WGCPARIS2015
WORLD GAS CONFERENCE
"GROWING TOGETHER TOWARDS A FRIENDLY PLANET"

26th World Gas Conference | 1-5 June 2015 | Paris, France

Natural gas life cycle assessment from the wells to the gas transmission system based on the case study of the largest gas production company OAO "Gazprom"

Kruglova Nataliya, Senior Research Associate
OOO «Gazprom VNIIGAZ», Russia

Akopova Gretta, Chief of Laboratory
OOO «Gazprom VNIIGAZ», Russia

Andreev Oleg, General Director of
OOO «Gazprom Dobycha Yamburg», Russia

Arabskiy Anatoliy, Deputy Chief Engineer
OOO «Gazprom Dobycha Yamburg», Russia

Arno Oleg, Chief Engineer of OOO «Gazprom Dobycha Yamburg», Russia

Table of Contents

Background

Natural gas is the most environmentally friendly hydrocarbon fuel, which is associated with much lower carbon dioxide emissions compared with other fossil fuels as a result of combustion. Natural gas is a perfect platform for introducing combined power plants running on renewable energy sources.

Nevertheless, at all stages of the production chain from the extraction of natural gas to the delivery to end users a significant amount of greenhouse gases is emitted provided the existing technologies are in use. This determines the carbon footprint of natural gas.

One of the methods of environmental management in terms of assessment and subsequent reduction of environmental impacts is the life cycle assessment (LCA). In relation to the Russian oil and gas sector, the life cycle assessment (LCA) allows the evaluation of the contribution of natural gas to climate changes at each stage of the production process, which, in turn, is the key to the identification and prioritization of a company's management decisions about the necessary measures to stabilize and reduce greenhouse gas emissions.

At natural gas production facilities of OAO "Gazprom", the major greenhouse gases released into the atmosphere from the process operation , are methane and carbon dioxide.

The result of the completed work is the natural gas life cycle assessment in the context of greenhouse gas emissions and climate change based on the case study the Gazprom largest gas producer OOO "Gazprom Dobycha Yamburg".

Aim

The study focuses on the application of the natural gas life cycle assessment (LCA) for greenhouse emissions from the well to the gas transmission system based on the case study the Gazprom largest gas producer "Gazprom Dobycha Yamburg".

Methods

Russia has a set of national standards for life cycle assessment: GOST R ISO 14040-2010, GOST R ISO 14041-2000, GOST R ISO 14042-2001, GOST R ISO 14043-2001 и GOST R ISO 14044-2007. These standards are identical to international standards ISO 14040:2006 «Environmental Management - Life cycle assessment - Principles and framework», ISO 14041:98 "Environmental management. Life cycle assessment. Goal and scope definition and inventory analysis", ISO 14042:2000 "Environmental management. Life cycle assessment. Life cycle impact assessment", ISO 14043:2001 "Environmental management. Life cycle assessment. Life cycle interpretation" and ISO 14044:2006 "Environmental management. Life cycle assessment. Requirements and guidelines" respectively.

The natural gas life cycle assessment in the context of greenhouse gas emissions was carried out in accordance with the above-mentioned standards for the case study of the gas producer "Gazprom Dobycha Yamburg".

Analytical, statistical, instrumental, and programming tools were used to carry out the natural gas life cycle inventory analysis (LCI).

Calculations of methane emissions into the atmosphere from natural gas leaks through bleeding equipment are based on the actual field study data gathered from a complex gas treatment unit (CGTU-1V) and individual wells of "Gazprom Dobycha Yamburg".

Results

The natural gas life cycle assessment in the context of greenhouse gas emissions was made for the case study of a Gazprom production subsidiary "Gazprom Dobycha Yamburg".

OOO "Gazprom Dobycha Yamburg" is the Gazprom largest upstream subsidiary. The main business of the company is production of gas, gas condensate and gas treatment. The company annually produces 220 to 230 billion m^3 of natural gas and 1.5 million tons of gas condensate. The boundaries of the company's liability are: "Gazprom dobycha Yamburg" holds licenses for development of five fields: Yamburgskoye, Zapolyarnoye, Tazovskoye, South and North-Parusovoye, the last three are preparing for development. Overview map of the activity area "Gazprom dobycha Yamburg" is shown in the Figure 1.

Figure 1 – Overview map of the OOO "Gazprom dobycha Yamburg" activity area

In 2009, according to the decision of OAO "Gazprom", OOO "Gazprom dobycha Yamburg" was entrusted with the development and construction of new and production fields in the Gulf of Ob and Taz Bay. Natural gas reserves in these fields and waterside exceed 1.5 trillion m^3.

Currently gas treatment is carried out at 18 complex gas treatment plants and preliminary gas processing terminals, and all are connected to more than 2,000 gas and gas condensate wells. The total length of operated pipelines is over 2,000 km. Block diagram of the company is shown in the Figure 2.

