Ministry of Environment Protection of the Republic of Kazakhstan

REPUBLICAN STATE ENTERPRISE “KAZAKH RESEARCH INSTITUTE OF ECOLOGY AND CLIMATE »
(KAZNIIEK)

GREENHOUSE GAS EMISSIONS INVENTORY, 2004

Astana, 2006

CONTENT

LIST OF ABBREVIATIONS, SYMBOLS AND UNITS

IPCC		Intergovernmental Panel on Climate Change
MEP RK	-	Ministry of Environment Protection
NC	-	National Communication
GHG	-	Greenhouse gases
GWP	-	Global warming potential
UNFCCC	-	UN Framework Convention on Climate Change
FAO	-	Food and Agriculture Organization
GDP	-	Gross Domestic Product
UN ECE	-	UN Economic commission for Europe
LPG	-	Liquefied Petroleum Gas
CNG	-	Compressed Natural Gas

Chemical symbols

CH_4	-	Methane
N_2O	-	Nitrous oxide
CO_2	-	Carbon dioxide
HFSs	-	Hydrofluorocarbons
PFCs	-	Perfluorocarbons
SF_6	-	Sulphur hexafluoride

1. TOTAL GREENHOUSE GAS EMISSIONS

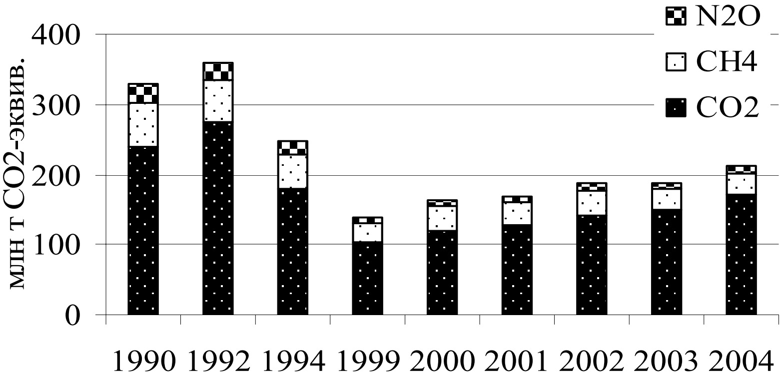
Due to the 2004 Greenhouse Gas Inventory implemented in Kazakhstan total emissions of gases with direct greenhouse effect resulted in **213.3 mln**. t CO_2-equ including **172.2 mln**. t CO_2-equ emissions from the energy sector, *16.6* mln. t CO_2-equ from industrial processes, 19.7 mln. t CO_2-equ from agriculture and 4,8 mln. t CO_2-equ from wastes as shown in Picture 1.1 and in Table 1.1. CO_2 removals by forests in 2004 were 7.5 mln. t. Thus, the net emissions including absorption (sequestration) of CO_2 by forests are estimated in **205.8** mln. t CO_2-equ. The total specific GHG emissions in 2004 were more than 13,6 t per capita, and about 11,4 t out of them are referred only to CO_2.

Table 1.1 – Total emissions with direct greenhouse effect, mln.t CO_2-equ.

IPCC source categories	1990	1992	1994	2002	2003	2004
CO_2	**238,4**	**274,7**	**179,4**	**142,6**	**144.8**	**172.2**
Energy activity	218,3	257,8	171,9	128,3	129.8	155.6
Fuel combustion	*213,5*	*252,9*	*168,1*	*119,4*	*124,9*	*150.4*
Fugitive emissions	*4,8*	*4,9*	*3,8*	*8,9*	*4.1*	*5,2*
Industrial processes	20,0	16,9	7,5	*14,4*	*15,8*	*16,6*
Land use change and forestry (sinks)	**-10,5**	**-10,4**	**-10,0**	**-8,3**	**-8,3**	**-7,5**
CH_4	**58,1**	**51,3**	**39,5**	**25,7**	**28,1**	**29.4**
Energy activity	38,7	32,6	23,6	13,2	15,9	16.1
Fuel combustion	1,5	1,9	1,1	0,4	0,5	1.4
Fugitive emissions	37,2	30,7	22,5	12,7	15,4	14,6
Industrial processes	0,04	0,03	0,02	0,03	0,03	0,02
Agriculture	16,5	16,1	13,4	7,9	7,9	8,9
Wastes	2,7	2,7	2,5	4,6	4,3	4,5
N2O	26,9	24,9	17,2	10,2	10,3	11.7
Energy activity	0,8	0,9	0,6	0,4	0,5	0.6
Fuel combustion	0,8	0,9	0,6	0,4	0,5	0.6
Agriculture	25,6	23,6	16,1	9,4	9,4	10,2
Wastes	0,5	0,4	0,5	0,4	0,4	0.3
Total emissions	323,3	351,0	302,7	178,5	182.2	213.3

Net emissions (sources and sinks)	312,8	340,6	292,7	170,2	174.9	205.8

Picture 1.1 illustrates the summarized trend of total GHG emissions in Kazakhstan by types of gases within 1990, 1992, 1994, 2002, 2004 years. The percentage contribution share of each out of the three most important gases with direct greenhouse effect in 2004 is as follows: CO_2 – 80 %, CH_4 – 13,7 %, N_2O – 5,8 %.



Picture 1.1 – Emissions of direct greenhouse gases without sinks in 1990-2004.

2. ENERGY ACTIVITY

The main source of anthropogenic greenhouse gas emissions in Kazakhstan is the "Energy activity" source category.

In 2004 total greenhouse gas emissions from the category "Energy activity" were 172.2 mln. t CO_2-equ, i.e. is about 81.1 % from total national emissions.

The largest contribution to total national emissions (71.4 %) comes from combustion of fossil fuel amounting 152.4 mln. t CO_2-equ. in 2004.Contribution of GHG fugitive emissions in 2004 was 19.7 mln. t CO_2-equ., or 9.2 % from total national emissions.

In the "Energy activity" category the analysis of GHG emissions estimation (CO_2, CH_4, N_2O) showed, that emissions of carbon dioxide make up 90%, methane – 9.2 %, nitrous oxide – 0,3 %. Contribution of CO_2 emissions from the "Energy activity" category was 73 % in 2004 from total national emissions.

The results of GHG emissions estimation in 2004 by main source categories from the energy activity are presented in Table 2.1.

Table 2.1 – Greenhouse gas emissions in 2004 in «Energy activity» category, thous. tons CO_2-equ.

GHG Source	CO_2	CH_4	N_2O	Total
Energy activity	**155617**	**16032**	**576**	**172225**
A. Fuel combustion				
1.Energy industries	95967	34	341	96342
2.Manufacturing industries and construction	30164	42	124	30330
3.Transport	8406	831	68	9305
4.Other sectors	11 784	420	31	12235
5. Other	4124	110	12	4246
B. Fugitive emissions from fuel (coal, oil and gas)				
6. Coal		10899		10899
7. Oil and gas	5171	3696		8867

Trends in emissions of main greenhouse gases (1990, 1992, 1994, 2002, 2003)

Tendencies of changes in emissions of main greenhouse gases by main sources in the category "Energy activity" within 1990-2004 period are presented in Table 2.2. As shown in this table the total greenhouse gas emissions from the category "Energy activity" in 2004 have been increased to 12% against the previous year but do not reach the 1992 level of emissions and consist 59,4% from that level.

Table 2.2 – Trends of greenhouse gas emissions in the "Energy activity" sector, mln tons CO_2-equ.

Main sub-category / greenhouse gas	1990	1992	1994	2002	2003	2004
CO_2						
A. Fuel combustion	*213,5*	*252,9*	*168,1*	*119,4*	*124,8*	*150,4*
1. Energy industries	102,6	106,1	74,5	68,8	72,1	95,9
2. Manufacturing industries and construction	33,9	71,9	42,9	28,5	29,3	30,1
3. Transport	23,9	24,5	14,7	7,2	8,9	8,4
4. Other sectors	44,5	47,3	31,8	10,9	11,9	11,8
5. Other	8,4	3,1	4,2	3,9	2,7	4,1
B. Fugitive emissions from fuel	*4,8*	*4,9*	*3,8*	*8 9*	*8,9,*	
2. Oil and gas	4,8	4,9	3,8	8,9	9,7	5,1
Total by CO2	***218,3***	***257,8***	***171,9***	***128,3***	***134,5***	***155,6***
CH_4						
A. Fuel combustion	*1,6*	*1,9*	*0,9*	*0,4*	*0,5*	*0,6*
1. Energy industries	0,04	0,03	0,02	0,02	0,02	0,03
2. Manufacturing industries and construction	0,06	0,1	0,08	0,05	0,05	0,04
3. Transport	0,08	0,09	0,05	0,02	0,02	0,8
4. Other sectors	1,0	1,5	0,7	0,3	0,3	0,4
5. Other	0,3	0,1	0,1	0,09	0,08	0,1
B. Fugitive emissions from fuel	*42,0*	*39,5*	*32,7*	*21,2*	*21,2*	*14,6*
1. Coal	24,9	23,3	18,4	9,5	11,9	10,9
2. Oil and gas	12,3	7,4	4,1	3,2	3,4	3,7
Total by CH4	***38,7***	***32,6***	***23,6***	***13,2***	***15,9***	***16,6***
N_2O						
A. Fuel combustion	*0,8*	*0,9*	*0,6*	*0,4*	*0,5*	*0,6*
1. Energy industries	0,4	0,4	0,3	*0,3*	*0,3*	*0,3*
2. Manufacturing industries and construction	0,1	0,3	0,1	*0,1*	*0,1*	*0,1*
3. Transport	0,06	0,07	0,04	*0,02*	*0,02*	*0,06*
4. Other sectors	0,2	0,2	0,1	*0,04*	*0,05*	*0,03*
5. Other	0,03	0,01	0,01	*0,01*	*0,01*	*0,01*
Total by N_2O	***0,8***	***0,9***	***0,6***	***0,4***	***0,5***	**0,6**
Total by main GHG	**257,9**	**291,3**	**262,6**	**141,9**	**150,9**	**172,2**

2.1 Fuel combustion

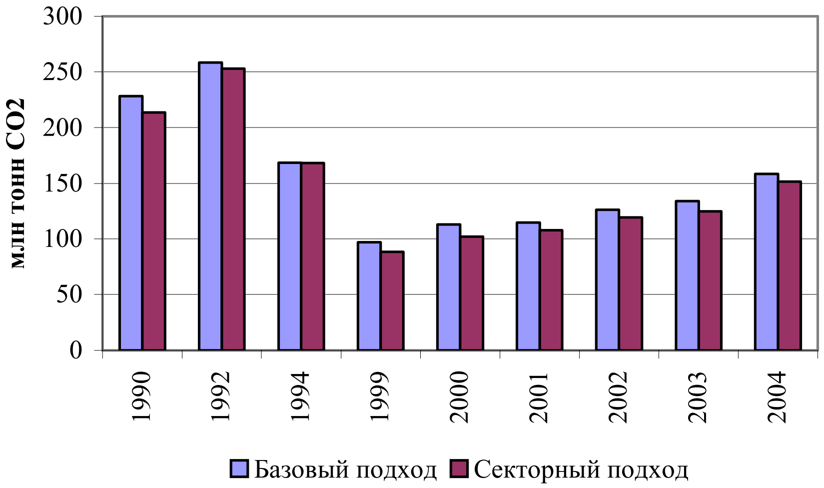
Combustion of solid fuel (coal, coal briquettes) is the reason of the largest emissions of carbon dioxide and their share in CO_2 emissions connected with the energy activity was 56,7 % in 2004. CO_2 emissions at combusting liquefied types of fuels (diesel oil, stove oil, gasoline etc.) are also considerable and their share is 5,3 %. Contribution of emissions from combusting gaseous fuels in 2004 was 3,3 %.

