

## 3. Change of Climate

### Air temperature

This indicator shows the average annual air temperature, its change over the certain period of time and deviation from historical averages the country as a whole and for individual regions.

In the period 2005-2009 Belarus climate warming was continued, it began in the late 1980's. The average temperature in these years varied between 6,8-8,0 °C, that is higher than long-term climatic norm for 1,0-2,0 °C (Figure 3.1). At the same time the year of 2008 as well as the year 1989 was the warmest for the entire period of meteorological observations.

Among the regions of Belarus the warmest are Brest and Gomel. During the period 2005-2009 the average temperature were, respectively 7,2-8,8 °C and 6,9-8,7 °C. The coldest is Vitebsk region with an average temperature 5,7-7,4 °C.

As can be seen from Figure 3.1, winter was characterized by the greatest temperature contrasts in these years. Average winter temperatures ranged from -1.0 to -6,4 °C for the climatic norm -5,5 °C. Thus, deviations from the climatic norm were from -0.9 to 4,5 °C. In

this case, winter of 2005-2006 with an average of temperature of air -6,4 °C and the deviation from the climatic norm -0,9 °C was the coldest one. The winter of 2007-2008 with an average temperature of -1,0 °C and the deviation from the climatic norm 4,5 °C was the warmest one.

For certain regions of Belarus the average winter temperature is varied to a greater extent (Table 3.1). The coldest winter in all years of the period under review were characteristic for Mogilev region (from -1.9 to -7,2 °C) and warmest – for Brest region (from -0,1 to -5,5 °C). For these regions the observed outmost points of average winter temperature for the entire period of meteorological observations is characterized.

Spring in Belarus during the period 2005-2009 was characterized by average temperatures of the air from 5,5 to 8,9 °C and deviated from climate norms from -0.2 to 3,2 °C (climatic norm 5,7 °C). The warmest spring was in 2007, the coldest – in 2006. The spring of 2007 was the warmest for the entire period of meteorological observations in Belarus as for the whole of the country, and so for four of the six regions

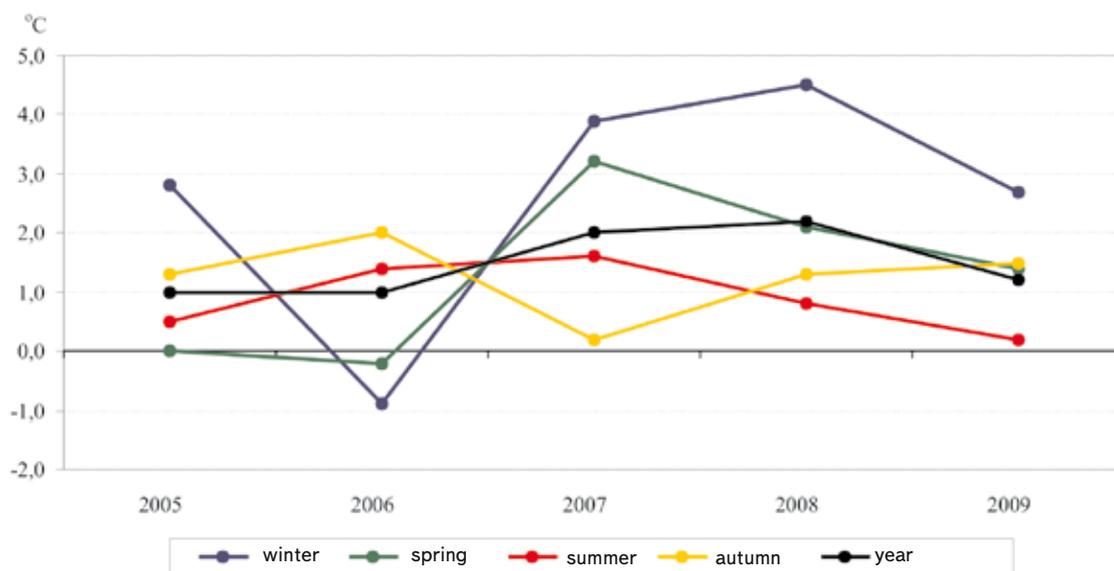


Figure 3.1 – The average deviation and average for the season in air temperature in Belarus from climatic norm in the period 2005-2009