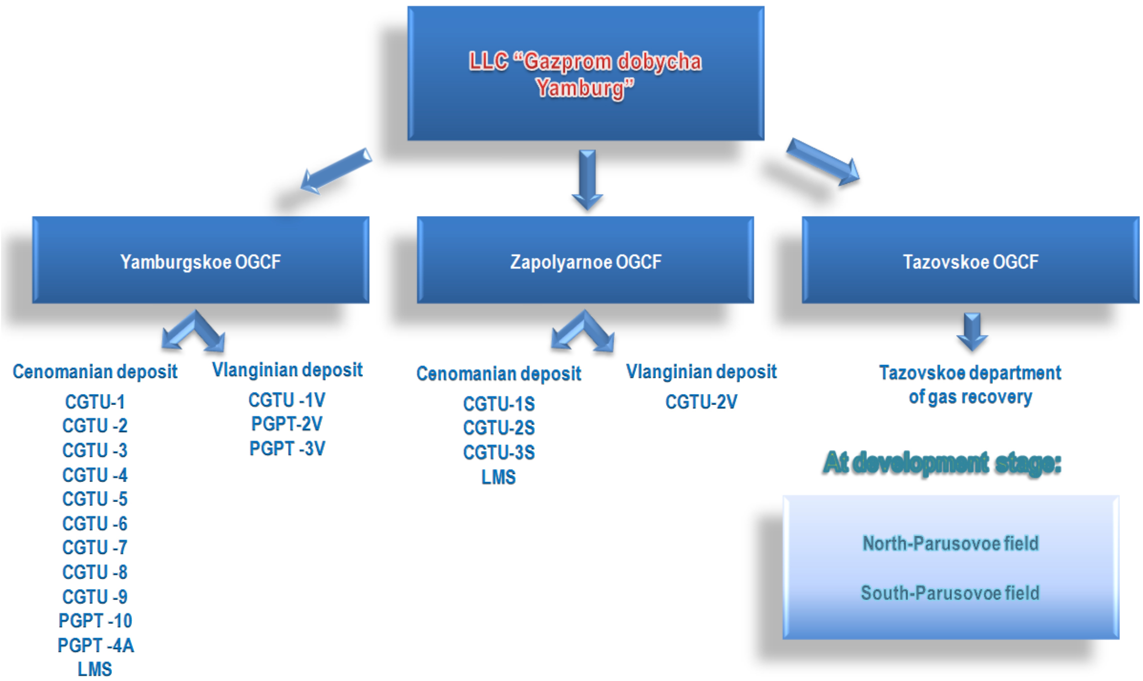

Figure 2 - Block diagram of the production objects "Gazprom dobycha Yamburg"

Greenhouse gas emissions associated with the company's operations (due to operations of the equipment located at the above-mentioned technological facilities), and as a result of the company supplementary operations (due to use of motor vehicles, generation and purchase of heat and electricity for own process needs, and generate waste, which is subject to further neutralization, disposal, landfilling and the transfer to specialized third-party entities).

The study included next stages:

- goal and scope definition;

- the natural gas life cycle inventory analysis;

- the natural gas life cycle impact assessment;

- the natural gas life cycle interpretation.

The goal of applying the LCA method was to assess greenhouse gas emissions throughout the company's natural gas production chain, from the wells to the gas transmission system.

The study scope covers all processes of the main and supplementary operations that caused greenhouse gas emissions.

The natural gas life cycle inventory analysis

The estimate scope at the natural gas LCI stage included all the major processes and sources of the company's gas production activities associated with carbon dioxide and methane emissions.

The study involved acquisition and processing of qualitative and quantitative engineering and technological information for each operation and statistical analysis of the collected information.

Qualitative assessment of the greenhouse gas emission was carried out for process and supplementary operations and emission sources throughout the natural gas life cycle.

Greenhouse gas emissions from production operations were divided into two categories – process emissions and fugitive emissions.

In the study we adopted the following definitions:

- process emissions result from the basic and auxiliary processes of production activities, due to operating conditions and characteristics of the equipment, and enter the atmosphere through specially constructed flues, exhaust vents, torches and pipes.

- fugitive emissions are emissions entering the atmosphere as a non-directional flow of gas, for example, as a result of an equipment leak.

The major greenhouse gases emitted from technological facilities of "Gazprom dobycha Yamburg" are methane and carbon dioxide.

Carbon dioxide is a major compound of combustion products discharged into the atmosphere from process sources resulting from the use of natural gas for the company's own technological needs (as fuel to generate heat and electricity, for gas compressor units (GCU), for burning of bleeding gas in flare units, for combustion of industrial waste, etc.

It is worth noting, the bulk of electricity is produced by the company itself, and a small share is supplied on a contractual basis.

List of main sources of process carbon dioxide emissions in the facilities of "Gazprom dobycha Yamburg" is shown in Table 1.

Table 1 – The list of process carbon dioxide (CO_2) emission sources for "Gazprom dobycha Yamburg "

Emission source CO_2	Generation source of CO_2 emission	Industrial process that leads to CO_2 emission
Horizontal flare	Well	Gas blowdown: - after drilling and overhaul maintenance; - for elimination of hydrate and liquid plugs; - during studies
Exhaust GCU pipe	Gas compressor units (GCU) of booster compressor station	Combustion of fuel gas for compression
Flue gas duct	Boiler unit (auxiliary boiler)	Combustion of gas for heat generation
Flue gas duct	Turbine (captive power plant)	Combustion of gas for power generation
Flue gas duct	Heaters of various applications	Combustion of gas for product heating: - condensate; - chemical reagents; - fuel gas, start-up gas, - water supply tank (WST)
Flare unit	Process equipment	Release Blowdown Displacement of air by gas Inspection
Exhaust chamber	BCS process equipment	Release Blowdown Venting during (de)pressurization of GCU Displacement of air by gas Inspection
Flare unit	Process pipelines	Release of flow lines, reservoirs, gas pipelines Displacement of air by gas Blowdown of flow lines, reservoirs, gas pipelines
Pilot burning	Flare units	Combustion of gas to maintain continuous work of burners
Horizontal flare (HF)	Gas condensate treatment units, chemical regeneration units	Combustion of gas at HF after weathering (degassing)
Horizontal flare	Combustion units for industrial waste waters	Combustion of gas at HF for disposal of waste waters
Flue gas duct	Boiler unit for field camps	Combustion of gas for heating in field camps
Flue gas duct	Power plant for field camps	Combustion of gas for energy in field camps
Flue gas duct	WST heaters for field camps	Combustion of gas for WST heating in field camps

Methane is the major compound of process emissions resulting from the use of natural gas for the company's own technological needs which do not originate from fuel combustion (e.g. purging and emptying of pipelines, GCU start up/shutdown; venting of equipment, etc.). A small part of methane is emitted to the atmosphere as a result of manufacturing operations, followed by burning natural gas as a result of incomplete combustion.

List of main sources of process methane emissions entering the atmosphere from the natural gas process facilities of "Gazprom dobycha Yamburg" is shown in Table 2.

The methane emissions (as a result of incomplete combustion) sources of the combustion products are similar to process carbon dioxide emissions sources (Table 1).

Table 2 – List of process methane emission source (CH_4) of natural gas for "Gazprom dobycha Yamburg" facilities.