2.1.1 CO_2 Emissions

The Kazakhstan inventory has assessed carbon dioxide emissions by two methods – Tier 1 (baseline approach) and (sector approach).

2.1.2 Differences of CO_2 emissions, estimated by baseline and sector approaches

Differences of CO_2 emissions, estimated by baseline and sector approaches (in accordance with IPCC Guidelines) was 9,7 % in 2004. Picture 2.1 represents the dynamics of CO_2 emissions by both approaches from the energy activity in the Republic of Kazakhstan. The disparity of CO_2 emissions from the energy activity in 2004 as compared with the base 1992 year was 36 %.



Picture 2.1. – Dynamics of CO_2 emissions by two approaches from the energy activity

2.1.3 Activity data

Activity data for both approaches: baseline and sector includes the amount and type of fuel combusted. These data are available in the Yearbook “Fuel-Energy Balance of the Republic of Kazakhstan” of the Statistics Agency of the Republic of Kazakhstan. Additional input data were taken form the following yearbooks «Feasibility indicators of power and hydro stations and boilers operation of the Republic of Kazakhstan», «Electricity Balance of the Republic of Kazakhstan. Composition of energy equipment».

Fuel and categories of fuel

Table 2.3 – IPCC categories of fuel and types of fuel used in accordance to them

IPCC categories of fuel	Categories of fuel used by Kazakhstan's Statistics	Net Calorific Value, Qн, TJ/ 10^3 tonnes	Carbon Emission Factor (t C/TJ)
Crude oil	Crude oil Gas condensate	40,12[CS]	20,31[CS]
Gasoline	Jet kerosene Regular grade gasoline Jet engine fuel (Gasoline type)	44,21[CS]	19,13[CS]
Jet Kerosene	et engine fuel (Kerosene type)	43,32[CS]	19,78[CS]
Naphtha	Other Kerosene	44,75	19,6
Gas/Diesel Oil	Diesel Oil	43,02[CS]	19,98[CS]
	Stove Oil	42,54[CS]	20,29[CS]
	Motor oil	42,34[CS]	20,22[CS]
Residual Fuel Oil	Oil fuel (mazut) Lubricants	41,15[CS]	20,84[CS]
LPG	Propane and Butane liquefied Dry gas fuel	47,31[D]	17,2[D]
Bitumen	Bitumen and share oil	40,19[D]	22[D]
Lubricants	Other oils	40,19[D]	20[D]
Petroleum Coke	Petroleum Coke and Refinery Feedstock	31,0[D]	27,5[D]
Other Types of Fuel	Other Types of Fuel	29,309[D]	20[D]
Coking Coal	Coking Coal from Karaganda basin	24,01[CS]	24,89[CS]
Sub-bituminous Coal	Concentrate Coal	17,62[PS]	25,58[PS]
Lignite	Lignite	15,73[PS]	25,15[PS]
Coke	Coke	25,12[D]	29,5[D]
Coke gas	Coke gas	16,73[PS]	13[D]
Blast Furnace and Coke Gases	Blast Furnace and Coke Gases	4,19[PS]	66[D]
Natural gas	Natural gas	34,78[CS]	15,04[CS]
Biomass	Firewood for heating	10,22[CS]	29,48[CS]
Note: D – IPCC data (IPCC default); *CS – national data (country specific);* *PS – enterprises data (plant specific).*			

2.2 Baseline approach: CO_2 emissions at fuel combustion

Emission factors

Values of specific heat of combustion for crude oil, gasoline, jet kerosene, diesel oil, stove oil, coal, natural gas, emission factors for different categories of fuel have been identified by specialists of the Institute "KazNIPIenergoprom". The values for coke gas and blast furnace gas were submitted by Karaganda CPS, and the rest data were used from the IPCC Guidelines. The average weighted values have been estimated for diesel oil, sub- bituminous coal and lignite and presented in Table 2.4. Other types of fuel used coefficients presented in Table 2.3.

Table 2.4 – Average weighted coefficients applied for the baseline approach in 2004

Category of fuel	Specific combustion value, TJ/thous. tons	Carbon emission coefficient, tC/TJ
Diesel oil	43,04	19,97
Sub-bituminous Coal	17,71	25,57
Lignite	15,75	25,11

Activity data

Activity data which are used as national input data for estimating GHG emissions have been obtained from the National Energy Balance compiled in the Statistics Agency of the Republic of Kazakhstan.

Fuel used for raw and non-fuel needs

Bitumen and Lubricants

As an input data for estimating accumulated carbon in these types of fuel is sued the sum of national production and actual consumption.

Synthetic liquid fuel from coal and tar

If there is no the detailed information related to production of synthetic liquid fuel from coal and tar it is agreed that 6% of carbon in the consumed coke coal is transformed to synthetic liquid fuel and tar.

Natural gas, LPG, ethane, ligroin, gasoil/diesel oil

The input data for this category is the fuel used as the raw material or material for non-energy needs.

Fraction of carbon accumulated

Values of fraction of carbon accumulated were used default IPCC Guidelines and presented in Table 2.5.

Table 2.5 – Fraction of carbon accumulated in different types of fuel used as the raw material for non-energy purposes

Type of fuel	Fraction of carbon accumulated
Crude oil	0,8
Lubricants	0,5
Bitumen	1,0
Diesel oil	0,5
Gasoline	1,0
LPG	0,8
Ethane	0,8
Residual fuel oil	1,0
Synthetic liquid fuel and tar (from coking	0,75

coal)	
Natural gas	0,33
Coke	1,0

Activity data

As the input data are used those categories which are indicated in the Resource part of Energy balance in the item "as material for non-fuel needs" and "as raw material for production of chemical, petrochemical and other non-fuel products". The structure of categories of fuel and carbon accumulated is shown in Table 2.6.

Table 2.6 – Structure of fuel used for non-energy purposes and carbon accumulated in them

Category of fuel	**Estimated quantity of fuel, TJ**	**Carbon accumulated, thous. tons C**
Gasoline	1149.1	17.6
Other oils	11032.6	110.3
Synthetic liquid fuel from coal	12716.8	246.1
Bitumen and shale oil	8910.2	196.0
Natural gas	91902.7	456.1
Diesel oil	2151.5	21.5
LPG	632.7	8.7
Other types of fuel	3032.1	60.6
Coke oil and shale	58.3	1.6
Residual fuel oil	18744.8	312.6
Coke	9531.7	281.2

2.3. Sector approach: CO2 emissions at fuel combustion

Compliance of classification of economic activities types from the National Energy Balance with the source categories from the IPCC Guidelines is presented in Table 2.7.

Table 2.7 – Compliance of source categories presented in the IPCC Guidelines and the National Energy Balance

IPCC categories of sources		**Types of economic activities in Kazakhstan**
IA1 Energy Industry-fuel refining, power generation and transfer		
IA1a Public Electricity and Heat Production		Generation and distribution of energy; Hot water and steam supply
IA1b Petroleum Refining		Extraction of crude oil and natural gas;

		Services connected with oil and gas extraction; Petroleum refining
IA1c Manufacture of Solid Fuels and Other Energy Industries	***i*** *S*olid fuel converting	Coal and lignite production, peat development;
	ii *Other energy generation sectors*	Iron ore production; Other sectors of extracting industry; Gas fuel production and distribution;
IA2 Manufacturing Industries and Construction		
IA2a Iron and Steel	Iron industry	Iron industry; Production of cast iron, steel and ferroalloys; Casting of metals
IA2b Non-Ferrous Metals	non-ferrous metallurgy	Non-ferrous metals, non-ferrous metals ore;
IA2c Chemicals	Chemical industry	Production of fertilizers, nitrogen components; Pharmaceutical preparation; Rubber and plastic units production; Non-metal mineral products production
IA2d Pulp, Paper and Print		Wood raw materials and wood products production; Paper and carton production;
		Publishing, typography;
IA2e Food Processing, Beverages and Tobacco		Beverage foods production, and tobacco products production;
IA2g Mechanical engineering	Mechanical engineering	Metal final products; Cars and equipment production; Agricultural technique production; electrical and electronic equipment production; transport equipment production;
IA2h Light industry	Light industry	Textile and clothing industry; Leather production, leather products and foot wear production; furniture production;
IA2f Others		
		Other sectors of manufacturing industry;
		Construction

IA3 Transport		
IA3a Civil Aviation		Civil Aviation
IA3b Road Transportation		Road, pipeline and civil Transportation;
IA3c Railways		Railways
IA3d Navigation		Navigation
A3d Pipelines transportation;		Pipelines transportation;
IA4 Other Sectors		
IA4a Commercial/Institutional	Commercial/ Institutional sector	Gathering, cleaning and distribution of water; Hotels and other places for hosting;
		Restaurants, bars and canteen; Post and communication; Other public services; Education, Public health; Financial activity; Operation with real assets
IA4b Residential		Sold to population
IA4c Agriculture/Forestry/Fishing		Agriculture, hunting and other related activities Forestry and other related services Fishery
IA5 Others (not specified)		Оптовая торговля и торговля через агентов, кроме торговли автомобилями и мотоциклами; Motors marketing, emergency service and cars repair; Wholesale trade; retail trade; Governmental management and defense, insurance industry and governmental service; Auxiliary and additional transport activity

Emission factors

IPCC default values have been applied at estimating carbon dioxide emissions for some types of fuel. "KazNIPIEnergoprom" specialists have provided coefficients of specific heat of combustion, carbon emissions and fraction of carbon oxidation for crude oil, gasoline, diesel, stove, motor oil, residual fuel oil, lubricants, coal, natural gas and biomass (firewood).