Table 3.1

**Average annual temperature in administrative regions of Belarus  
in 2005-2009, °C**

Region	2005	2006	2007	2008	2009	Observed outmost points of maximum average winter temperature			
						maximum	year	minimum	year
Winter									
Vitebsk	-3,3	-7,2	-2,6	-1,3	-3,3	-1,1	1989 / 90	-11,1	1984 / 85
Minsk	-2,8	-6,5	-1,7	-1,0	-3,0	-0,2	1989 / 90	-10,5	1984 / 85
Grodno	-2,0	-5,9	-0,9	-0,4	-2,6	0,6	1989 / 90	-9,7	1962 / 63
Mogilev	-3,7	-7,2	-2,5	-1,9	-3,6	-1,2	1989 / 90	-11,8	1984 / 85
Brest	-1,8	-5,5	-0,1	-0,3	-1,9	1,3	1989 / 90	-9,6	1962 / 63
Gomel	-2,7	-6,0	-1,2	-1,3	-2,7	0,3	1989 / 90	-10,7	1984 / 85
Belarus	-2,7	-6,4	-1,6	-1,0	-2,8	-0,1	1989 / 90	-10,4	1984 / 85
Spring									
Vitebsk	4,7	4,5	8,1	6,9	6,3	8,1	2007	1,7	1952
Minsk	5,4	5,2	8,6	7,5	7,0	8,6	2007	2,6	1955
Grodno	5,7	5,4	8,9	7,6	7,3	8,9	2007	2,9	1980
Mogilev	5,4	5,0	8,6	7,7	6,6	8,7	1975	2,3	1980
Brest	6,5	6,4	9,6	8,2	8,0	9,6	2007	3,6	1980
Gomel	6,8	6,4	9,7	8,8	8,0	9,8	1975	3,6	1952
Belarus	5,7	5,5	8,9	7,8	7,1	8,9	2007	2,9	1980
Summer									
Vitebsk	16,8	17,6	17,6	16,8	16,1	19,0	1999	14,2	1962
Minsk	17,2	18,2	18,4	17,3	16,8	19,7	1999	14,6	1962
Grodno	17,0	18,2	18,1	17,2	16,8	18,8	1999	14,7	1962
Mogilev	17,1	17,8	18,2	17,5	16,8	19,3	1999	14,9	1993
Brest	17,6	18,6	18,8	18,0	17,6	19,4	1999	15,4	1962
Gomel	18,1	18,7	19,4	18,6	18,1	20,1	1999	15,8	1962
Belarus	17,3	18,2	18,4	17,6	17,0	19,4	1999	14,9	1962
Autumn									
Vitebsk	7,1	7,9	5,9	7,1	7,2	8,3	1967	2,3	1993
Minsk	7,5	8,2	6,4	7,5	7,6	8,9	1967	3,0	1993
Grodno	7,9	9,0	6,7	7,9	7,6	9,3	1967	3,8	1993
Mogilev	7,1	7,6	6,1	7,1	7,8	8,4	1967	2,2	1993
Brest	8,1	9,2	7,0	8,1	8,2	9,8	1967	4,6	1993
Gomel	7,8	8,4	7,0	7,8	8,6	9,3	1967	3,5	1993
Belarus	7,6	8,3	6,5	7,6	7,8	9,0	1967	3,2	1993

(Vitebsk, Minsk, Grodno and Brest) (see Table 3.1).

Regional differences in spring temperatures were also quite contrasting: the highest temperatures in all years were typical of Gomel region (6,4-9,7 °C), the lowest – for Vitebsk (4,5-8,1 °C). The difference of maximum and minimum average temperatures was 1,6-2,1 °C.

The average air temperature in summer period of 2005-2009 in Belarus ranged from 17,0 to 18,4 °C, the deviations from the climatic norm – from 0,2 to 1,6 °C (climatic norm 16,8 °C). The warmest summer was in 2007, the coldest – in 2009.

Among the regions of Belarus, the warmest summer in the period under review was typical for Gomel region (the average temperature from 18,1 to 19,4 °C), the coldest – for Vitebsk region (the average temperature from 16,1 to 17,6 °C).

Autumn in Belarus in the period 2005-2009 is characterized by the average air temperature from 6,5 to 8,3 °C and the deviations from the climatic norm from 0,2 to 2,0 °C (climatic norm 6,3 °C). The warmest autumn was in 2006, the coldest – in 2007.

Regional differences in average autumn air temperatures in Belarus appear as follows:



the warmest autumn is characteristic for Brest and Gomel regions (average temperature is respectively 7,0-9,2 °C and 7,0-8,6 °C), the coldest – for Vitebsk and Mogilev regions (respectively 5,9-7,9 °C and 6,1-7,8 °C).