Emission source CH_4	**Generation source of CH_4 emission**	**Industrial process that leads to CH_4 emission**
Vent stack	Process equipment	Release Blowdown Displacement of air by gas Inspection
Vent stack	BCS process equipment	Release Blowdown Venting during (de)pressurization of GCU Displacement of air by gas Inspection
Vent stack	Process pipelines	Release of flow lines, reservoirs, gas pipelines Displacement of air by gas Blowdown of flow lines, reservoirs, gas pipelines
Vent stack	Process unit	Venting gas for sampling
Dump valve	Pneumatic equipment for shut-off and control valves	Venting for gas supply to the shut-off valve control system
Vent stack	Gas collection: - blowdown - actuation of safety valves	Maintenance of supervisory and automatic devices, safety valves

The main greenhouse gas fugitively emitted from the processing facilities of "Gazprom dobycha Yamburg" is methane as a major compound of natural gas leakage. The cause of methane emissions is inability to achieve the absolute sealness of equipment fittings in practice.

The main types of identified leak sources and bleeding components at CGTU -1V, are in the Table 3.

Table 3 – Major methane emission sources of "Gazprom dobycha Yamburg" facilities.

Emission source	Point of leakage
Pipeline control valves, incl.:	
Valves, sliders, bolt gates	- valve rod, - flanges, - valve casing
Flange coupling	- flange stud, - flange casing
Valves (venting, shut-off, pressure controllers etc.)	- valve rod, - valve casing, - pressure regulator unit
Anti surge valves of gas compressor units	- valve process hole
Small shut-off and control fittings (threaded joints of pulse tubes, needle valves, inserts for gauges and thermometers, etc.)	- threaded joint of pressure gauge tie-in, - needle valve rod, - threaded joint of pulse tube
Vent stack (stack valves are in OFF position)	- from stack mouth

The emissions with indirect greenhouse effect - carbon dioxide (CO), nitrogen oxides (NOx), sulphur dioxide (SO_2) and non-methane volatile organic compounds (NMVOC) have been estimated. They are formed by the combustion of natural gas for own process needs. Also they are emitted from motor fuel combustion by operating vehicles. Sulfur dioxide (SO_2) originates from welding job and power plants running on diesel.

The main sources of emissions with indirect greenhouse effect are similar to carbon dioxide emission sources and shown in the Table 1.

The company auxiliary activities includes use of motor vehicles; collection, storage, landfilling of waste and the transfer to specialized third-party entities; purchasing part of power. These activities are accompanied by greenhouse gas emissions, though the main part of it is only indirectly related to "Gazprom dobycha Yamburg" activity.

Nevertheless, the greenhouse emission assessment caused by the company auxiliary activities was made in other to complete coverage of all available information in the framework of the study.

It is also important to note that the company has its own waste landfills. But the company transfers a portion of the waste to specialized organizations for further storage, disposal, landfilling, etc.

In view of the presence of such specificity in "Gazprom Dobycha Yamburg" activities the following assumption was taken for the natural gas life cycle assessment:

- because in the Russian Federation the scope of liability for the emissions (by use of motor vehicles, consumption purchase power, the outsourced waste handling) has not been defined yet, the amount of greenhouse gas emissions was taken into account, but they are not added to the profile emissions in order to avoid double counting of the greenhouse gas emissions.

The initial data for the natural gas life cycle inventory were obtained by collecting and processing information from the following sources: monthly report data on gas consumption for own process purpose (OPP), statistical reporting form "2-TP air" and "2-TP waste", the information request in the Technical Transport and Special Machinery Department and in the Department of Chief Energy Engineer of "Gazprom dobycha Yamburg".

The results of the natural gas life cycle inventory are shown below.

1. Process emissions (CO_2 и CH_4) with natural gas combustion and its sources

The main consumption of natural gas is the fuel for gas compressor units, which determines the amount of carbon dioxide emissions coming from the exhaust pipes of GCU - 65%. About 24% of natural gas is burned in flares (vertical flares, horizontal flares wells and horizontal flares industrial wastes), approximately 6% is spent on the heat and energy power of field camps and the Technical Transport and Special Machinery Department, and about 5% - on the boiler own process purpose (OPP) of company.

Breakdown of natural gas combustion of OPP "Gazprom dobycha Yamburg" by emission sources is shown in the Figure 3.

Methane emitted with combustion products is insignificant and amounts to 0.01% of the total greenhouse gas emissions of (carbon dioxide + methane).

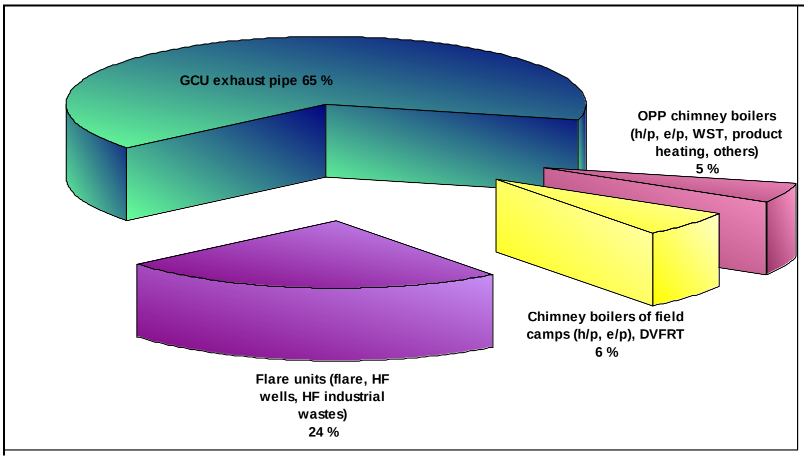

Figure 3 – Breakdown of natural gas volume for OPP combustion by sources

2. Process and fugitive methane emission sources without combustion

The majority of methane is emitted from vent stack of process equipment and pipelines - more than 61%. A part of the emission is emitted from equipment leakiness – 23 %. A less significant part emission is given off from vent stack degassing –13 %.

Breakdown of methane emissions by sources is shown in the Figure 4.