Activity data

Data for this type of economic activity at the sector approach have been taken from the Distribution part of the Energy Balance of the Republic of Kazakhstan. All types of economic activities have been aggregated in accordance with the source categories of the IPCC Guidelines (Table 2.7).

2.4. Transport

Methodology.

Estimations of greenhouse gas emissions have been implemented based on recommendations of the IPCC Guidelines on GHG Inventory. Moreover, the specific heat of combustion and emission coefficients have been estimated by the Institute "KazNIPIEnergoprom" in Kazakhstan as the most appropriate to our types of fuel. These coefficients are presented in Table 2.4.1

Activity data

Data on the dynamics of development and quantity of fuel combusted by main sub-categories of transport have been taken from the official digests of the Statistics Agency of the Republic of Kazakhstan.

Data on the amount of consumed fuel then recalculated to the carbon content by sub-categories of transport and by types are given in Tables 2.8 and 2.9.

Table 2.8. – Amount of fuel consumed by types of fuel and categories of transport

Transport	Consumption. thous.t/ thous. m^3	Conversion factor, TJ /unit	Consumption, TJ	Carbon emissions factor (TC/ TJ)	Carbon concentration (T C)	Carbon concentration (G C)
Domestic aviation						
Jet kerosene. thous.t	7.645	44.21	337.99	19.13	6465.75	6.47
Regular grade gasoline. thous.t	1.249	44.21	55.22	19.13	1066.36	1.07
Kerosene and Jet engine fuel	300.000	43.32	12 996.0	19.78	257064.88	257.06
Total by sub-section	-	-	**13389.21**	-	**264596.99**	**264.60**
Road transportation						
Natural gas,	578532	34.78	20111.34	15.04	302474.55	302.47

thous. m^3						
LPG, thous. m^3	1.211	47.31	57.24	17.20	984.53	0.98
Gasoline. thous. t	143.917	44.21	8237.41	19.30	158982.02	158.98
Gas/Diesel Oil. thous. t	809.054	43.02	34805.33	19.98	695410.49	695.41
Propane and Butane liquefied. thous. t	10.341	47.31	489.19	17.20	8414.07	8.41
Total by sub-section	-	-	**63700.51**	-	**1166265.6**	**1166.25**
Railway transport						
Regular grade gasoline. thous. t	3.876	44.21	171.53	19.13	3281.37	3.28
Diesel Oil, thous. t	234.435	43.02	10085.51	19.98	201508.49	201.51
Oil fuel (mazut), thous. t	145.346	41.15	5981.15	41.15	246124.32	246.12
Lubricants, thous. t	3.750	40.19	150.71	20.00	3014.20	3.01
Total by sub-section	-	-	**16388.90**	-	**453928.38**	**453.92**
Non-international navigation						
Regular grade gasoline. thous. t	0.192	44.21	8.40	19.13	160.69	0.16
Diesel Oil, thous. t	2.162	43.02	92.92	19.98	1856.54	1.86
Natural gas, thous. m^3	33	34.78	1.15	15.04	17.30	0.02
Lubricants, thous. t	0.026	40.19	1.26	20.00	25.20	0.03
Total by sub-section	-	-	**103.73**	-	**2059.73**	**2.06**
Pipeline transport						
Regular grade gasoline. thous. t	5.785	44.21	255.54	19.13	4888.48	4.89

Natural gas, thous. m^3	768,1	34.78	26714,4	15.04	401783,4	401,78
Crude oil, thous. t	1.507	40.12	60.58	20.31	1230.38	1.23
Diesel Oil, thous. t	8.700	43.02	374.27	19.98	7410.55	7.41
Kerosene, thous. t	8.701	43.32	376.88	19.78	7453.69	7.45
Total by sub-section	-	-	27781,7	-	422766,5	422,76
Grand Total by Transport	-	-	**121364,0**	-	**2309617,3**	**2309,6**

Table 2.9. – CO_2 Emission Values by categories of transport and types of fuel

Transport	Carbon concentration (Gg C)	Carbon oxidation fraction	Actual carbon emissions	Actual CO_2 emissions
Domestic aviation				
Jet engine fuel. thous.t	6.47	0.99	6.41	23.50
Regular grade gasoline. thous.t	1.07	0.99	1.06	3.90
Kerosene and Jet engine fuel	257.06	0.99	254.56	925.05
Total by sub-section	**264.60**	-	**261.93**	**952.45**
Road Transportation				
Natural Gas, thous. m^3	302.47	0.99	299.40	1097.80
LPG, thous. m^3	0.98	0.99	0.97	3.55
Gasoline. thous. t	158.98	0.99	157.40	577.10
Gas/Diesel Oil. thous. t	695.41	0.99	688.40	2524.10
Propane and Butane liquefied. thous. t	8.41	0.99	8.35	30.61
Total by sub-section	**1166.26**	**-**	**1154.42**	**4233.16**
Railway transport				
Regular grade gasoline. thous. t	3.28	0.99	3.25	11.91
Diesel Oil, thous. t	201.51	0.99	199.50	731.49
Oil fuel (mazut), thous. t	246.12	0.99	243.60	898.20
Lubricants, thous. t	3.01	0.99	2.98	10.98
Total by sub-section	**453.93**	**-**	**449.33**	**1652.58**
Non international water transport				

Regular grade gasoline. thous. t	0.16	0.99	0.15	0.55
Diesel Oil, thous. t	1.86	0.99	1.84	6.75
Natural Gas, thous. m^3	0.02	0.99	0.02	0.08
Lubricants, thous. t	0.03	0.99	0.03	0.11
Total by sub-section	**2.06**	-	**2.04**	**7.49**
Pipeline Transport				
Regular grade gasoline. thous. t	4.89	0.99	4.84	17.76
Natural Gas, thous. m^3	401,78	0.99	397,8	1458,5
Crude Oil, thous. t	1.23	0.99	1.22	4.47
Diesel Oil, thous. t	7.41	0.99	7.35	26.12
Kerosene, thous. t.	7.45	0.99	7.35	26.12
Total by sub-section	**422,8**	-	**418,5**	**1533,0**
Grand Total by transport	**2309,6**	-	**2286,3**	**8378,7**

Table 2.10. – CO_2 emission values by sub-categories "transport", thous.t.

Sub-categories	1990	1992	1994	2002	2003	2004
Aviation	44	1185	519	787	858	952.4
Road transportation	12524	20025	11048	2990	3913	4233.2
Railway	4793	1583	1532	1042	1220	1652.6
Navigation	204	194	947	8	9	7.5
Pipeline Transportation	444	276	674	2632	3495	1533,0
Total	**18014**	**23263**	**14721**	**7938**	**9782**	**8378,7**

Estimation of other greenhouse gas emissions without CO_2.

Table 2.11. – N_2O emission values, estimated under Tier II (equivalent CO_2).

Type of transport	Amount of fuel used, TJ	Coefficient kg/TJ	Quantity N_2O kg
Aviation	13389,21	0.6	8033.53
Road Transportation	63700.51	0.6	38220.31
Railway Transport	16388.90	0.6	9833.34
Navigation	103.73	0.6	62.30
Pipeline Transportation	26781,7	0.6	16661,2
Total	-	-	**72810,4 т**

Table 2.12. – CH_4 emission values, estimated under Tier II (equivalent CO_2).

Types of transport	Gasoline TJ	Coefficient kg/ TJ	Quantity CH_4, t	Diesel oil and mazut	Coefficient kg/TJ	Quantity CH_4, tons
Aviation	393.21	0.5	0.19660	12 996.0	0.5	6,50
Road Transportation	8237.41	5	41.18705	34805.33	20	696,11
Railway Transport	171.53	5	0.85765	16066.66	5	80,33
Navigation	8.40	5	0.042	92.92	5	0,46
Pipeline transportation	27781,7	5	139,91	376.88	10	3,77
Total, t			**182,14**			**787,17**
Total, t						**967,4**

Table 2.13. – Distribution of vehicles by types and types of fuel (items).

Type of vehicles	Gasoline	Diesel oil	Gas	**Total**
Trucks less than 3.5 tons and m/auto	68250	70400	1370	140020
Trucks more than 3.5 тонн	68945	75081	2918	122944
Buses	31035	11448	1187	43670
Cars	777526	270300	13378	1061204
Total	**921756**	**427229**	**18853**	**1367838**
Motocycles	64391			64391

Table 2.14. – CO_2 emission values from sub-category "Transport" (in equivalent CO_2)

Substances	1990	1992	1994	2002	2003	2004
CO_2	18014	23263	14721	7938	9782	8379
CH_4	73	83	46	16	20	967
N_2O	41	65	41	15	16	73
Total, thous.t	**18128**	**23411**	**14808**	**7969**	**9818**	**9419**

Uncertainties in assessment of emissions

Uncertainty of greenhouse gas emissions in the transport sector has been estimated in accordance with IPCC Guidelines [5]. For greenhouse gases with direct greenhouse effect, i.e. for CO_2 and CH_4 the uncertainty was 11%. Among the sub-groups of transport the highest uncertainty of estimation was marked for the pipeline transport where it exceeds 13%. In other sub-groups of transport the uncertainties are somewhat lower or equal 10%.

2.5. «Other sectors» and «Other sources»

The source sub-category "Other sectors" includes three main sources: fuel combustion in commercial, institutional buildings and residential sector; private residential houses and agricultural farms; fuel combustion in agriculture, forestry and fishery including use of fuel for pumps, drying of grain, horticultural greenhouses etc.

The sub-category "Other sources" includes all other sources that were included into the previous source categories. The carbon dioxide emissions from the sub-categories "Other sectors" and "Other sources" are presented in Table 2.15.