Thus, the analysis of data on the average annual and average seasonal air temperatures in Belarus during the period 2005-2009 (Fig. 3.2) brings to the following conclusions:

- the period 2005-2009 was not an exception in a series of warm years of a period of warming that began in the late 1980's: the average air temperature during this period exceeded the climatic norm for 1,0-2,0 °C, only winter and spring of 2006 were below the climatic norm;

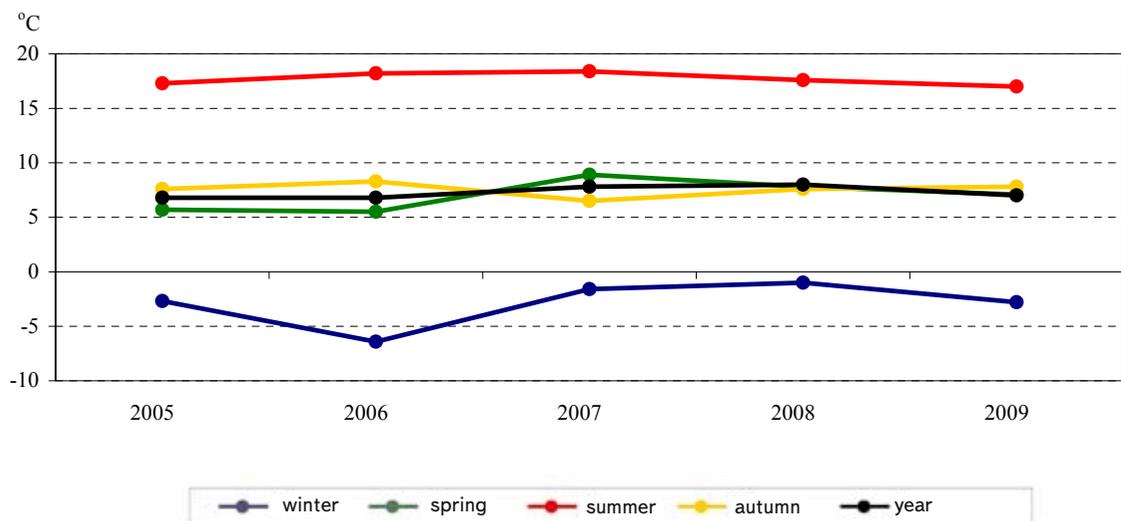
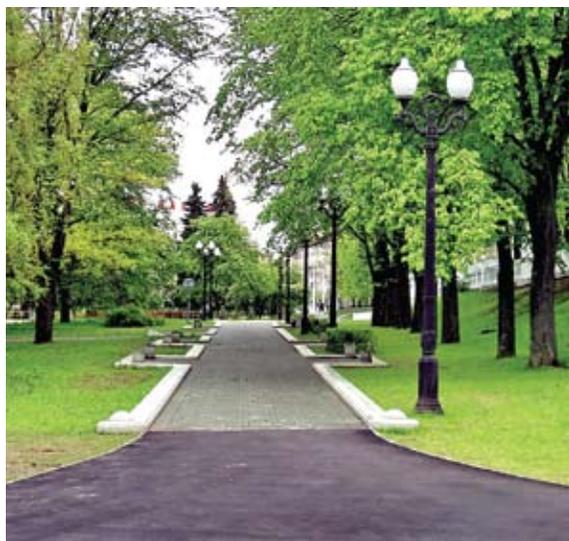


Figure 3.2 – Changes in average and average seasonal in air temperature in Belarus in 2005-2009



- along with 1989 the year 2008 was the warmest for the entire period of meteorological observations mainly due to warm winters;
- spring of 2007 was the warmest for the entire period of meteorological observations in Belarus;
- in the period under review, there are no any exceptional trends of average annual and average seasonal air temperatures.

## Precipitation

Analysis of long-term observations of basic climate characteristics, such as precipitation, temperature and humidity can

not only to define the structure of precipitation in a certain area, but also to assess the dynamics of change of the rainfall in the future, as well as related climate changes.

During the period 2005-2009 annual rainfall in Belarus generally was varied from 638 to 811 mm. In this case, the most «wet» year was 2009 (124% of the climatic ethical norms). The quantity of rainfall in 2005-2007 was closely to normal (97-99%), and in 2008 it was slightly higher than its norm (105%) (Fig. 3.3).

The spatial distribution of both annual rainfall and rainfall in separate seasons in Belarus regions are more even than the air temperature. It is difficult to single out any regional differences in the features of precipitation for this period of time.

Less than 20% of the total amount of precipitation falling on the territory of Belarus for the year is in winter (Figure 3.4). The winter of 2006-2007 is characterized by the greatest amount of precipitation – 141 mm or 123% of norm. Winters of 2005-2006 and 2007-2008 are characterized by low quantity of precipitation – 99-100 mm or 86-87% of norm. The quantity of precipitation in winter 2004-2005 and 2008-2009 was close to normal – 116-119 mm or 101-103% (norm – 115 mm).