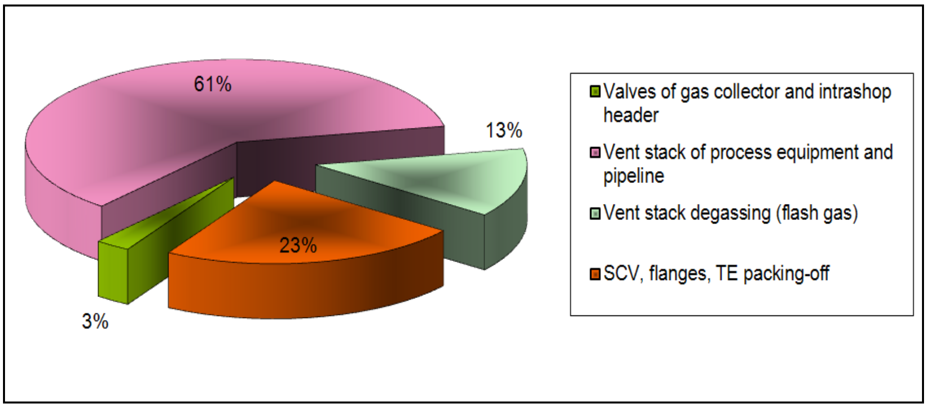

Figure 4 – Breakdown of methane emissions by sources

Methane leaks from surface process equipment of the from the complex gas treatment unit CGTU-1V of the Yamburgskoye field were studied to enable the further inventory analysis. Studies covered almost all production units, which have potential sources of methane leaks.

The estimate of methane emission from surface process equipment of CGTU-1V included:

- Instrumental examination for detection and measurement of parameters of methane emission with leaks from surface process equipment CGTU-1V;

- Calculation of methane emission volumes on the basis of instrumental examination results;

- Analysis of results received and evaluation of volumes of methane emissions with leaks from CGTU-1V facilities.

Instrumental examination covered almost all process equipment of CGTU-1V with potential points of occurrence of methane leaks. This enabled detection of actual sources of methane emission as the result of leaks and fulfillment of quite a correct estimate of this emission.

The completed instrumental examination results were used for determination of the quantitative and the percent share of process equipment of CGTU-1V units and plants that emitted methane in the air as the result of leaks. This value for valves is within the range of 0.5 to 30% (Figure 5) and for stands - from 30 to 67% (Figure 6).

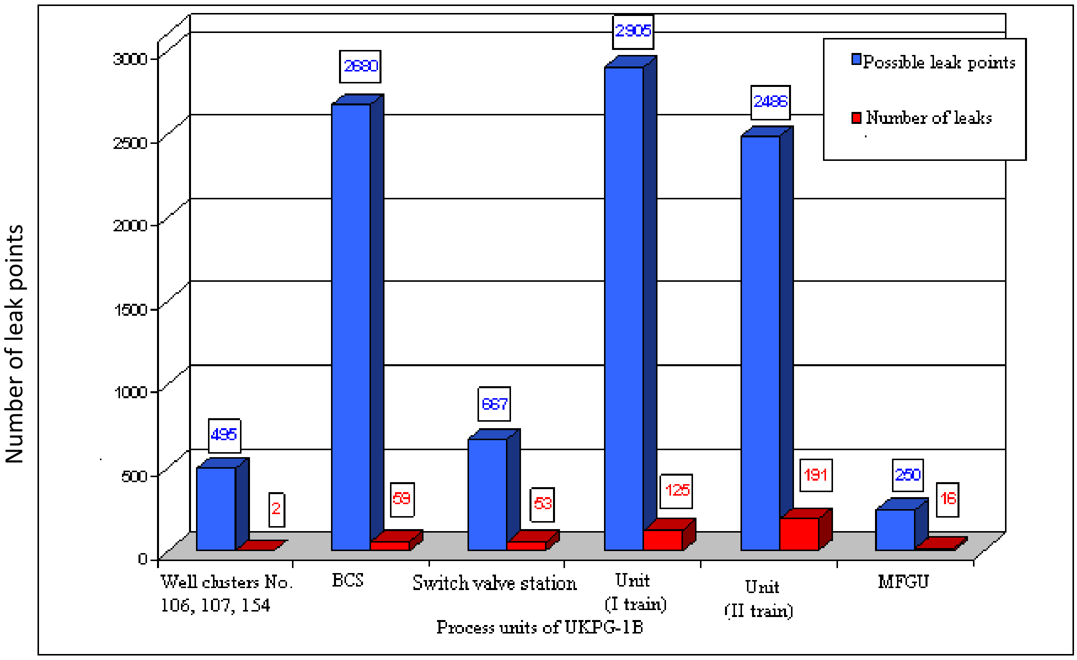

Figure 5 - Distribution of possible methane leak points detected on fittings

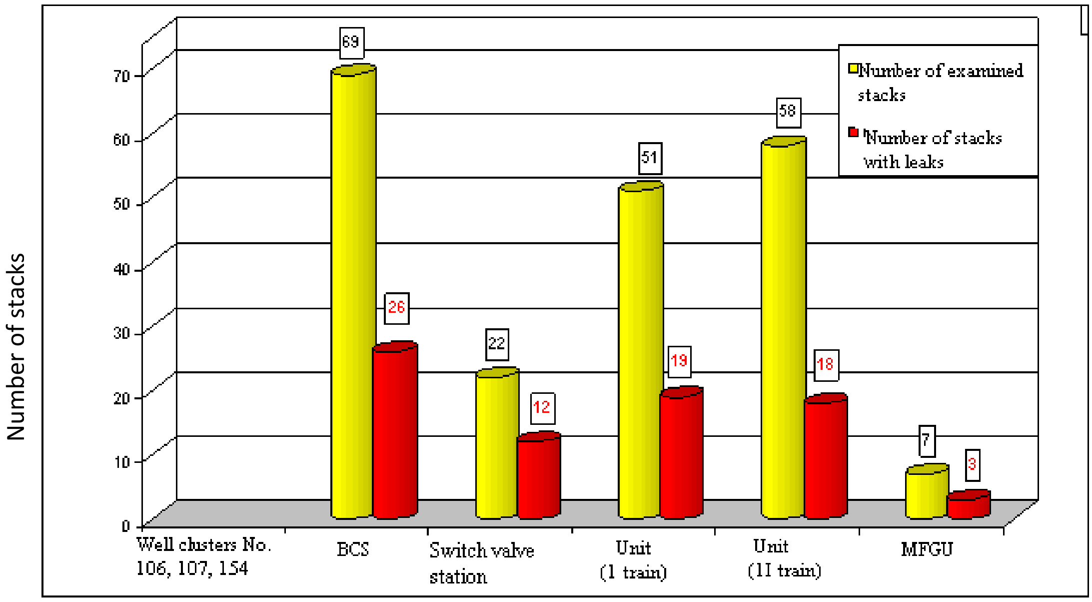

Figure 6 - Distribution of the number of examined stacks and detected leaks

The study has proved that the major volume of emissions is produced by vent stacks, which amounts to 74% of the total emissions volume, whereas fittings make 26% (Figure 7).