Table 2.15. – CO_2 emissions in Kazakhstan from the sub-categories "Other sectors" and "Other sources"

	1990		**1992**		**1994**		**2002**		**2003**		**2004**	
	mln t	**%**	**mln t**	**%**	**mln t**	**%**	**mln t**	**%**	**mln t**	**%**	**mln t**	**%**
Commercial/Institutional sector	27,2	61,1	15,3	32,3	12,1	38,2	4,1	37,3	4,1	33,8	2.4	20.3
Residential sector	16,4	36,9	19,7	41,6	10,9	34,4	4,5	41,6	5,6	45,8	7.0	59.3
Agriculture/ Forestry/ Fishery	0,9	2,0	12,3	26,0	8,7	27,4	2,3	21,1	2,5	20,4	2.4	20.3
Other sectors - Total	**44,5**	**100**	**47,3**	**100**	**31,7**	**100**	**10,9**	**100**	**12,2**	**100**	**11.8**	**100**
Other sources - Total	**8,4**	**100**	**3,1**	**100**	**4,2**	**100**	**3,9**	**100**	**2,8**	**100**	**4.1**	**100**

The uncertainty of emissions estimation at fuel combustion is considered as rather low. The uncertainty in emission factors is so small that could be ignored and the uncertainty in the data activity by main sources is usually within 1-5%. For some sources, for example off-highway vehicles, the uncertainty is the highest. Basically the uncertainty of total CO_2 emissions from fuel combustion in the category "Energy activity" id justified by equal small uncertainties in different sub-categories. That is why this is reasonable to use the uncertainty of the established key source as the basis of total uncertainties of CO_2 emissions.

2.6. CH_4 and N_2O emissions

Methodology

In the basis of estimating emissions from other gases is the use of data on combustion of all types of fuel, the amount of which is expressed in energy measuring units (TJ). All fuel is distributed by source categories and divided to 4 main groups:

1) coal;
2) natural gas;
3) petroleum and petroleum products (including residual fuel oil, gasoline and diesel oil);
4) biomass (firewood, woodworking waste).

Then all this fuel by source categories and groups of fuel is multiplied to the appropriate emission coefficient of corresponding gases identified in the IPCC Guidelines.

Emission factors

Table 2.16. – Emission factors (CH_4, N_2O), applied in Kazakhstan for estimations, kg/TJ

Main sources	CH_4				N_2O			
	Coal	GaS	Oil	Firewood	Coal	GaS	Oil	Firewood
Energy Industry	1	1	3	30	1,4	0,1	0,6	4
Manufacturing Industry	10	5	2	30	1,4	0,1	0,6	4
Aviation			0,5				2	
Road transportation		50	20(b) 5(c)			0,1	0,6(b) 0,6(c)	
Railway transport	10		5		1,4		0,6	
Navigation	10		5		1,4		0,6	
Commercial/Institutional sector	10	5	10	300	1,4	0,1	0,6	4
Residential sector	300	5	10	300	1,4	0,1	0,6	4
Agriculture/Forestry/ Fishery	300	5	10	300	1,4	0,1	0,6	4
Other sources	300	5	10	300	1,4	0,1	0,6	4

Note: (b) – gasoline;
(c) – diesel oil.

Activity data

To estimate CH_4, N_2O emissions and other gases the same data in the category “Energy activity” are used for estimating CO_2 emissions, but only all types of fuel used in Kazakhstan are incorporated in 4 main groups: coal, gas, oil and petroleum products and biofuel (firewood).

Table 2.17. – CH_4 emissions in Kazakhstan by main sources under the category «Energy activity» (fuel combustion), thous. t CO_2-equ.

	1990	**1992**	**1994**	**2002**	**2003**	**2004**
Energy Industry	*35*	*32*	*21*	*24*	*24*	*33,6*
Production of power and heat	32	28		15	16	*17,1*
Production and refining of oil	1	1		6	4	10,5
Production and processing of solid fuel	2	3		4	4	6,3
Manufacturing Industry	*63*	*134*	*84*	*49*	*51*	*42*
Ferrous metallurgy	36	87		27	28	29,4
Non-ferrous metallurgy	7	11		14	15	14,3
Chemical Industry	3	6		4	4	4,6
Pulp Industry and Publishing Industry	0	0,3		0	0,1	0,2
Food Processing, Beverages and Tobacco	1	4		2	2	1,9
Mechanical engineering	1	4		1	1	1,05
Light industry	0	1		0	0,2	0,2
Others	9	21		1	1	1,05
Transport	*81,7*	*89,3*	*45,8*	*16*	*20*	*37,2*
Aviation		0,17	0,1	0	0	0
Road Transportation	74,3	85,3	41,4	14	18	35,7
Railway transport	6,9	2,7	2,9	2	2	1,5
Navigation	0,3	0,9	1,3			0
Other sectors	*1041*	*1499*	*728*	*262*	*306*	*428,4*
Commercial/Institutional sector	79	44	34	11	13	9,0
Residential sector	891	1089	437	196	230	359
Agriculture/Forestry/Fishery	71	366	258	55	63	62,1
Other sources	*330*	*101*	*109*	*91*	*83*	*97,65*
Total	**1552**	**1885**	**988**	**442**	**484**	**651,7**

Table 2.18. – N_2O emissions in Kazakhstan by main sources under the category «Energy activity», thous. t CO_2-equ.

	1990	**1992**	**1994**	**2002**	**2003**	**2004**
Energy Industry	*388*	*409*	*326*	*261*	*281*	*328,6*
Production of power and heat	372	388		223	248	279
Production and refining of oil	3	6		16	10	18,6
Production and processing of solid fuel	12	16		23	23	31
Manufacturing Industry	*115*	*270*	*133*	*109*	*112*	*114,7*
Ferrous Metallurgy	74	180		63	64	65,1

Non-ferrous metallurgy	16	22		30	32	31
Chemical Industry	3	9		8	8	9,3
Pulp Industry and Publishing Industry					0,2	0
Food Processing, Beverages and Tobacco	3	6		4	3	3,1
Mechanical engineering	3	9		2	2	3,1
Light industry		3			0,3	0
Others	16	40		2	3	3,1
Transport	*58,9*	*71,3*	*40,3*	*15*	*16*	*21,7*
Aviation	0,3	9,9	4,3	4	2,5	2,8
Road Transportation	43,4	52,7	27,9	8	10	1,6
Railway transport	12,4	6,2	6,2	3	3	3,1
Navigation	0,5	1,6	2,5		0	0
Other sectors	*195*	*186*	*112*	*41*	*47*	*46,5*
Commercial/Institutional sector	121	62	47	17	19	9,3
Residential sector	68	84	34	17	20	27,9
Agriculture/Forestry/ Fishery	6	43	31	8	8	9,3
Other sources	*28*	*9*	*9*	*13*	*10*	*12,4*

The uncertainty of emission factors according to the IPCC Guidance is assessed within 50-100 %. The uncertainty of methane emissions is considerably lower than the uncertainty of nitrous oxide emissions. The uncertainty of data activity is negligible for all category “Energy activity”.

2.7. Fugitive emissions at activities connected with gas, oil and coal

The IPCC Guidelines Tier 3 methodology was used for estimating methane emissions at producing by closed method, storing and transporting coal. For large open coal mines that produce about 80% of the country open production, Tier 2 was used. Emissions for the rest of the open mines were calculated using Tier 1 and predefined coefficients due to lack of the data on methane content and production volumes.

Utilized or combusted methane as well as methane from liquidated mines was extracted from total methane emissions.

General methodology for evaluating GHG emissions from oil and gas sector covers emissions from main categories: oil sector, gas transportation, gas distribution, associated gas flaring.

IPCC methodology was used for calculating methane emissions from activities related to extraction, transportation, storing and initial processing of oil and gas. As basis we took Tier 3 (gas transportation and distribution, including CIS and flaring), and Tier 1 (oil extraction, transportation, storage and processing).

Below is formula for GHG emissions calculation from associated gas flaring:

$$M = F \times G$$

WHERE M – EMISSIONS OF A CERTAIN GAS (CH_4);

F – emission coefficient (0.0005 for CH_4);

G – volume of flared gas;

Evaluation of CO_2 emissions also takes into account the gas content:

$$Mco_2 = 0.01G \times (3.67n \times (C_m)+(CO2_m)) - Mco - Mc_{H4}$$

where M_{CO2} –CO_2 emissions ;

G – volume of flared gas;

n – faring efficiency that equals to 0.98 for flairs used in Kazakhstan;

$C_{m,}$ $CO2_m$, – mass share of carbon, CO_2 or sulfur, %

2.7.1. Uncertainty assessment

Total uncertainty of methane emissions from extraction, transportation and storage of coal is ± 20 %.

-emission assessment in the oil sector was based on improved data including railway transportation. But utilization of Tier 1 and IPCC predefined coefficients lead to relatively high uncertainty ±25%;

-uncertainty in assessing emissions from associated gas flaring is based on information extrapolation about gas content and volume, and amounts to ±20 %;

-emissions from gas sector were assessed using local gas loss rates with uncertainty ±25 %.

3. INDUSTRIAL PROCESSES

3.1. *General methodology*

The Kazakhstani inventory used simplified methods stated in Tier 1 and predefined coefficients proposed by IPCC Guidelines.

Initial data about production volumes necessary for emissions calculations were taken from Agency on Statistics of the Republic of Kazakhstan.

3.2. *Total emissions with direct greenhouse effect*

In module «Industrial Processes», includes the following three main CO_2 and CH_4 emission sources: 1) mineral production; 2) metal production; and 3) chemical industry, methane emissions occur only from chemical production.

Table 3.1. - GHG emissions from Industrial processes, thous. t CO_2-equ.

Sources of emissions /years	Production of metals	Production of mineral matters	Chemical Industry	***Total***
1990	12 933	5 745	1 396	***20 073***
1992	11 379	4 567	969	***16 915***
1994	5 707	1 600	238	***7 545***
1999	7 973	888	62	***8 922***
2000	9 205	2 569	50	***11 824***
2001	9 087	3 779	102	***12 968***
2002	9 452	4 843	103	***14 398***
2003	10 008	5 720	126	***15 855***
2004	10 507	5 963	209	***16 680***

Uncertainty in module «Industrial processes» caused by use of Tier 1 methodology, and averaged emission coefficients. In accordance with IPCC Guidelines total uncertainty in this module is ±10 %, though each subcategory has different figure.

3.3. *Production of metals*

In metal production in Kazakhstan we evaluate carbon dioxide emissions from steel and ferroalloy production. We used methodology of Tier 1b, that is based on produced metals volume by types. The method was used due to lack of precise data on deoxidizer quantity used for each metal type.

3.4. *Production of mineral matters*

This sub-category represents CO_2 emissions from production of cement, lime, limestone and dolomite. Methodology of Tier 1, was used for evaluating emissions from mineral matters production. Emissions coefficients were also taken from IPCC Guidelines. Calculation of the emissions from limestone and dolomite production was made basing on the production volume and presupposition that all produced volume was used the same tear.