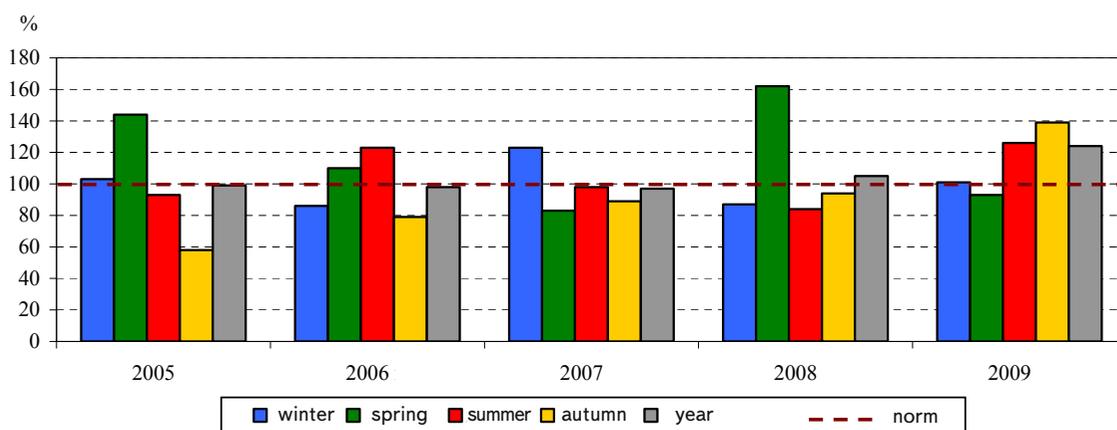


Figure 3.3 – Deviation of annual precipitation and seasonal precipitation from climatic norm in 2005-2009

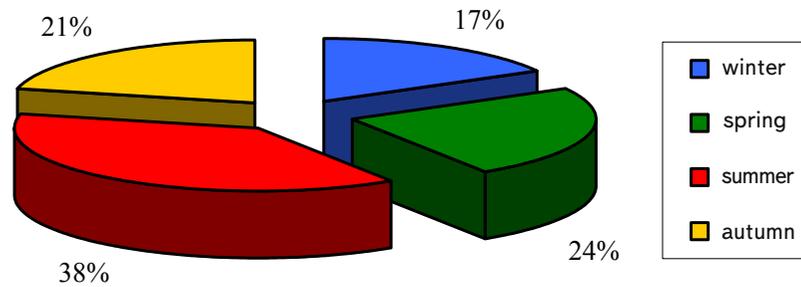


Figure 3.4 – Distribution of annual rainfall in Belarus by seasons in 2005-2009

Approximately one-fourth of the annual rainfall in Belarus fall in spring (see Figure 3.4). In the period 2005-2009 the spring of 2008 was very «wet», when rainfall exceeded the climatic norm by 62%, exceeded to 224 mm (norm – 139 mm). Such rainfall in spring was registered at the first time in Belarus for the entire period of meteorological observations. This «record» on the quantity of air rainfall in spring of 2008 was broken as for the whole country, and additionally for Vitebsk, Minsk and Mogilev regions.

The quantity of rainfall in spring 2005 and 2006 also exceeded the climatic norm (respectively 44 and 10%), amounting to 199 and 152 mm. In 2007 and 2009 the quantity of spring rainfall was below normal – 83 and 93%, or 114 and 129 mm.

The summer period in Belarus takes about 40% of annual rainfall. Summers of 2006 and 2009 were characterized by significant quantities of rainfall – respectively 301 and 306 mm or 123-126% of normal – 243 mm). The «shortage» of precipitation was observed in summers of 2005 and 2008 – respectively 228 and 206 mm or 93 and 84% of normal. The amount of rainfall in summer 2007 – 238 mm was close to the climatic norm.

The quantity of rainfall in autumn period in Belarus is about 20% in the number of annual precipitation. In the period of 2005-2009 the climatic norm for autumn precipitation was exceeded only in 2009 – 139% or 221 mm (at norm of 159 mm). In 2005-2008 the rainfall in autumn remained below normal – 58-94% or 92-150 mm.