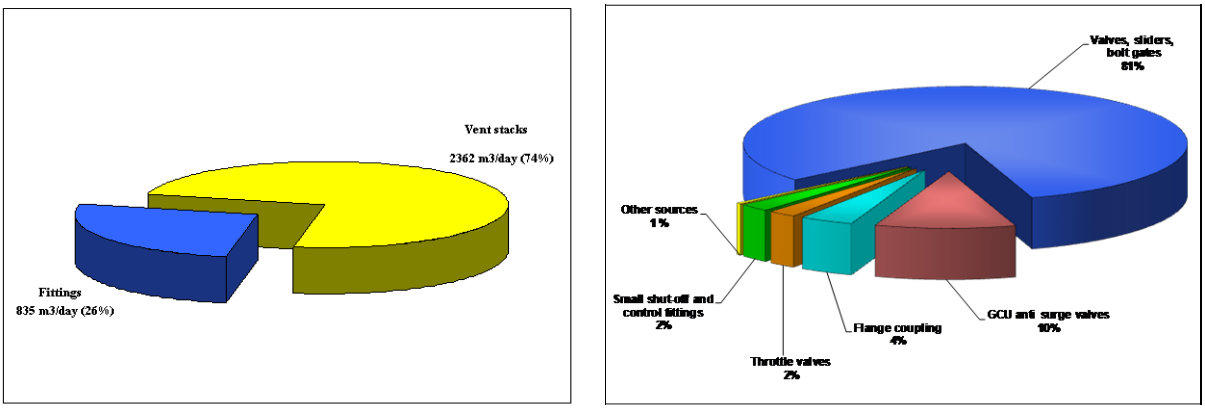

Figure 7 – Distribution of volumes of methane emission with leaks from equipment

Most valuable groups of leak sources were defined for the valves of gas producing facilities. Leaks from valves, sliders and bolt gates form the main share in the total volume of methane emission from fittings - 82%.

3. Carbon dioxide emissions as a result of motor vehicles using

The calculation method of the CO_2 emissions from mobile sources was based on fuel consumption.

The company operates 243 vehicles running on benzene and 478 vehicles running on diesel fuel.

The total annual motor fuel consumption by type detailed is shown in Table 4.

The total annual motor fuel consumption by type detailed is shown in Table 4.

Table 4 – Motor fuel consumption and carbon dioxide emission of "Gazprom dobycha Yamburg"

Fuel type	Quantity of motor vehicle	Consumption, ton	Emission CO_2, thousand ton
Diesel fuel	478	9671.343	31.031
Benzine	243	2104.608	6.534
Total	**721**	**11775.951**	**37.565**

Calculation of CO_2 emissions was made in accordance with the IPCC (1996) methodology of motor vehicle [1] by multiplying the volume of fuel consumed and the emission factor for each fuel type. This factor is calculated on the basis of calorific properties of the fuel and the fraction of oxidized carbon in the fuel.

4. Gaseous compound emissions with indirect greenhouse effect, its sources

Gaseous compound emissions with indirect greenhouse effect: carbon oxide (CO), nitrogen oxide (NOx), sulfur dioxide (SO_2) non-methane volatile organic component (NMVOC) are formed as a result of production and auxiliary activities of "Gazprom dobycha Yamburg".

The main sources of gaseous compound emissions with indirect greenhouse effect are similar to carbon dioxide emissions sources.

Data on indirect greenhouse gas emissions quantity of "Gazprom dobycha Yamburg" facilities are presented in Table 5.

Table 5 – Indirect greenhouse gas emissions quantity of "Gazprom dobycha Yamburg" facilities

Gaseous compound emissions with indirect greenhouse effect, ton			
CO	**NO_x**	**SO_2**	**NMVOC**
17780.5	6485.2	2.3	2348.8

3. Methane emissions from waste

The inventory analysis of sources of methane emission as the result of waste handling was carried out in compliance with the methodology of the Intergovernmental Panel on Climate Change 1996, 2006 [1, 2], as well as GOST R ISO 14064-1-2007, GOST R ISO 14064-2-2007 [3, 4].

Landfills are sources of methane emission as the result of waste handling. Anaerobic conditions lead to emission of methane on polygons for solid household waste disposal.

Taking into consideration the structure of data on waste types, the types of waste emitting methane as the result of decomposition were identified in the statistic report form "2 TP wastes" amidst all industrial wastes included in the report for the reported year. First and second class of hazard, liquid industrial waste, and agricultural wastes (if they are) are eliminated from the calculation of industrial waste.

In view of the data included in reports of the statistic report form "2 TP wastes" and GOST R ISO approaches 14064-1-2007 [3], methane emissions were divided into direct and indirect. Direct emissions are considered emissions from waste disposal sites operated, owned by the company. Indirect emissions are emissions from the waste produced in the company, but located at the facilities of other organizations.

Types of wastes participating in calculations of methane emissions from solid waste landfills were defined as the result of analysis of report data in the "2 TP wastes" form and were distributed in categories in compliance with the IPCC methodology and the Federal Classification Catalogue of Wastes.

Table 6 provides data on waste types buried on own landfills and transferred to outside specialized organizations.

