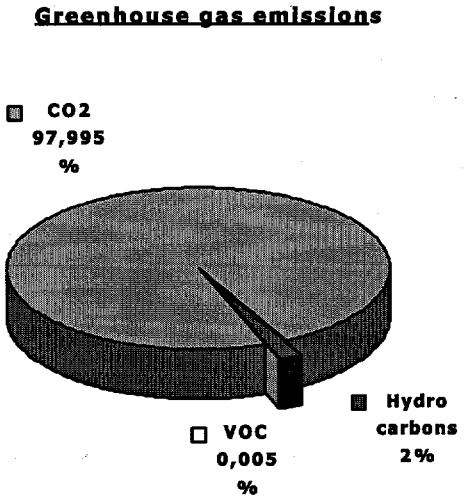

Fig.2

One of the priority tasks Gazprom are facing at while solving methane emission problem is reliable estimation, registration and analysis.

The basic directions to solve this problem include:

- Detection of sources and estimation of natural gas emission volume during HC production, natural gas processing, transportation, storing, distribution and consumption.
- Establishing of priority of sources based on a reliable estimation of natural gas emission volume and cost of separate measures on methane emission reduction.
- Development of progressive standards for natural gas emission in the gas industry.
- Development of recommendations on preventive measures and necessary changes in codes and procedures of design, construction and operation of Gazprom's facilities in order to cut natural gas losses.
- Development of an effective system of reducing and stabilizing natural gas emission into the atmosphere.

Registration of natural gas emission is to be performed from well drilling to a tip of burner, i.e. including gas wells, processing and treating facilities, gas mains and distribution gas grid.

Natural gas releases into the atmosphere during its involvement into technologically well-founded operations which are needed in the gas industry.

Natural gas can release from equipment tubing, processing units as well as during accidents.

Natural gas may be lost due to so-called «gas disbalancing» between shippers and consumers. Such disbalancing results from errors of measuring devices.

Methane emission is defined by volumes of natural gas entering the atmosphere due to technological needs and by technological losses due to poor gas tightness of equipment.

2.1. Technological needs. Technological needs include volumes of gas released into the atmosphere from «organized» sources such as GPU start and shut down, sealing oil separation on centrifugal pumps, blowing down of vessels, measuring devices, drive of stop valves, holes and gas discharge during repair of gas pipelines and equipment. The volumes of this gas are specified by the active codes and standards.

2.2. Technological losses. Technological losses include gas leakage due to poor gas tightness of equipment, stop and regulating valves, pipelines as well as a result of accidents. These losses are not

measured in time being. The losses taking place during accidents are estimated by calculation method and account for 5-6 million cubic meters for one accident.

Different methods are used for evaluating methane emission caused by technological needs and natural gas losses:

- Balance method – for rough estimation of natural gas emission
- Calculation-analytical method – for differential estimation
- Instrumental method – periodic (or planned) measurements at the gas industry's facilities.

Balance methods can be used both for the entire industry and its branches. These methods are based on analysis of material balances of structural units. The analysis of material balance of structural units has shown that methane emission into the atmosphere amounts to less than 2 % of production volumes. This is a formalistic indicator of a maximum possible volume of methane emission since an estimation error of the balance method may account for up to 50 % in the overestimation direction (at the expense of inaccuracy of measuring devices, accounting records, thefts, etc.). The calculation shows that methane emission during gas production and processing amounts to 10 % while gas transmission systems give 90 % of a total methane emission in the gas industry.

However, it should be noted that beginning from 1990 methane emission on gas transmission systems has decreased by 10-15 %.

A total natural gas losses on transmission systems (10^6 m^3/km) are 0.4×10^{-5} including 0.14×10^{-5} at compressor stations and 0.26×10^{-5} on pipelines.

These conclusions were made on the basis of full-scale investigations carried out on gas fields, transportation systems, storage and distribution grids.

Differential estimation of methane emission is carried out according to the codes and standards that in turn are based on calculation methods.

There are two levels of estimation:

- actual - by operating indicators;
- prediction, design and arbitrary - by normative indicators of technological process.

In order to define normative losses of gas both for scheduled blowing down and leakage from different equipment instrumental measurements are conducted.

In the period between 1995 and 1998 actual leakage and technological blow out of natural gas were measured under the frame of international program of co-operation between Gazprom (including VNIIGAZ) and Ruhrgas, Gas de France, USA Agency, Sumitomo and independent experts.

The full-scale field investigation on remote and contact detection of gas leakage and measurement of its volume on line sections of gas pipelines, compressor stations and gas fields has been performed.

Analysis of methane emission was carried out at the enterprises of Yugtransgaz (Storozhevskaya and Petrovskaya compressor stations), Mostransgaz (Pervomaiskaya and Chaplyginskaya compressor stations), Yamburggazdobycha, Tyumentransgaz (Rfzym and Verkhni Kazym compressor stations), Volgotransgaz (line section of the Sechenov gas pipelines) and Permtransgaz (Chaikjdskaya compressor station).