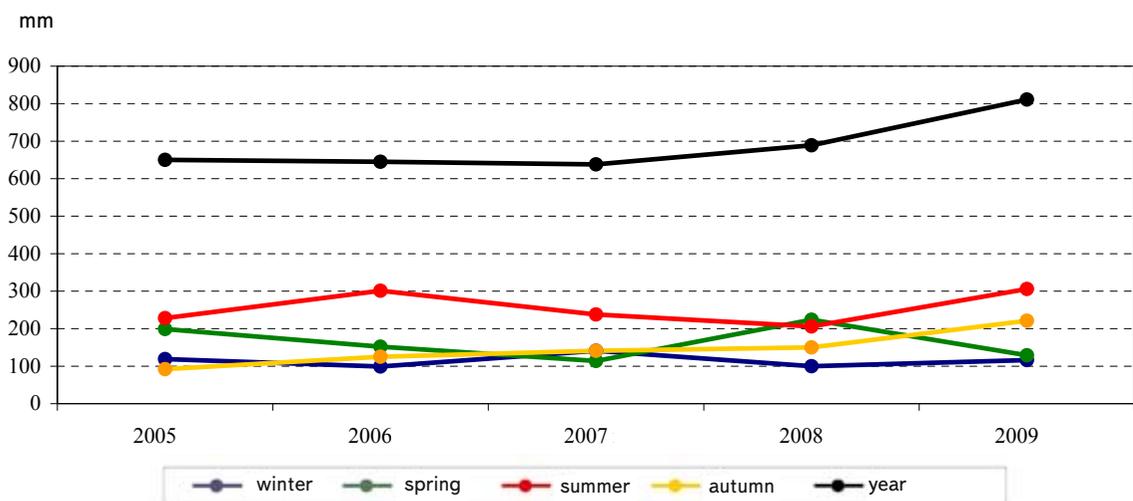


Figure 3.5 – Change in annual and seasonal rainfall in Belarus in 2005-2009



In *Figure 3.5* the dynamics of the annual and each seasons of atmospheric precipitation in Belarus in 2005-2009 is shown. As it is shown in the figure, a slight positive trend is typical for annual precipitation and spring season precipitation.

The analysis of data on the quantity of precipitation in Belarus in the period 2005-2009 brings to the following conclusions:

- annual precipitation of the period of 2005-2008 was close to the quantity of atmospheric norm, in 2009 the norm was exceeded by 24%;
- the maximum rainfall over the entire period meteorological observation not only for Belarus was marked in the spring of 2008, but as well as separately for Vitebsk, Minsk and Mogilev regions;
- for this period of time it is difficult to separate any regional differences in precipitation;
- the period of 2005-2009 is characterized by a slight increase in annual and spring seasonal precipitation in Belarus.

### **Dangerous hydrometeorological phenomena**

Dangerous meteorological phenomena are divided into meteorological, agrometeorological and hydrological. By

meteorological hazards we mean strong winds (including squalls and tornadoes), very heavy rain, very heavy rainfall, prolonged heavy rain, very heavy snow, severe storms, heavy icing, large hail, sleet and sticking complex deposition (a complex layer of ice, hoar-frost and sleet), heavy fog, hard frost, intense heat and dust storm; to dangerous agrometeorological – frost and drought; to dangerous hydrological – high water levels in flood-times, rain floods, ice jams and hanging ice dams, low water levels, as well as early formation of ice cover and the appearance of ice on navigable rivers .

Totally for the period from 2005 to 2009 on the territory of Belarus it was observed 72 cases of dangerous hydrometeorological phenomena, that means it were 14 cases annually on the average. The largest number (20 cases) occurred in 2007, the lowest (10 cases) – in 2005 and 2008.

During the specified period dangerous hydrometeorological phenomena in Belarus concerned to 9 types (*Figure 3.6*). On diagram 3.6 the most widespread dangerous agrometeorological phenomenon as freezing is not specified, which is observed every year in spring and in autumn in many parts of Belarus.

Annually such a dangerous phenomenon, as very heavy rain is often observed. During the period 2005-2009 38 cases of heavy rain were recorded, on the average 8.7 cases each year (the least quantity of cases was in 2005 – 4 cases, the highest in 2009 – 11 cases).

Strong winds with the speed of 25 m/s and more (including squalls and tornadoes) are the most destroying severe weather case. In the period 2005-2009 in Belarus from 2 to 5 cases of strong wind in the year were detected. The exception was 2008, when the dangerous phenomenon was not detected.

In recent years, the number of such dangerous phenomena as very heavy snow increased. During the period 2005-2009 5 cases of heavy snow were recorded.