Table 3.2. CO_2 emissions from production of mineral matters, thous. t

Categories of sources	1990	1992	1994	2003	2004
Total	5 745	4 567	1 600	5 720	5 963
Production of cement	4 138	3 208	1 014	1 287	1 826
Production of lime	1 580	1 344	586	624	682
Use of limestone and dolomite				3 809	3 455

3.5. Chemical Industry

CO_2 sources in chemical industry of Kazakhstan are production of calcium carbide and ammonia. CH_4 emissions are generated from production of ethylene, coke and styrene.

4. AGRICULTURE

The module "Agriculture" divides GHG emissions according to the following emission sources:

- enteric fermentation of agricultural animals, as well as collection, storage, use of manure and poultry dung;
- rice cultivation;
- field burning of agricultural residues;
- agricultural soils.

4.1. General methodology

Calculations have been made by using coefficients recommended by the IPCC Guidelines for Tier 1, national estimations (distribution of nitrogen by systems of manure, the ratio of plant residues/products, the share of biomass burnt on fields, the carbon content in dry biomass, the nitrogen content in nitrogen-fixing and non-nitrogen-fixing plants) as well as the national statistics by the corresponding types of activity.

Table 4.1 – CH_4 and N_2O emissions in Kazakhstan, thous. t CO_2-equ.

	1990	**1992**	**1994**	**2003**	**2004**
CH_4	16546	16102	13432	8305	8953
N_2O	25615	23598	16117	9724	10231
Total	***42161***	***39699***	***29550***	***18029***	***19184***

Volumes of greenhouse gas emissions from the category "Agriculture" by major sources are presented in Table 4.2.

Table 4.2 – GHG emissions from the category «Agriculture», thous. t CO_2-equ.

Sources of emissions	**1990**	**1992**	**1994**	**1999**	**2003**	**2004**
Enteric fermentation	14055	13730	11450	5722	6772	7347
Manure management	2278	2176	1804	1105	1307	1399
Rice cultivation	523	483	428	308	351	339
Combustion of agricultural wastes	89	94	45	55	88	97
Agricultural soils	25216	23216	15822	7745	9511	10002
Total	***42161***	***39699***	***29550***	***14935***	***18029***	***19184***

4.2. *Uncertainty assessment*

Errors in calculations implemented in the module “Agriculture” became due to the use of aggregated emission coefficients set in the IPCC Guidelines under Tier 1 and high degree of uncertainties in the national activity data.

Errors in estimation of the methane and nitrous oxide emissions from livestock breeding are within ±80 %. This resulted from the uncertainty of input statistical data by cattle stock (±10 %), inaccuracies in emission factor from enteric fermentation (±50 %) and uncertainties of national coefficients for manure distribution by various systems of collection, storage and use (±20 %).

The uncertainty of the methane emissions estimations from rice plantations equals ±45 %, as the sum of errors in input statistical data by harvested areas of rice (±10 %), the uncertainty in the emission factor integrated within a season as well as the correction factor for registering fertilizers in soils (correspondingly, ±30 % and ±5 %).

Estimations of air emissions GHG from burning agricultural residues on fields have the error of ±60 %. The uncertainties of national factors equal ±30 %. The errors in emission coefficients identified in the Guidelines are as ±20 %. The national statistics has also the uncertainty as ±10 %.

The error in estimating nitrous oxide from agricultural lands management is ±55 %. This resulted from the uncertainty level of input statistical data by production of crops (±10 %), inaccuracy in factors of direct emissions from agricultural soils (±20 %), uncertainties in national values of the nitrogen content in dry biomass for nitrogen-fixing and non-nitrogen fixing plants (±25 %).

According to the IPCC Guidelines [6] the total uncertainty in estimations done in the module is assessed in ±240 %.

4.3. *Planning improvements*

To improve a methodology of estimating greenhouse gas air emissions from agricultural activity a number of national coefficients should be enlarged. Also it is required to specify the statistics on cattle stock, harvested areas, production of crops and use of chemical fertilizers.

5. LAND USE, LAND USE CHANGE AND FORESTRY

5.1. GHG emissions/sinks inventory in the sector Forestry

5.1.1. Choice of a methodology

1. Guidelines "Good Practice Guidance for Land Use, Land-Use Change and Forestry" (GPG-LULUCF 2003) [1],

The database on forests inventory in Kazakhstan includes information by areas where grow various groups, species of trees, their age structure as well as all changes than occur in the given sub-sections.

When estimating GHG emissions/sinks the following 5 sources of carbon which is either accumulated or extracted have been distinguished. They are:

1. carbon stock change in above-ground part of living biomass (LB);
2. carbon stock change in below-ground part of LB;
3. carbon stock change in dead wood;
4. carbon stock change in refuse (small branches, foliage etc.);
5. carbon stock change in soils.

5.1.2. Methodology and input data

According to 2003 GPG-LULUCF the land use category "forest land" has to assess carbon stock change, GHG emissions/sinks that are related to changes in forest wood stock as well as in soils as they contain organic carbon. Soils are divided into 2 categories of lands:

– forests remaining forests (FF) and
– lands converted to forest lands (FL).

In the first case carbon stock change is estimated by those forest areas that were forests during the last 7 years. In the second case carbon stock change is estimated in lands converted to forest lands.

The main forest forming species of the forest fund in 2004 are presented by the following groups of species:

1. *coniferous* – pine, spruce, silver fir, larch, cedar, juniper (archa);
2. *soft leaf* – birch, aspen, alder, poplar, willow;
3. *hard leaf* –oak, ash, maple, elm, locust;
4. *saxaul* – saxaul black, saxaul white;
5. *other trees* – apricot, walnut, hackberry, mountain ash, plum-tree Sogdian (alycha), pistachio, bird cherry tree, apple tree, oleaster, other;
6. *shrubs* – hawthorn, tamarisk, sloe, juniper, sea-buckthorn, currants, saltwort, dog-rose, spiraea, other surbs

Though the saxaul plants and shrubs occupy about 74 % of all forest areas they consist only 2 % of total stock of wood whereas coniferous and soft leaf contribute 95% to total volume of wood .

5.1.3. Forests remaining forests (FF)

Caron stock change in forest lands remaining forests is estimated according to the formula 3.2.1., set in 2003 GPG-LULUCF Guidelines.

a. Carbon stock change in living biomass

For estimating carbon stock change in living biomass the 2nd method (stock change method) was used that calculates C stock change in living wood biomass in the land category FF. This method uses a formula 3.2.3., from 2003 GPG-LULUCF Guidelines.

The main data source for wood biomass stock change is the results of a single state registration of forests in RK conducted every five years (registration data as of January 1, 1988, 1993, 1998, 2003). During registration the area and stock of raw growing wood are identified by main groups of species taking into account the age group. This inventory determines distribution of areas and stocks by predominant species that are divided into groups of species.

Table 5.1 – Area (thous. ha) and stock of wood (mln. m^3), major groups of forest species in RK.

Year	Group of species											
	Coniferous		Softwood		Hardwood		Saxaul		Other trees		Shrubs	
	Area	Stock	Area	Stock	Area	Stock	Area	Stock	Area	Stock	Area	Stock
1988	1737.5	221.1	1303.3	115.6	86.5	2.3	4815.2	9.7	43.9	1.0	1410.0	6.5
1993	1800.2	240.4	1406.1	123.3	95.3	2.8	5091.4	10.7	80.8	1.4	2068.8	7.0
1998	1719.0	236.6	1430.5	126.0	98.1	2.9	5421.4	10.2	82.5	1.5	2675.6	9.3
2003	1650.8	228.6	1415.6	131.1	100.	3.1	6252.8	15.2	137.	2.6	3094.5	11.

Source: Kazakh forest management enterprise [2]

Content of dry matter in different species and types of trees was taken from "Ranger Guidelines" [3] in order to estimate average weighted content of dry matter for main forest forming species. Values were used for estimating wood density by all groups of trees.

Table 5.2 – Weight 1m^3 of wood in dry condition of wood-shrub species of RK.

Main groups of species	Average weighted content of d.m., (kg)
Coniferous	504
Soft leaf	597

Hard leaf	711
Other trees	554
Saxaul	711
Shrubs	384

To convert values of dry matter content (dm) to carbon stock a default coefficient was used which equals 0,5 t dm/m^3 and 0,5 t C/t dm. Instead of biomass expansion factor (BEF) and correlation “root – above ground part of biomass” there was used a percentage ratio of amount of branches, sprouts, suckers and stems of above ground biomass. These data are presented in Table 5. 3 both by groups species and groups of age.

Table 5.3 – Amount of branches and roots

Group of species	Underwood		Old trees	
	Branches and sprouts, %wood	Stems and roots, % above ground biomass	Branches and sprouts, % wood	Stems and roots, % above ground biomass
Coniderous	4	18	11	27
Soft leaf	5	22	12	24
Hard leaf	6	22	15	35
Saxaul	10	40	10	40
Other trees	5	22	12	24
Shrubs	3	20	8	20

Source: Forests Inventory Guidelines [3]

б. Carbon stock change in dead wood

At estimating carbon stock change in DW the second method has been also used which calculates only the fallen wood. Data of the total fallen wood stock were obtained from the national inventory of forests.

Table 5.4 – distribution of area (thous.ha) and fallen wood stock (mln. m^3) by groups of trees.

Year	Group of species											
	Coniferous		Soft leaf		Hard leaf		Saxaul		Other trees		Shrubs	
	area	stock	area	stock	area	stock	area	stock	area	stock	area	stock
1988	1737.5	101.84	1303.3	38.39	36.5	2.19	4815.2	2.62	43.9	0.20	1410.0	4
1993	1800.2	101.77	1406.1	37.66	95.3	1.55	5091.4	3.47	80.8	0.24	2068.8	2.23
1998	1719.0	101.99	1430.5	40.36	98.1	1.69	5421.4	3.83	82.5	0.27	2675.6	2.64
2003	1650.8	103.19	1415.6	42.18	100.3	1.83	6252.8	3.88	137.	0.43	3094.5	2.59

Source: Kazakh forest management enterprise [2]

No significant changes influencing to carbon stock from wood refuse happen therefore carbon stock change is supposed to be 0.

в. Carbon stock change in soils

In this section estimations have not been done due to the lack of detailed data on carbon content in soils of forests, their mineralization, experience in forestry management and so on. Moreover, for Kazakhstan this category is insignificant. The Guidelines restricts carbon emission estimation, the content of which is related to drainage soils in managed forests.