The results of these investigations have allowed to estimate methane emission during gas production and transportation including:

- Estimation of methane emission by standards which are now in force in the gas industry for different process equipment
- Estimation of methane emission by the results of instrumental measurements
- Specific indicators of methane emission per unit of equipment (mileage of pipeline, capacity of equipment, station, production rate etc.)
- Standartization of methane emission
- Quantitative estimation of methane emission for the entire gas industry of Russia.

Specific indicators of gas losses due to leakage were obtained on the experimental basis.

Both domestic and foreign control methods and measuring devices were used in the experiments (Table 2). Depending on end-user methods and means of recording, detection and measurement of leakage are separated and grouped (Table3).

Table 2

Objects of leakage control

Object	Units subject to control	Methods used
Gas production facilities	Valving Flanged joints Gas drives	Contact, using gas analysers
Linear parts of gas mains	Pipelines Crane sites Couplings Valving Fittings	Contact methods Radiolocation within mobile laboratory Remote probe with heatvision, laser, and spectrozonal equipment Calculation (forecast models) Acoustic
Compressor stations	Fittings of compressor shops Stand cranes Flanged joints	Contact, using gas analysers Soap solutions and special aerosols
Gas processing facilities	Measuring points Technological units	Contact methods
UGS	UGS cap Well	Contact methods Remote probe with heatvision, laser, and spectrozonal equipment Calculation (forecast models) Acoustic
Gas distribution stations	Cut-off valve Valving Measuring points Gas consumption meters Pressure regulators	Contact, using gas analysers

Table 3

Leakage control methods

Methods	**Instruments**	**Application**
	Detection of leakage	
Contact	Ionisation leakage detectors, signalling devices («Farmek» Bielorussia)	LP GM, UGS, CS, CGPU, GDS
Remote	Laser gas analysers (VNIIEgazprom, Russia, Gas Research Institute, USA) Heatvision systems (Institute of Air space instruments building, Tatarstan, «Agema», Sweden, «Folcon», USA) Radiolocation units («RIDIM-gas», Russia)	LP GM, UGS, CS LP GM, UGS, CS LP GM, UGS, CS
Organoleptic	Use of aerosols, special solutions (Germany, «Snam», Italy)	CS
Acoustic	WaveAlert VII (Marubeni, Japan)	LP GM
Calculation-forecast	LAVDAL system (Petrol Natural gas, Slovenia)	LP GM
Bioindication	Use of vegetative cover (Germany, USA, Russia)	UGS
Measurement of leakage		
Contact	**Automatic gas analysers («Khimavtomtika», Russia, «Environment», France, «Ukranalit», Ukraine, «Thermo», «Foxboro», USA) and gas analytic complexes («Monitor Labs», USA, «Horiba», Japan)** Sampling systems («Khimko», Russia, «Inframetrics», USA) with the following analysis of samples in stationary chemical laboratories Anemometers, flow meters (Germany, Russia), gas meters «Gasdeveis»	LP GM, UGS, CS, CGPU, **GDS** UGS, CS, CGPU, GDS UGS, CS, CGPU, GDS

LP GM – linear part of gas mains
UGS – underground gas storage
CS – compressor station
CGPU – complex gas processing unit
GDS – gas distributing station

Specific indicators of leakage for each element of technological process were also found on the experimental basis.

Methane emission can be described as percent to a total gas production or transmission (averaged): production and processing – 0.1 %, pipelines and valves – 0.2 %, compressor stations – 0.7 %. That is 1 % for gas production and transmission.

Gas losses at compressor stations (CS) account for one third of the total losses, while on line sections (LS) of gas pipelines this figure is two third. Around 20 % of the CS losses amount to technological needs and 80 % amount to leakage. The LS losses structure is as follows: technological needs – 35 %, leakage – 12 %, emergency discharge – 1 %, and leakage at gas distributing stations – 52 %.

In the period between 1996 and 1999 complex instrumental measurements of the distribution of greenhouse gases and chemically active compounds in the atmosphere were carried out on the basis of an automated complex of high-precision measuring and recording equipment. The measurements were conducted along the Moscow-Vladivostok rout covering the major part of the Russian Federation. Among other methods and means the complex included continuous isotope analysis of air samples along the entire rout. This analysis allows to determine the origin of CH_4 and CO including the detection of leakage during gas production, transportation and utilization.

The most important result of this investigation lies in the fact that a wide zone of the increased concentration of CH_4 over western Siberia is not related to CH_4 production and processing. Isotope analysis strongly suggests that practically the whole atmospheric methane is of bacterial origin (emission from marshes and overmoistened soil).