Table 6 - Quantity of wastes by categories of the IPCC, buried on own landfills and transferred to outside organizations

Waste as per the Federal Classification Catalogue of Wastes	Quantity of wastes to be buried, ton	
	within own facilities	at facilities of outside organizations
Industrial waste type "Paper and textile"	269.5	72.7
Industrial waste type "Wastes from gardens and parks (nonfood)"	-	-
Industrial waste type "Wood or straw"	1046.6	113.7
Municipal waste	4739.7	317.2

Figure 8 shows proportion of emissions from waste buried at company's landfills, and transferred to another companies for burial.

The most intensive is formation of methane emission from municipal waste. In this case, 94% of municipal waste were buried at own landfills, and 6% transferred to another companies for burial. From industrial wastes such as "wood or straw", 90% - buried at company's landfills, and 10% - transferred to another companies for burial. The minimum methane emissions volume was formed from industrial wastes such as "Paper and Textile", 79% buried at company's landfills, and 21% transferred to another companies for burial.

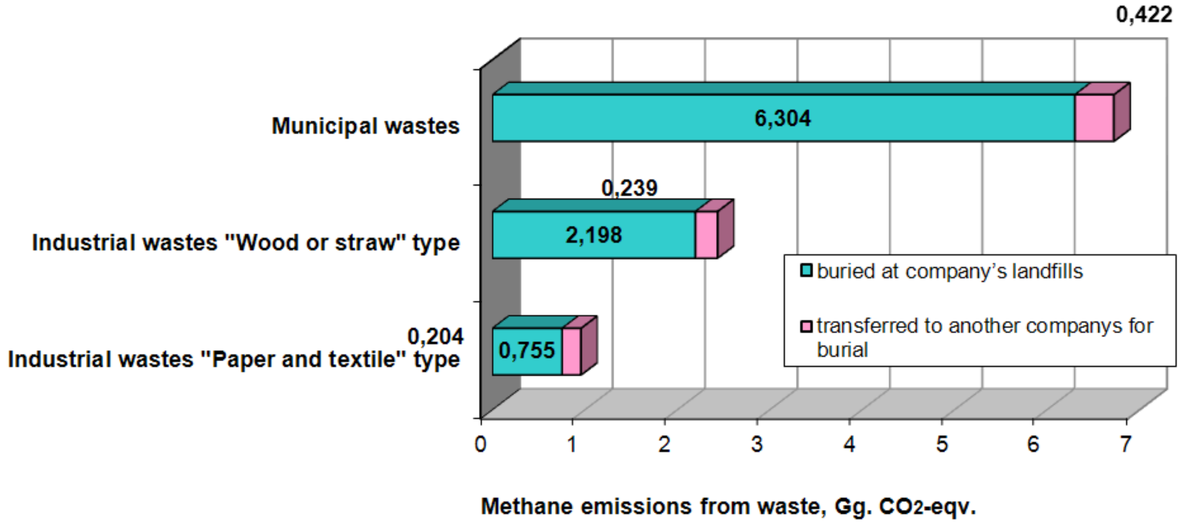

Figure 8 - Quantity and ratio of methane emission from wastes buried within own landfills and transferred for burial to outside organizations

The natural gas life cycle impact assessment

Climate change is the category of impact in this study. The results received at the stage of inventory analysis were referred to this category of impact, including bringing of quantitative values of greenhouse gas emission from various process operations to a single category indicator - Gg CO_2-equivalent.

The methodology of the Intergovernmental Panel on Climate Change is a characteristic model for re-calculation of quantitative values of greenhouse gas emission into Gg CO_2-equivalent [1, 2, 5, 6]. The global warming potential (GWP_{100}) is a characteristic ratio. This ratio defines the impact degree of the emitting power of specific greenhouse gas one mass unit in relation to a corresponding unit of carbon dioxide during the set period of time (100 years).

1. For impact assessment of carbon dioxide and methane emissions with natural gas combustion the IPCC conversion factor are used [1]. Table 7 provides values of conversion factors.

Table 7 – The conversion factors CO_2 и CH_4 emissions with natural gas combustion

Fuel type	**Factor of CO_2 emission with account of incomplete combustion, t CO_2/TJ**	**Factor of CH_4 emission as the result of incomplete combustion, t CH_4/TJ**
Natural combustion gas	55.82	0.005

Conversion factors of the Intergovernmental Panel on Climate Change were used for transformation of input data to general energy units (TJ).

The factor of conversion to CO_2-equivalent (global warming potential) in compliance with the IPCC 1996 [1] for carbon dioxide is 1, and for methane is 21.

The results of evaluation of the greenhouse gas impact during processes and operations accompanied by emission of combustion products in the air are given in Table 8.

Table 8 - Emission of greenhouse gases formed as the result of natural gas combustion processes and operations

Processes/operations accompanied by emissions of combustion products into the atmosphere	GHG emissions, Gg CO_2-eqv.	
	Carbon dioxide	**Methane**
Blowing of wells with burning on a horizontal flare (fluid plugs, after drilling, inspections)	650.701	1.224
Work of booster compressor stations (fuel gas of gas-compressor units)	2603.426	4.897
Work of boiler stations for heat energy generation	24.872	0.047
Work of boiler stations for electric energy generation	62.756	0.118
Product (condensate, methanol, DEG, fuel start-up gas, WST) heating	92.822	0.175
Flare (work of a pilot burner, burning of gas after process equipment blowdown)	5.611	0.011
Drain water disposal at horizontal industrial effluents flare	308.440	0.580
Work of field camp boiler stations for generation of electric energy	245.022	0.461
Work of field camp boiler stations for generation of heat energy	1.306	0.002
Needs of the Technical Transport and Special Machinery Department	1.127	0.002
Other operations	7.055	0.013
Total	**4003.138**	**7.530**

The results of impact assessment of the greenhouse gas during processes and operations accompanied by natural gas emissions in the air without burning are given in Table 9.