In addition during this period 5 cases of large hail, 3 cases of adhesion of sleet and complex deposits, 3 cases of extreme heat,

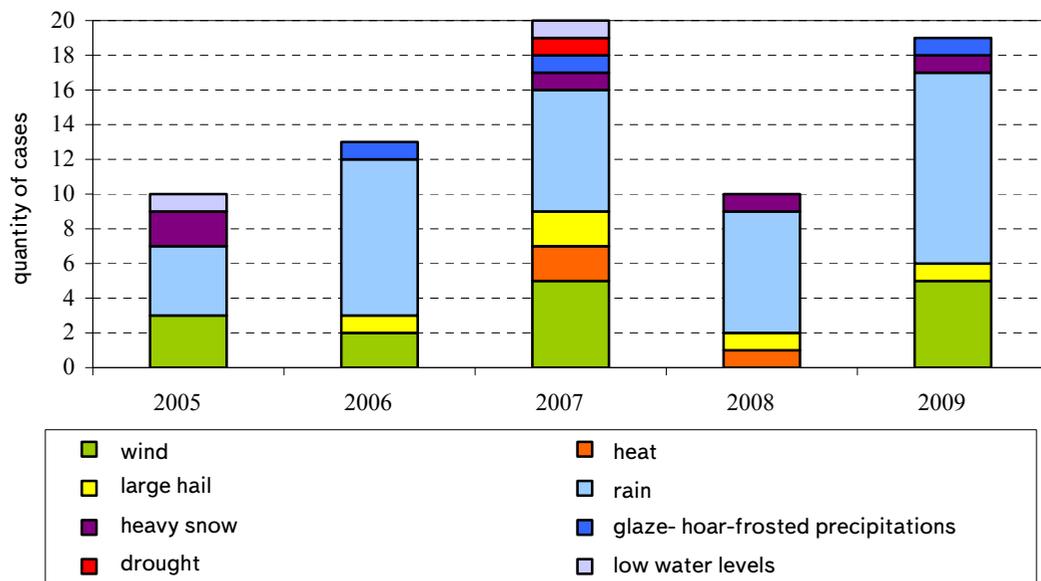


Figure 3.6 – Distribution of the number and types of hazardous weather events on the territory of Belarus in 2005-2009

drought and two cases of low water levels were observed.

It should be noted that the warming climate in Belarus is accompanied by an increase of the number of dangerous meteorological and agrometeorological phenomena (squall lines, heavy rains, frost in the southern part of the country on the land-reclaimed areas, droughts). At the same time the number of other hazards has decreased (hail, fog, glaze-hoar-frosted precipitations).



### Greenhouse gas emissions

To greenhouse gases (GHG) emissions include: Carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF<sub>6</sub>).

The main sources of greenhouse gases are the following sectors of economy: energy (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O), industry (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, SF<sub>6</sub>), the use of solvents (N<sub>2</sub>O), agriculture (CH<sub>4</sub>, N<sub>2</sub>O), land use, changes in land use and forestry (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O), wastes (CH<sub>4</sub>, N<sub>2</sub>O). Such category as land use, changes in land-use and forestry is also the source of removal greenhouse gases from the atmosphere by absorbing them by vegetation.

Figure 3.7 shows the dynamics of changes in greenhouse gas emissions in Belarus in the period 2005-2008 (2008 was the last year of GHG inventory). As it can be seen from the figure, the total GHG emissions in the period under review increased from 84.5 million tons in 2005 to 91.1 million tons in 2008 (excluding carbon dioxide absorption in the category «land use, changes in land use and forestry»). Taking into account the absorption of carbon

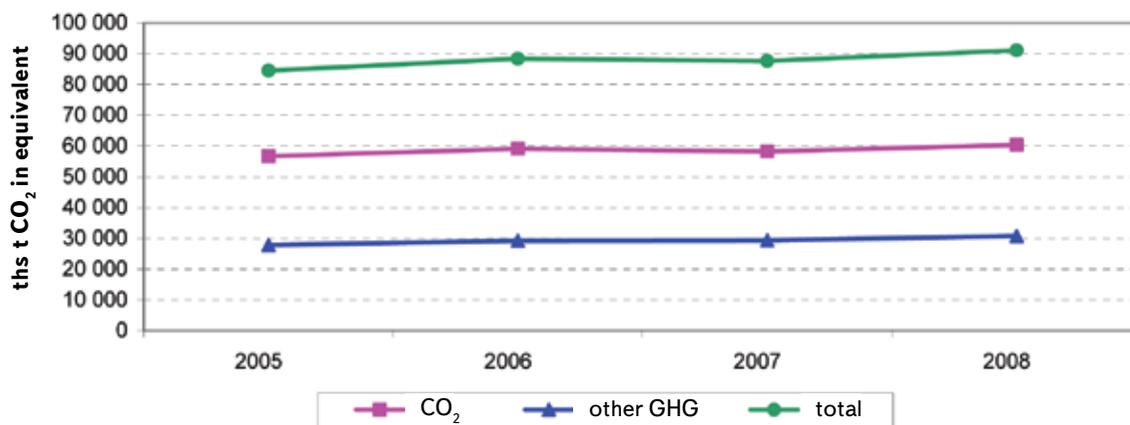


Figure 3.7 – Dynamics of greenhouse gases in Belarus in 2005-2008.  
(Without carbon dioxide absorption in the category of land use, land-use change and forestry)

dioxide in this category the total greenhouse gas emissions from 2005 to 2008 increased from 53.7 million tons to 60.0 million tons.