5.1.4. - Lands converted to forest lands (FL)

This section covers GHG emissions/sinks estimation from the category of managed lands converted to forest lands due to afforestation, artificial regeneration as well as under influence of other natural factors. Carbon stock change was estimated in lands converted to forest lands within the last 7 years as 85% of RK areas were converted to forest lands due to planting coniferous trees.

a. Carbon stock change in living biomass

Based on the available input data Tier 1 method was applied which estimates wood biomass stock change taking into account the option that all forests in Kazakhstan are managed.

Table 5.5 – Area of lands converted to forest lands, thous. ha.

Years	Area
1990	69.0
1991	61.3
1992	74.0
1993	39.9
1994	35.3
1995	25.1
1996	4.7
1997	3.6
1998	13.5
1999	4.0
2000	7.0
2001	6.0
2002	8.4
2003	10.7
2004	10.4

Source: Statistical Yearbook of the RK Statistics Agency [5]

Data of the land areas converted to forest lands within 1986-1989 were interpolated using the values as of 3.215 thous. ha., obtained from the Initial National Communication.

Carbon emissions/sinks in living biomass were estimated by summation of data on wood growth by each inventory year both on land areas converted to forest lands in the inventory year and within the last 6 years.

Values of Table 5.3 have been used for estimating average weighted factor BEF_1 and the correlation "root – above ground biomass" for underwood. The wood density has been estimated due to wood stock by each group of trees in the total volume.

Experts of the Kazakh forest management enterprise estimated a coefficient of the average weighted annual growth of biomass which equals 1.6 m^3/ha due to the share of each group of species from the total volume of wood stock.

In Kazakhstan the lands have been converted to forest lands through the intensive management – planting new species, active works on forests restoration. Losses were caused by felling for firewood and other reasons. However, such cases have not been registered on new forest areas restored, therefore data on losses were estimated as zero. Thus, annual reduction of carbon stock from living biomass happening due to data on losses is considered as zero.

b. Carbon stock change in dead organic substances

Felling and refuse do not significantly contribute to the carbon stock, therefore it is supposed that carbon stock change equals to zero.

c. Carbon stock change in soils

Calculations in this section have not been done due to the lack of detailed data by carbon content in forest soils, their mineralization, experience in forestry management etc. Moreover, for RK this category is insignificant. The Guideline restricts estimations of carbon emissions which content relates to drainage soils in managed forests.

5.1.5. GHG emissions from burnt biomass (Fires)

This section estimates greenhouse gas emissions that were generated from fires, they are - CO_2, CH_4, N_2O, CO, and NOx. Analysis of available data demonstrates that Tier 1 method is more appropriate for estimating GHG emissions from fires and emissions are estimated by a formula 3.2.20 of 2003 GPG-LULUCF Guidelines. Input data are shown in Table 5.6. Also default coefficients have been applied for the following parameters:

- Mass of "available fuel" in tons of dry matter per hectare. Data on the mass and wood density are presented in Table of the Guidelines - T3A.1.13.
- Coefficients of burnt biomass are presented in Table T3A.1.12 for temperate forests.
- Emission factors for all gases are presented in Table T3A.1.16 GPG-LULUCF 2003 for fires with different types of flora.

Table 5.6 – Area, covered by fires, thous. ha

Years	*Area*
1990	1.33

1991	4.99
1992	1.19
1993	0.73
1994	5.10
1995	22.5
1996	12.8
1997	216.9
1998	16.3
1999	26.5
2000	27.9
2001	30.8
2002	31.4
2003	91.9
2004	59.5

Source: Statistical Yearbook of the RK Statistics Agency [5]

As shown in the Table the largest quantity of fires was registered in 1997, the total area fired covered 216,9 thous. ha, as this year was extremely hot and dry within the last 20 years. Moreover, fires continued to increase from 2000 till 2003 as the air temperature was higher than normal.

5.1.6. Inventory outcomes of GHG emissions/sinks in the forestry sector

GHG emissions/sinks in the forestry sector were estimated from the following data activity:

1) Forests remaining as forests (FF)
2) Lands converted to forest lands (LF)
3) Forest fires including methane and nitrous oxide emissions.

Table 5.7 presents results of investigations where «+» means sinks, and «-» means emissions. This sector including estimations of GHG emissions/sinks from forest lands remaining forests has considered only 2 sources of carbon – felling and living biomass. The sector "Lands converted to forest lands" estimated carbon emissions/sinks only in living biomass. Also CO_2, CH_4 and N_2O emissions generated from forest fires were estimated.

Table 5.7 – GHG emissions/sinks from the RK forestry sector, mln. tons CO_2

Year	FF		LF	FIRES	NET STOCK
	LB	DW			
1990	4,73	-0.097	0.930	-0.006	5,56
1992	4,73	-0.097	0.988	-0.006	5,62
1994	1,78	0.825	0.834	-0.026	3,42
1999	4,25	0.695	0.251	-0.136	5,06
2000	4,25	0.695	0.183	-0.144	4,98
2001	4,25	0.695	0.119	-0.158	4,91
2002	4,25	0.695	0.084	-0.161	4,87
2003	4,25	0.695	0.090	-0.473	4,56

2004	4,25	0.695	0.088	-0.730	4,30

According to the 2004 inventory outcomes the amount of carbon absorbed by forests of Kazakhstan was 5,02 mln.tCO_2 (pic. 5.4). Release of carbon resulted to increase of carbon dioxide content in the air to 0,73 mln. tons. So, at changes in forest and other wood biomass stocks the net absorption or net stock equals 4.3 mln. Tons of carbon dioxide.

5.1.7. *Uncertainty assessment*

Accordingly summing up all available uncertainty assessments by each section of this sector, the total percentage of uncertainty is 90%.

5.1.8. *Planning improvements*

The Kazakhstan inventory of forests estimates distribution of basic forest forming species by areas and the species data are divided into groups – coniferous, hard leaf, soft leaf, saxauls, other trees, shrubs. Such division requires summation of different factors – biomass expansion coefficient, correlation "root – above ground biomass", wood density that lead to supplementary uncertainties. So, in the next inventories this could be improved through emissions/sinks estimation for each group of trees.

In the section "Lands converted to forest lands" it should have been better to separate coniferous from other groups of trees as the period of including them into the section "forest lands remaining forests" differs from other types.

5.2. *Land Use, Land Use Change (LULUC)*

5.2.1. *Main emissions/sinks sources and input data*

Kazakhstan has the unified database system on lad use which includes all existing categories of land use that correspond to the new Guidelines. But it should be marked that the data on land use are insufficiently detailed that is why the Tier 1 method was used for estimations.

The main categories of lands included into this section according to the new Guidelines GPG-LULUCF 2003 are as follows:

1. *Forest lands.*
2. *Cropland.*
3. *Grassland.*
4. *Wetland.*
5. *Settlements .*
6. *Other land.*

Table 5.8 – Difference of land areas due to the different practice of land use, thous. ha

Categories and	*1990-*	*1995-*	*2000-*	*2001-*	*2002-*	*2003-*	*2004-*	*2004-*

sub-categories	*1980*	*1990*	*1995*	*2000*	*2001*	*2002*	*2003*	*1990*
Perennial plants	27.8	-20.6	-8.2	-9.9	-2.9	-1.2	-2.1	-44.9
Tillage	91.6	-3633.9	-12333.7	1073.9	934.6	-87.8	622.0	-13424.9
Hayfields	-875.0	-257.2	-2051.6	-71.9	-94.0	-80.3	-26.2	-2581.2
Neglected tillage	-62.5	2850.5	7573.2	-1875.9	-1952.0	81.5	-488.9	6188.4
Unaccounted hayfields	-15.1	136.9	2016.6	93.2	104.5	79.6	23.6	2454.4
Non-degraded grassland	3026.8	-8843.2	-67762.1	-1965.2	-3987.2	-1505.1	-160.5	-84223.3
Regenerated/improved grasslands	218.2	42.0	-2851.4	-57.2	135.3	66.2	105.9	-2559.2
Unmanaged non-degraded grasslands	-3894.9	9354.8	73362.2	2742.8	5101.7	1506.7	1.9	92070.1
Unmanaged regenerated grasslands	1.5	27.9	1685.0	97.9	-134.6	-52.4	-77.4	1546.4
Forest areas	4068.8	-57.9	93.6	-3.6	5.7	6.6	-15.8	28.6
Wetlands	-411.1	224.4	-288.8	1.4	-4.7	-2.7	0.2	-70.2
Settlements with woody plants	0.0	0.0	0.0	0.2	2.0	-0.1	0.0	2.1
Other settlements	109.1	43.8	-48.1	-6.6	-2.2	-3.2	4.2	-12.1
Other lands	-2286.3	133.6	613.3	-19.1	-106.2	-7.8	13.1	626.9
Balance	-1.1	1.1	0.0	0.0	0.0	0.0	0.0	1.1

Source: RK Agency on Land Resources Management

5.2.2. Methodology and Inventory Outcomes

5.2.2.1. Croplands

GPG-LULUCF 2003 Guidelines identifies the inventory and reporting by GHG emissions/sinks in the land categories: "Remaining croplands" (RC) and "Lands converted to croplands" (LC). However, Kazakhstan within the last 20 years lacks the practice of converting lands to croplands.

Remaining croplands (RC)

The Statistics Agency provides data on areas of perennial wood plants divided into three groups: areas occupied by orchards; vineyards; other wood crops. Due to the lack of data on the velocity of carbon accumulation as well carbon losses by data of three groups a default coefficient set in the *GPG-LULUCF 2003* Guidelines has been used in order to estimate carbon stock change in living biomass suing Tier 1 method.

Losses are estimated by multiplying a value of carbon stock per cropland area where perennial wood plants were collected or lost. Kazakhstan doesn't have statistical data on the yield of perennial wood plants. According to *GPG-LULUCF 2003* Guidelines the following values were used for estimation: carbon stock above ground biomass coefficient during harvest equals 63 t carbon per year, carbon accumulation velocity – 2,1 t carbon per hectare a year, yield period – 30 years, and carbon losses in biomass were 63 t carbon per hectare. Annual velocity of growth was estimated by dividing old biomass stock to the period of harvest ripening (Table 5.9).

Table 5.9 – Data for estimating carbon stock change in LB of those areas where grow perennial plants.