Table 8 - Emission of greenhouse gases formed as the result of processes and operations accompanied by natural gas emissions

Processes/operations accompanied by natural gas emissions into the atmosphere	Methane, Gg CO_2-eqv.
Blow-down of gas-collecting system and collector and intershop header	4.123
Emptying of process equipment	85.381
Displacement of air by gas	3.356
Blowing of process equipment	0.370
Maintenance (blowing) of supervisory and automatic devices	2.123
Degassing (flash gases)	20.517
Sampling	4.013
Leaks	35.140
Total	**155.023**

2. The GHG emissions impact from motor vehicles was carried out using the IPCC (1996) methodology of motor vehicle [1].

Calculation of CO_2 emissions was made by multiplying the volume of fuel consumed and the emission factor for each fuel type. This factor is calculated on the basis of calorific properties of the fuel and the fraction of oxidized carbon in the fuel.

For this calculation, the fraction of oxidized carbon is assumed equal to 100% because of greenhouse gas emissions from mobile sources are not major for "Gazprom dobycha Yamburg" and it has an insignificant part of company's emission. I.e. the calculation of methane emission as the result of chemical underburning was not carried out.

The heat net values for certain types of motor fuels in accordance with the Methodology of the IPCC in 1996 [1] used by the company are listed in Table 10.

Table 10 - Heat net values for motor fuel types

Refined products	Fuel calorific capacity (TJ/Gg)	Emission factor, Gg CO_2/TJ
Benzine	44.8	0.0693
Gasoil/diesel fuel	43.3	0.0741

Results of CO_2 emission impact assessment due to motor fuel combustion are presented in table 11.

Table 11 – Carbon dioxide emission due to motor fuel consumption

Type of motor fuel	CO_2 emission, Gg CO_2-eqv.
Diesel fuel	31.031
Benzine	6.534
Total	**37.565**

3. Impact assessment of methane emission from waste was carried out in accordance with methodology IPCC [1, 2, 5] and based on the default method, according to one IPCC, as methane emissions of waste are not the company's profile sources.

Results of methane emission impact assessment from waste buried at landfills and waste of the company, which transferred to other companies for burial, are presented in Tables 12.

Table 12 – Results of methane emission from waste

Methane emission from waste:	Category of wastes			Total methane emission, Gg CO_2-eqv.
	Paper and textile	Wood or straw (excluding carbon lignin)	Municipal waste	
- own landfills	0.755	2.198	6.304	9.256
- transferred to outside specialized organizations	0.204	0.239	0.422	0.864

The highest quantity of wastes is formed in the category "Communal wastes", respectively, the maximum amount of methane is emitted from this category after burial.

3. Impact assessment of GHG emission from purchased energy consumption is based on The Greenhouse Gas Protocol methodology. [7]. Greenhouse gas emissions are calculated as the product of data on using electricity volume (kW • h)) and the conversion factor (emission factor) for the calculation of quantitative emission (Gg CO_2/kW • h).

It is not recommended to use this method for evaluation of methane emission from consumption of purchased electric energy due to a complexity of this task and the growing degree of indefiniteness in calculations.

Results of impact assessment of carbon dioxide emissions from purchased energy consumption are presented in table 13.

Таблица 13 – Consumption of purchased energy and carbon dioxide emission from purchased energy consumption

Energy consumption, kW*h	**CO_2 emission, Gg**
11736.626	3.814

The natural gas life cycle interpretation

Climate change is the category of impact in this study.

The summarized data of greenhouse gas emissions from production and auxiliary activities within the scope of liability of "Gazprom dobycha Yamburg" are presented in the table 14.

Table 14 - Emissions of greenhouse gases as the result of production activity of "Gazprom dobycha Yamburg"

Greenhouse gas emission, Gg CO_2-eqv				
Methane emission				Carbon dioxide emission from burning of natural gas as a part of combustion products
Total, including:	- from process and fugitive sources of emissions as a part of natural gas	- from wastes buried at the landfills of the Company	- from burning of natural gas as a part of combustion products	
171.809	155.023	9.256	7.530	4003.138
Rating of value	B	C	C	A
Rating of controllability	B	C	C	B

Note:

Rating of value: A – significant emission requiring high-priority measures for reduction B - emission recommended for reduction, C- insignificant emission that can be neglected.

Rating of controllability allowing for improvement: A - major control capabilities, B - limited control capability, C - non-feasibility of high-priority control due to insignificance of emission.

Carbon dioxide emission formed in the air as the result of natural gas burning contributes most to the total emission of greenhouse gases of the company.

Methane emission as a part of natural gas supplied from stationary sources of natural gas emission contributes significantly as well.

Insignificant emission is supplied from wastes buried within own landfills of the company. On average it is about 3% from the total methane emission.

The details of the controllability rating are given in Tables 15 and 16.

Table 15 - Details of the rating of controllability of processes accompanied by combustion products emissions

Processes/operations accompanied by emissions of combustion products into the atmosphere	GHG emissions, Gg CO_2-eqv.		Rating of controllability
	CO_2	CH_4	
Blowing of wells with burning on a horizontal flare (fluid plugs, after drilling, inspections)	650.701	1.224	A
Work of booster compressor stations (fuel gas of gas-compressor units)	2603.426	4.897	B
Work of boiler stations for heat energy generation	24.872	0.047	B
Work of boiler stations for electric energy generation	62.756	0.118	B
Product (condensate, methanol, DEG, fuel start-up gas, WST) heating	92.822	0.175	B
Flare (work of a pilot burner, burning of gas after process equipment blowdown)	5.611	0.011	C
Drain water disposal at horizontal industrial effluents flare	308.440	0.580	B
Work of field camp boiler stations for generation of electric energy	245.022	0.461	B
Work of field camp boiler stations for generation of heat energy	1.306	0.002	C
Needs of the Technical Transport and Special Machinery Department	1.127	0.002	C
Other operations	7.055	0.013	C
Total	**4003.138**	**7.530**	**B**

Table 16 - Details of the rating of controllability of processes accompanied by natural gas emissions

Processes/operations accompanied by natural gas emissions into the atmosphere	Methane, Gg CO_2-eqv	Rating of controllability
Blow-down of gas-collecting system and collector and intershop header	4.123	B
Emptying of process equipment	85.381	B
Displacement of air by gas	3.356	B
Blowing of process equipment	0.370	C
Maintenance (blowing) of supervisory and automatic devices	2.123	C
Degassing (flash gases)	20.517	A
Sampling	4.013	C
Leaks	35.140	B
Total	**155.023**	**B**

Table 17 provides summarized data on greenhouse gas emissions as the result of auxiliary activity, for which the sphere of responsibility is undefined.