The main greenhouse gas is carbon dioxide. In the overall structure of GHG emissions, its share is about 66% (Figure 3.8). Approximately 17.5% is nitrous oxide, about 16% – methane. Emissions of other greenhouse gases in the amount are less than 1%.

During the period 2005-2008 for both carbon dioxide and other greenhouse gases a small dynamics is noted in increasing of emissions: carbon dioxide – from 56.7 to 60.4 million tons (excluding absorption), nitrous oxide – from 14.6 to 15.9 million tons, methane – from 13.2 to 14.8 million tons, hydrofluorocarbons – from 26.2 to 35.8 thousand tons, sulfur hexafluoride – from 1,5 to 2,4 tons. Taking into account the absorption of carbon dioxide in the category «land use,

changes in land-use and forestry», emissions of CO<sub>2</sub> increased from 25.8 in 2005 to 29.3 million tons in 2008.

The leading role of greenhouse gas emissions in the structure in sectors of economy belongs to energy – 64% (Fig. 3.9). Approximately 25% of emissions is in agriculture. Other sectors add up to about 10% of greenhouse gas emissions.

During the period 2005-2008 greenhouse gas emissions in «energy» sector have increased from 55.3 to 58.7 million tons, in «industry» sector – from 3,5 to 4,0 million tons, in the sector «agriculture» – from 21.0 up to 22.7 million tons, in «waste» sector – from 4,6 to 5,6 million tons (Figure 3.10). Greenhouse gas emissions from the sector, «the use of solvents», slightly decreased (from 69.2 to 64.1 tons). The absorption of carbon dioxide in the sector «Land use, changes in

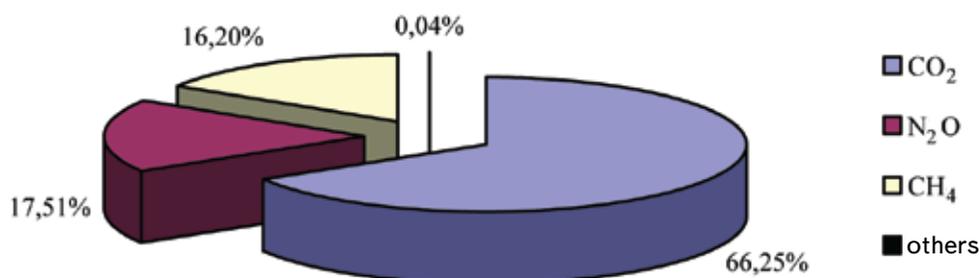


Figure 3.8 – Structure of greenhouse gases in Belarus (according to 2008)

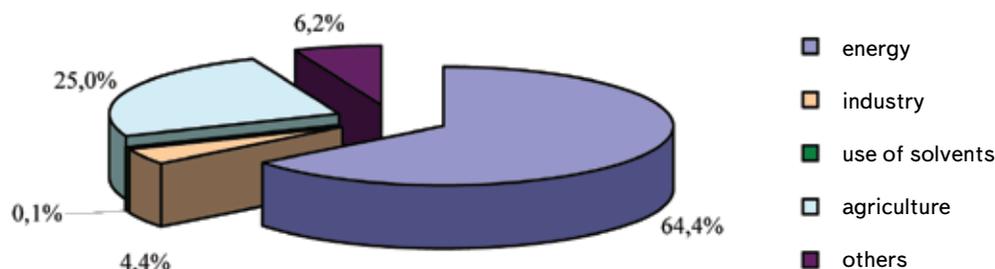


Figure 3.9 – Structure of the greenhouse gas emissions by sector (according to 2008)

land-use and forestry» during the period under consideration was about 29,8-31,9 million tons per year.

For easing the comparison, to estimate greenhouse gas emissions among various countries it used the value of specific emission, that means per unit area of the country and per capita of the population. *Table 3.2* presents the results of the calculation of specific emissions of greenhouse gases for the Republic of Belarus.

In the period 2005-2008 the value of specific emissions of greenhouse gases in Belarus was equal to an average of 423.5 t/km<sup>2</sup> a year without taking into account the absorption and 272.9 t/km<sup>2</sup> a year, taking into account the absorption of carbon dioxide. And from 2005 to 2008, this value has increased accordingly from 407.1 to 438.9 t/km<sup>2</sup> a year and 258.8 to 289.4 t/km<sup>2</sup> a year (see *Table 3.2*).