Besides, a gas leakage rate over the whole territory of Russia, from Moscow to Vladivostok, does not fall outside of the standards used in the West. The results of the above investigation show that the territory of Russia (and first of all western Siberia) is an extensive natural source of methane, while the share of methane in atmosphere caused by man activity is small. A preliminary analysis of available data allows to suggest that in a global emission of CH_4 the share of Russia's oil and gas industry does not exceed the share of West Europe. However, detailed processing, analysis and interpretation of an extensive information will require the efforts of many specialists.

3. METHODS OF METHANE EMISSION REDUCTION

The knowledge of the importance of different articles of gas consumption for own technological needs will allow to develop specific measures directed to reducing gas consumption and to replacing old processes to those which do not require gas.

3.1.Leakage and accidents. The reduction of methane emission is possible through decreasing a number of accidents on gas pipelines. One of the way to solve this task is to expand the use of intelligent pigs and rehabilitation of gas mains. The introduction of telemetry on gas pipelines will enable to reduce leakage by 2-3 times. The future modernization and reconstruction of gas pipelines will be accompanied by the introduction of telemetry in the Unified Gas Supply System of Russia.

The most effective way to solve the problem of gas leakage at process units, pipes, valves, etc. is an extensive introduction of gas detection monitoring (especially on risers). An outdated «Aeroposk-3» system is being currently used for gas leakage monitoring. «Redim-gaz» radar complex has been recently developed for detecting gas leakage within 30 km. The development of a new laser thermal imaging complex is under completion.

At present, in order to prevent gas leakage in valving a lubricant of the «Sealwell» company is employed and there is an agreement in the framework of «Rusogas» project on the enlistment services of two Canadian companies on the terms of trading by greenhouse gases emission quotas.

As to the reduction of gas emission for technological needs, 30% of them account for the maintenance works. In perspective, it is planned to install compressor and ejector units for pumping out gas out of pipeline sections under repair. At present, works aimed at the removal of gas leakage are carried out without emptying the pipeline sections, the start-up of units of the new generation is envisaged without use of natural gas for these purposes.

3.2.Gas unbalance. Gas unbalance means unaccounted losses or flowmeter losses. The value of these losses is significant, and for the last two years it is reduced by 50%.

The main reasons of gas unbalance are as follows:

- errors in measurements of gas entering Unified Gas System
- errors in measurements of gas issued to consumers
- unaccounted gas issued to third party consumers
- unaccounted gas used for local needs
- book-keeping.

According to estimations of many experts, gas metering equipment accounts for the main part of gas unbalance. Thus, according to Gaz de France the metering equipment accounts for three quaters of unbalance, and an American company PG&E considers this figure to be two thirds. The reduction of the unbalance value can be secured by using the metering equipment with an error up to 0.1%. Such program is being realised, although slowly, in Gazprom, it covers the major measuring points and should be extended to cover 100% of measuring devices, including inter-industrial ones. Apart from usage of new measuring equipment, it is extremely important to secure the proper quality of measured gas. The presence in gas of water, condensate, oil and mechanical admixtures reduces to nothing the high accuracy of new measuring equipment. We have a program on improvement of gas quality, with its successful implementation primarily depending on the application of means of measuring of the moisture and hydrocarbons dew point. It should be noted that the error in measuring of gas quantity is closely related to the stability of a number of physical parameters of gas itself – absence of pulsation, stability of pressure, value of compressibility factor and temperature.

It is important to note, that if there is no theft, the main part of the unbalance is not lost (not emitted into atmosphere) – it is really only the matter of wrong book-keeping.

4. CONCLUSION

Gazprom widely employs the mechanism of international co-operation and during a number of years maintains contacts with many business partners. It is ecological projects carried out jointly with renowned foreign companies. They are aimed at the reduction of greenhouse gases emission, methane included, enhancing of energy efficiency and reduction of fuel gas consumption.

The reduction of gas consumption is very important not only for enhancing of the production efficiency at the expense of hydrocarbon raw materials realisation, but also improves the environmental state in the area of the industry facilities operation, showing the level of technological discipline, reliability and safety of operation.

The strategy of reduction of methane emissions call for a priority development of scientific and technical and normative base, defining the requirements to new technics and technology and the mechanism of its application.

This will provide the co-ordination of pragmatic efforts in the framework of the national program in connection with the transition of the industry to the energy- and resources-saving technologies. The latter are expedient not only in terms of environment but also economically.

In accordance with the United Nations Framework Convention on Climate Change at the time being the terms and rules of trading by greenhouse gas emission quotas are being established, in order to create a basis at an international level for the reduction of emissions at minimal costs.

The gas industry of Russia may reach its goals by reducing own emissions with the help of selling of permissions for emissions of other countries.

The further progress in the solution of the global problem of climate change can be reached on the basis of the interdisciplinary approach using a powerful arsenal of modern means for carrying out large-scale theoretic and experimental investigations, and on the assumption of integration of the international community efforts.