Year under inventory	Area of perennial plants, thous. ha	Change of areas of perennial plants, thous. ha / year	Losses of carbon in biomass, t C/ha	Losses of carbon in biomass, t C/ha	Velocity of biomass accumulation, t C/g	Carbon accumulation, thous. t C/ year	Net change in carbon sink, thous. t C/year
1	2	3	4	5=3*4	6	7=2*6	8=7-5
1980	137.0	-	-	-	-	-	-
1990	164.8	2.8	-	-	2.1	346.1	346.1
1995	144.2	-4.1	63	-259.6	2.1	302.8	43.3
2000	136.0	-1.6	63	-103.3	2.1	285.6	182.3
2001	126.1	-9.9	63	-623.7	2.1	264.8	-358.9
2002	123.2	-2.9	63	-182.7	2.1	258.7	76.0
2003	122.0	-1.2	63	-75.6	2.1	256.2	180.6
2004	119.9	-2.1	63	-132.3	2.1	251.8	119.5

To identify an annual change of perennial plant areas within 1989 – 1990, 1990 – 1995 and 1995 – 2000, a linear interpolation has been done. 1990 lacks the data on harvests. Decrease of carbon stock in perennial crops from 1990 to 2004 could be explained by the areas reduced for perennial cereals. In 2001 the annual carbon stock was increased due to the growth of biomass was less than the value of biomass losses. In order to convert tons C into Giga-grams CO_2, the net changes on carbon stock set in thous.tons C per year have been multiplied to the value 44/12 (Table 5.10).

Table 5.10 – CO_2 annual emissions (-) / sinks (+) from areas of perennial wood plants, Gg CO_2/year

Years	1990	1995	2000	2001	2002	2003	2004
CO_2 emissions/sinks	1269.0	158.6	668.4	-1315.9	278.7	662.2	438.1

Carbon stock change in soils. In Kazakhstan cultivation of mineralized soils could be considered due to the carbon stock change in soils of the land category “remaining croplands”. Organic soils had not been cultivated more than 20 years as there was not a practice of liming. This section estimates carbon stock in mineralized soils for croplands and hayfields.

Changes in DOS and non-organic carbon of soils where grow perennial wood crops have been taken as 0 for Tiers 1 and 2 methods. Tier 1 was used for estimating carbon stock in mineralized soils.

Table 5.11 represents the data on areas of croplands, hayfields and temporally unregistered tillages. As the most lands suitable for agriculture were ploughed even before 70s, it is supposed that all areas were managed within more than 20 years.

Table 5.11 – Areas of croplands, grasslands and temporally unaccounted tillage lands

Years	Area of cropland, thous. ha	Area of grassland, thous. ha	Areas of temporally neglected tillage lands, thous. ha	
			Croplands	Grasslands
1990	35595.3	5115.0	196.7	58.2
1995	31961.4	4857.8	3047.2	195.1
2000	19627.7	2806.2	10620.4	2211.7
2001	20701.6	2734.3	8744.5	2304.9
2002	21636.2	2640.3	6792.5	2409.4
2003	21548.4	2560.0	6874.0	2489.0
2004	22170.4	2533.8	6385.1	2512.6

Carbon stock change happened due to conversion of croplands into grasslands have been assessed in the section “Lands converted to grasslands” (GL).

For mineralized soils an estimation method is based on carbon stock change in soils in the limited period following the changes in their management which influences to the carbon in soil. The previous carbon stock and carbon stock in soils for the inventory year by areas of croplands are estimated by the values of carbon stock and coefficients of stock changes set in *GPG-LULUCF 2003* Guidelines.

Table 5.12 demonstrates values of carbon stock change for different sub-categories of croplands both for the beginning period of inventory and the inventory within a year.

Table 5.12 – Coefficients of stock change applied to different sub-categories of croplands of Kazakhstan.

Croplands	*Coefficient of sink change*	*Start of inventory*	*Year under inventory*
	F_{LU}	0.82	0.82
Tillage	F_{MG}	1.10	1.10
	F_I	1.00	1.00
	F_{LU}	0.82	0.82
Grassland	F_{MG}	1.10	1.10
	F_I	1.00	1.00
	F_{LU}	0.82	0.93
Temporally unaccounted croplands	F_{MG}	1.10	1.00

	F_I	1.00	1.00
	F_{LU}	0.82	0.93
Temporally unaccounted grasslands	F_{MG}	1.10	1.00
	F_I	1.00	1.00

Source: 2003 GPG LULUCF Guidelines

Based on the data from Table 5.13 for temporally neglected croplands an annual change of carbon stock is estimated in 0,48 t carbon per hectare a year, and for temporally neglected hayfields an annual change of carbon stock is estimated in 0,32 t carbon per hectare a year.

For converting t carbon into Giga-grams CO_2, the net change of carbon stock in soils (thous.tons C per year) was multiplied to a conversion factor 44/12 (Table 5.13). Thus, areas of temporally neglected croplands and hayfields are carbon sinks.

Table 5.13 – Annual emissions (-)/sinks (+) CO_2 from mineralized soils of croplands Gg CO_2 per year

Croplands	1990	1995	2000	2001	2002	2003	2004
Arable and tillage lands	0	0	0	0	0	0	0
Hayfields	0	0	0	0	0	0	0
Temporally unaccounted croplands	50.5	782.1	2725.9	2244.4	1743.4	1764.3	1638.8
Temporally unaccounted hayfields	14.9	50.1	567.7	591.6	618.4	638.8	644.9

5.2.2.2. Grassland

Remaining grasslands (RG). According to *GPG-LULUCF 2003* Guidelines carbon stock change is estimated by two sources: living biomass and soils. To date the information in incomplete and insufficient for calculating a default coefficient for estimating carbon stock change in dead organic substances. Based on the annual report data of the RK Agency on Land Resources the country has about 10 % shrubs which grow alternately with perennial grass. Above ground living biomass of woods constituting grassland vegetation is insignificant due to climatic conditions. Moreover, Tier 1 method does not estimate carbon stock change in living biomass, therefore these changes have not been estimated in this document.

1) **Carbon stock change in soils.**

Table 5.15 presents factors of stock change for different sub-categories of grasslands that could be used for future works. This report separates only one sub-category from the total areas of grassland which is about 3% grasslands, improved by crops species and irrigation. Another part of grasslands is identified as non-degraded type o grassland (see Table 5.8 otherwise there are grasslands that are medium or strongly degraded, for example, areas of degraded grasslands in 2003 were about 15% from the total areas of grasslands.

Table 5.14 – Stock change factors for different sub-categories of grasslands in RK

Sub-categories of grasslands	Factor of carbon sink change	Year under inventory	Definition
Non-degraded grasslands	F_{LU}	1.0	All permanent grasslands - factor 1.
	F_{MG}	1.0	Non-degraded grasslands with sustainable management without changes.
	F_I	-	-
Medium degraded grasslands	F_{LU}	1.0	All permanent grasslands - factor 1.
	F_{MG}	0.95	Medium degraded grasslands with some reduction of productivity and without management.
	F_I	-	-
Strongly degraded grasslands	F_{LU}	1.0	All permanent grasslands - factor 1.
	F_{MG}	0.7	Loss of productivity, vegetation during long period due to soil erosion
	F_I	-	-
Improved grasslands	F_{LU}	1.0	All permanent grasslands - factor 1.
	F_{MG}	1.14	Grasslands with medium load having sustainable management, getting one of improvements – improvement of species or irrigation.
	F_I	1.11	Applicable to improved grasslands having introduced one or several additional improvements.

Source: GPG-LULUCF 2003

For RG land category the factor of land use always equals 1. Table 5.8 provides the data on grassland areas. In order to identify an annual change in areas with changes in management a liner interpolation has been done between the following years from 1989 to 1990, 1990 – 1995, 1995 – 2000.

As grasslands had not been changed within an inventory period by the following sub-categories: non-degraded grasslands remaining non-degraded grasslands, and improved grasslands remaining improved grasslands, then there were no changes of carbon stock in soils (Table 5.15). The same results were found for unmanaged non-degraded grasslands converted to unmanaged grasslands in 1990 and in 1995-2004 as all factors of carbon stock change equal 1.

Table 5.15 – CO_2 annual emissions (-)/sinks (+), in Giga – grams CO_2 per year

Sub-categories of grasslands	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**

Non-degraded grasslands remaining non-degraded grasslands	0	0	0	0	0	0	0
Improved grasslands remaining improved grasslands	0	0	0	0	0	0	0
Non-degraded grasslands converted to unmanaged non-degraded grasslands	0	0	0	0	0	0	0
Unmanaged non-degraded grasslands converted to non-degraded grasslands.	0	0	0	0	0	0	0
Improved grasslands converted to unmanaged non-degraded grasslands	0	0	-383.5	0	0	0	0
Improved grasslands converted to unmanaged improved grasslands	0	0	-803.2	-136.3	0	0	0
Unmanaged grasslands converted to improved grasslands	0	0	0	0	320.8	124.9	184.5

Lands converted to grassland (GL). This section estimates changes in living biomass and soils related to conversion of land use into new grasslands. Mainly croplands in RK were converted to grasslands starting since 1990 till 2004. in this case carbon stock change was estimated in mineralized soils as the above ground living biomass is supposed to be equal to 0.

Carbon stock change in soils. According to the Guidelines, SOC_{REF} – the base carbon stock in organic soils equals 50 ton C per hectare. Factors of stock change are given in Tables 5.12 and 5.14, which are used for estimating SOC_0 и $SOC_{(0-T)}$, values of which vary according to a type of land management before and after conversion as well as by type of land use.

Table 5.16 provides the data on lands converted to different sub-categories of grasslands with corresponding use of coefficients and also annual carbon stock change.

Table 5.16 – Areas of lands converted to grasslands (thous.ha), coefficients and annual carbon stock change (t C per hectare a year)

Sub-categories of land use	*1990-1980*	*1995-1990*	*2000-1995*	*2001-2000*	*2002-2001*	*200320 02*	*2004-2003*	F_{LU}	F_{MG}	F_I	*Annual change of carbon stock*
Croplands		-3633.9	-12333.7			-87.8		0.82	1.1	1	
Unmanaged non-degraded grasslands		783.4	4760.5			6.3		1	1	1	0.25
Hayfields	-875.0	-257.2	-2051.6	-71.9	-94	-80.3	-26.2	0.82	1.1	1	
Unmanaged grasslands	656.8							1	1	1	0.25
Improved grasslands	218.2	42.0						1	1.14	1.11	0.90
Unmanaged non-degraded grasslands		50.4	35.0				1.9	1	1	1	0.25
Unmanaged improved grasslands		27.9						1	1	1	0.25

Sub-categories of land use	*1990-1980*	*1995-1990*	*2000-1995*	*2001-2000*	*2002-2001*	*200320 02*	*2004-2003*	F_{LU}	F_{MG}	F_I	*Annual change of carbon stock*
Unaccounted croplands				-1875.9	-1952		-488.9	0.93	1	1	
Unmanaged non-degraded grasslands				777.6	1017.4			1	1	1	0.20

Table 5.17 – Annual emissions (-)/sinks (+) from the land category LU, Giga-gram CO_2 per year.