The average greenhouse gas emissions per capita in the period under review composed

9.3 tons per capita a year without taking into account the absorption and 6,0 tons per capita a year, taking into account the absorption of carbon dioxide. From 2005 to 2008, this value increased, respectively from 8,9 to 9,6 tons per capita a year, and from 5,7 to 6,3 tons per capita (t/c) a year (see *Table 3.2*).

The analysis of data on the volume and dynamics of greenhouse gas emissions in Belarus led to the following conclusions:

- during the period 2005-2008 greenhouse gas emissions in Belarus amounted to an average of 87.9 million tons a year without taking into account absorption and 56.6 million tons a year, taking into account the absorption of carbon dioxide;

- in the structure of greenhouse gas emissions more than 65% is carbon dioxide, about 17% – nitrous oxide, about 16% – methane, other greenhouse gases in the amount are less than 1% of total emissions;

- in the structure of sectors of economy about 64% of greenhouse gases are related

Table 3.2

### Specific emissions of greenhouse gases in the atmosphere in Belarus in 2005-2009

Единица измерения		2005	2006	2007	2008
t/km <sup>2</sup>	without taking into account the absorption	407.1	425.7	422.1	438.9
	taking into account the absorption	258.8	271.7	271.7	289.4
t / c	without taking into account the absorption	8.9	9.3	9.2	9.6
	taking into account the absorption	5.7	6.0	5.9	6.3

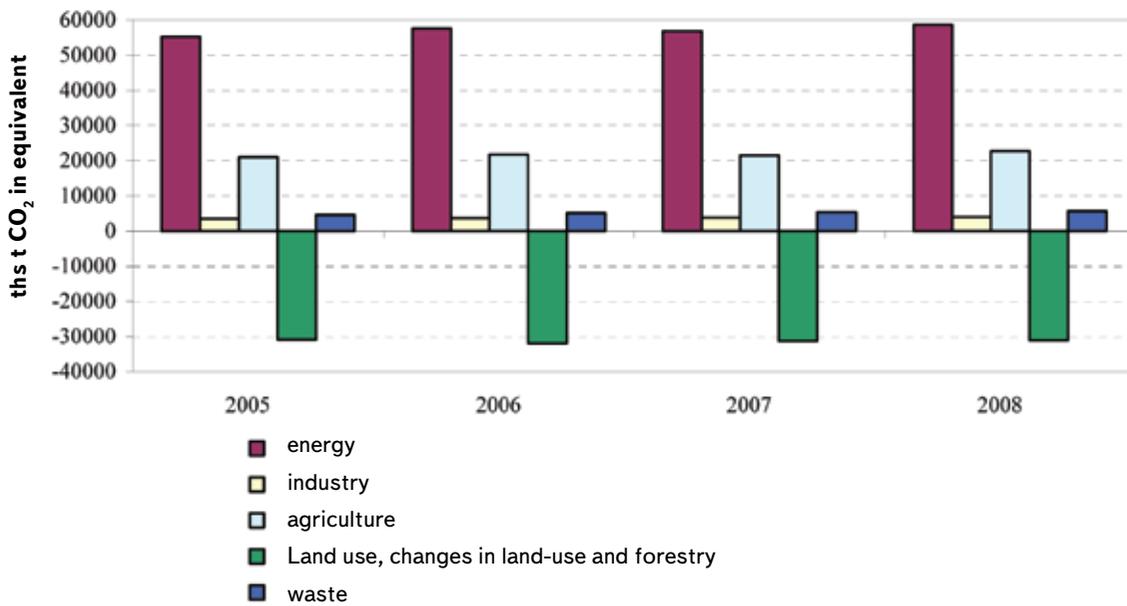


Figure 3.10 – The dynamics of greenhouse gas emissions in Belarus by main sectors of the economy in 2005-2009

with «energy»; 25% – with «agriculture»; «industry», «solvent» and «wastes» totally give about 10% of greenhouse gas emissions;



– from 2005 to 2008, total emissions of greenhouse gases has increased from 84.5 to 91.1 million tons without absorption and from 53.7 to 60.0 million tons, taking into account the absorption of carbon dioxide; the increase occurred in all sectors of economy with the exception of «the use of solvents»;

– the value of the specific greenhouse gas emissions in the period under review amounted to the average of 423.5 t/km<sup>2</sup> a year without taking into account the absorption and 272.9 t/km<sup>2</sup> a year, taking into account the absorption of carbon dioxide; per capita – 9,3 t/c a year without taking into account the absorption and 6,0 t/c a year, taking into account the absorption of carbon dioxide.