Table 17 - Dynamics of emissions of greenhouse gases from auxiliary activity of Gazprom dobycha Yamburg

Greenhouse gas emission, Gg CO_2-eq.		
CO_2 emission from operation of motor transport	**CO_2 emission from purchased electric energy**	**CH_4 emission from wastes transferred to outside organizations**
37.565	3.814	0.864

The emission of carbon dioxide as the result of engine fuel combustion during motor transport operation has an insignificant input - about 0.8% from the total emission of carbon dioxide in the company.

Methane emission from wastes transferred to outside specialized organizations is no more than 0.4% from the total volume of methane emission in the company.

The data on the quantity of emissions of gaseous compounds with indirect greenhouse effect from the facilities of "Gazprom dobycha Yamburg" is given in Table 18.

Table 18 – Weight of emissions of gaseous compounds with indirect greenhouse effect from the facilities of "Gazprom dobycha Yamburg"

Gaseous compound emissions with indirect greenhouse effect, ton			
CO	**NO_x**	**SO_2**	**NMVOC**
17780.5	6485.2	2.3	2348.8

The highest quantity of emissions of gaseous compounds with indirect greenhouse effect falls on carbon oxide and nitrogen oxides - on average for the period under study 63 and 27% respectively.

In order to assess and ensure the quality of the data provided was the inventory was exposed to standard procedures, including: coordinated review to ensure the consistency, correctness and completeness of the data, identification and correction of errors and omissions, recording and archivation of inventory material, registration of the quality control results, comparison of emission estimates for different years. The methodological issues of the data collection were clarified and corrected as a result of discussions with the "Gazprom dobycha Yamburg" experts.

The assessment of the "Gazprom dobycha Yamburg" overall inventory uncertainty was performed in accordance with the recommendations of the IPCC guidelines [1, 5]. The assessment scope included: uncertainty of operation data, uncertainty of emission factor and other. The total uncertainty of "Gazprom dobycha Yamburg" inventory is no more than 6.8 %.

Conclusions

Due to the increasing role of natural gas as an energy source, it is especially important to focus on resource saving and reduction of the environmental impact of gas production operations of the oil and gas sector in Russia.

Using the method of life cycle assessment and the case study of the Gazprom largest gas producer, we managed to identify the environmental impact of production operations of extraction and primary pre-piping processing.

As a result of the inventory analysis, the evaluation data of the well-to-pipeline life cycle were obtained in the greenhouse gas emission context considering the evaluated uncertainty. The analysis enabled to identify the technological processes and resources which stand for the most of the greenhouse gas emissions at a gas production company.

The carbon dioxide emissions as a combustion product from natural gas combustion stand for the major part of total greenhouse gas emissions. Another significant part of these emissions is methane emitted from natural gas operations (venting, purging of equipment and pipelines, losses).

The methane emissions which refer to the incomplete fuel combustion is less than 0.2% of the total GHG emissions from natural gas combustion.

Methane emissions from waste do not exceed 3% of the "Gazprom dobycha Yamburg" total methane emissions.

Carbon dioxide emissions from motor fuel combustion stand for about 0.8% of the "Gazprom dobycha Yamburg" total carbon dioxide emission.

Carbon dioxide emissions from purchased energy amount for about 0.05% of the company's total carbon dioxide emissions.

Analysis of values of specific greenhouse gas emissions from single process operations allows a comparison of identical processes of gas production companies. This in its turn enables to assess the natural gas impact on climate at each stage of production in different companies and facilitate emission reductions in companies, where they can be achieved.

The results of this study are used by the company for production control and greenhouse gas emissions management, as well as the development of rational, cost-effective and environmentally friendly solutions for the emissions mitigation and reduction.

For example, tank vapor gas stands for a significant methane emission "Gazprom dobycha Yamburg" (about 13 % of all methane emissions), which is subject to reduction. In other gas production companies of Gazprom this problem seems as significant. "Gazprom VNIIGAZ" and "Gazprom dobycha Yamburg" jointly proposed vapor emission reduction solutions for Nadym-Pur-Taz region based on the corporate inventions of patent protected model № 135095 «Vapor utilization unit» and patent protected invention № 2515242 «Vapor utilization technique».

References

1. IPCC, 1996: Guidelines for National Greenhouse Gas Inventories. Book 2 – Workbook on greenhouse gas inventory. IPCC, IPCC - OECD - IEA, 1996
2. IPCC 2006: Guidelines for National Greenhouse Gas Inventories IPCC. Book 5 - Wastes. IPCC, 2006
3. GOST R ISO 14064-1-2007 Requirements and guidance of quantification and reporting of greenhouse gas emissions disposal in organization. Moscow, Standartinform, 2010
4. GOST R ISO 14064-2-2007 Requirements and guidance of quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements at the project level. Moscow, Standartinform, 2010
5. IPCC, 2000: Guidelines of effective practice and uncertainty management in national greenhouse gas inventories. (International methodology of effective practice), IPCC - OECD-IEA, 2000
6. IPCC, 2006: Guidelines for National Greenhouse Gas Inventories IPCC, Book 1, Book 2 – General guidelines and reporting. IPCC national greenhouse gas program, IPCC-OECD-IEA, 2006
7. The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standart. Revised edition. World Business Council for Sustainable Development/World Resources Institute, USA, 2002
8. STO Gazprom 3-2005 "Greenhouse gas emissions inventory. General requirements of content and design", p.63
9. STO Gazprom 031-2007 "Methodology of monitoring methane emission volume at OAO "Gazprom" facilities". p.61
10. STO Gazprom 027-2006 "A model program for evaluating natural gas emissions at Gazprom operations", p.45
11. STO Gazprom 102-2011 "Greenhouse Gas Emissions Inventories", p.53
12. STO Gazprom 092-2011 Union industrial waste and consumption inventory of subsidiaries OAO "Gazprom"