Categories of land use	1990	1995	2000	2001	2002	2003	2004
Croplands converted to unmanaged non-degraded grasslands		143.6	872.8			5.8	
Hayfields converted to non-degraded grasslands	590.0						
Hayfields converted to improved grasslands	3.3	27.7					
Hayfields converted to unmanaged non-degraded grasslands		9.2	6.4				0.3
Hayfields converted to unmanaged improved grasslands		5.1					
Neglected croplands converted to unmanaged non-degraded grasslands				570.2	746.1		

5.2.2.3. Wetlands

In RK there is no statistical data on areas occupied by wetlands and even more by their division to managed and unmanaged. The Guidelines requires to estimate carbon stock change in wetlands remaining wetlands and in lands converted to wetlands and as such practice was not used in the republic within the 1990 – 2004 period then accordingly the estimations suggested in the Guidelines are inapplicable.

5.2.2.4. Settlements (S)

This section estimates carbon stock change in living biomass of wood and shrub plants growing in settlements. Also according to the Guidelines they are divided to two categories: settlements remaining settlements and lands converted to settlements (SL).

Remaining settlements (RS). Tier 1 method was used to estimate GHG emissions/sinks in living biomass of wood and shrub plants growing in remaining settlements. The required data are the total area of crown in hectares (Table 5.18) and a coefficient of increased crown which equals 2.9 t C per year.

Table 5.18 – Total area of wood and shrub plants in settlements, thous.ha

1990	1995	2000	2001	2002	2003	2004
20.4	20.4	20.4	20.6	22.6	22.5	22.5

Source: Statistics Agency

It is supposed that carbon stock change happening due to the loss of living biomass in RS equals 0. the method is based on the assumption that wood and shrub plants in settlements and remaining settlements (RS) are carbon sinks when they actively grow during 20 years. The annual carbon stock from the land category "Remaining settlements" is presented in Table 5.19.

Table 5.19 – Annual stock of CO_2 from RS, Gg CO_2 per year

1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
216.9	216.9	216.9	219.0	240.3	239.3	239.3

Lands converted to settlements (SL). This section estimates carbon stock change in LB before conversion to S which will be lost due to their conversion to S that is why equals 0 and therefore no changes happen in carbon stock.

5.2.2.5. Other lands

Here changes are estimated from rocks, glaciers etc. That were not included into the category of five first lands and as the methodology has not been developed then correspondingly no estimations.

5.2.3. Annual estimation of CO_2 emissions and sinks in the land use and land use change sector (LULUC)

Table 5.20 represents outcomes of CO_2 emissions/sinks in the LULUC sector divided into types of land categories. Mainly soils are the sources for CO_2 stock because the big areas of grasslands, croplands, hayfields were temporally neglected in use or were converted to unmanaged lands. Starting from 2001 a tendency of big areas returning back into operation process has been observed. However, not all unmanaged lands have been converted to managed lands as some part of croplands and grasslands are still remaining non-productive.

Table 5.20 – Annual estimation of CO_2 emissions/sinks in LULUC sector (Gg CO_2)

Land use category / Type of conversion	1990	1995	2000	2001	2002	2003	2004
Croplands with perennial wood plants	1269,0	158,6	668,4	-1315,9	278,7	662,2	438,1
Temporally neglected	50,5	782,1	2725,9	2244,4	1743,4	1764,3	1638,8

croplands							
Temporally neglected hayfields	14,9	50,1	567,7	591,6	618,4	638,8	644,9
Improved grasslands converted to unmanaged non-degraded grasslands			-383,5				
Improved grasslands converted to unmanaged improved grasslands			-803,2	-136,3			
Unmanaged improved grasslands converted to improved grasslands					320,8	124,9	184,5
Croplands converted to unmanaged non-degraded grasslands		143,6	872,8			5,8	
Hayfields converted to non-degraded grasslands	590,0						
Hayfields converted to improved grasslands	3,3	27,7					
Hayfields converted to non-degraded unmanaged grasslands		9,2	6,4				0,3
Hayfields converted to improved unmanaged grasslands		5,1					
Neglected croplands converted to unmanaged non–degraded grasslands				570,2	746,1		
RS	216,9	216,9	216,9	219,0	240,3	239,3	239,3
TOTAL	2144,6	1393,3	3871,4	2173,0	3947,7	3435,3	3145,9

6. WASTES

The main GHG emission sources in the module "Wastes" are solid municipal wastes (SMW) dumps and waste water cleaning facilities.

6.1. General Methodology

The lack of detailed and adjusted information about SMW dumps management and waste water cleaning facilities in the country regions determined use of predetermined coefficients recommended by IPCC Guidelines for Tier 1, national activity indicators (total generation of municipal solid wastes; the share of anaerobic and aerobic treatment of waste water), national statistics on cities' population and industrial production, as well as albumen consumption by the population from FAO tables.

Table 6.1 – GHG emissions from "Waste" category in Kazakhstan, thous. t CO_2-equivalent.

	1990	**1992**	**1994**	**2003**	**2004**
CH_4	2747	2653	2464	4456	4486
N_2O	453	446	485	382	385
Total	***3200***	***3100***	***2949***	***4838***	***4870***

Note: the sums may differ due to rounding of figures

Table 6.2. – GHG emissions from «Waste» module, thus. t. of CO_2-equivalent.

Emission sources	**1990**	**1992**	**1994**	**1999**	**2003**	**2004**
Solid municipal wastes	1960	1999	1962	2632	3712	3739
Waste water systems	787	654	502	356	744	747
including,						
municipal	*219*	*223*	*210*	*192*	*194*	*195*
industrial	*568*	*431*	*292*	*163*	*551*	*552*
Human sewage	453	446	485	308	382	385
Total	**3200**	**3100**	**2949**	**3296**	**4838**	**4870**

Note: the sums may differ due to rounding of figures

6.2. Uncertainty assessment

The Guidelines defines high uncertainty level in assessing GHG emissions from "Waste" module because it is made in a country with low quality data [9]. The uncertainty relates to use of aggregated emission coefficients of Tier 1 and national activity data.

Uncertainty in methane emissions from MSW is ±100 %. This is the sum of uncertainties from IPCC proposed factors (± 60 %), national data of year-average SMW generation (± 35 %) and national statistics on city population (± 5 %).

Uncertainty in assessing methane emissions from municipal waste water cleaning is ± 70 %. IPCC emission calculation data have ± 30 % of uncertainty, for maximal methane generation ± 5 %. The national city population statistics has ± 5 % of uncertainty. National index of anaerobic and aerobic treatment fractions has ± 30 % of uncertainty.

The uncertainty level of emissions from industrial waste waters and precipitations is ± 95 %. The coefficient of maximal methane generation has ± 25 % of uncertainty, the uncertainty of emissions from industrial products processing is ± 30 %. The uncertainty level of anaerobic and aerobic treatment fractions has ± 30 %. The statistics of industrial production has uncertainty level of ± 10 %.

The uncertainty of nitrous oxide emissions from vital functions is ± 40 %. It is made from uncertainty of IPCC emission factors (± 30 %), national statistics on population (± 5 %) and FAO data uncertainty (± 5 %).

7. EMISSIONS OF FLUOROCARBONS AND SULFUR HEXAFLUORIDE

Emissions of these gases were not included into national emission assessment in 2000, due to lack of information of sources and emission volumes. We have only preliminary assessment of possible emissions of HFSs, PFCs and SF_6. in accordance with the Kyoto Protocol provisions, Annex I countries have to include in GHG calculation for the first budgeting period (2008-2012) emissions of hudrofluorocarbons, perfluorocarbons and sulfur hexafluoride. The Article 3.8 of the Protocol recommends using 1995 as base year for these gases. Emissions of these gases, that have very high global worming potential, shall be summed up to the total emissions of three main GHG gases (CO_2, CH_4 and N_2O) in CO_2-equivalent. But even in such industrialized countries as USA, the share of these gases in national GHG emissions is less than 2 %, in Netherlands – 4-5 % [3].

According to IPCC Guidelines, the main sources of these emissions are the following activities:

1. phase out of ozone depleting substances;
2. HCFC-22 production;
3. electric energy transmitting and distribution;
4. primary aluminum production;
5. semiconductor production;
6. magnesia production and processing.

Only first and third activities out of the list take place in Kazakhstan. Kazakhstan does not produce but only imports HFCs and PFCs which used as alternatives to ozone depleting substances in refrigeration equipment, conditioners, fire extinguishers, substances used as solvents and foaming agents. Therefore the main information source on their consumption is customs statistics that was established in Kazakhstan only in 1995. But officially import registration of these gases is not performed. This even more complicates evaluating process of their emissions.

But we can use some data collected in frames of the Montreal Protocol implementation in 1998. According to the data, in 1998 Kazakhstan imported about 240kg. of HFC-134a that is primarily used for charging mobile air conditioners. Therefore this quantity may be treated as HFCs emissions.

According to expert studies, about 10 % of all refrigerators imported into the country use this refrigerant. These refrigerators are quite new at the Kazakhstani market; therefore there is not enough data for using detailed methodic of Tier 2.

Taking into account all the above stated, we can use only simplified methodic (Tier 1) that provides assessment of potential emissions. In accordance with the formula the annual consumption is calculated as production minus export plus import minus utilization (destruction). Out from these components we can take only import that makes 240 kg of *HFC*-134a emissions in 1998. The live time of this fluorocarbon in atmosphere is over 10 years and its global worming potential is 1300, therefore HFC-134a emissions amounted to 312 tons of CO_2 equivalent.

It is obvious that during ODS phase out process in frames of the Montreal Protocol consumption of HFCs and PFCs will grow. It is necessary to perform special researches and conduct customs registering for these substances in order to evaluate their emissions. Meanwhile it is impossible to evaluate emissions from this source.

PFCs and sulfur hexafluoride emissions connected with production of aluminum and magnesium, which are absent now in Kazakhstan. Global worming potential of sulfur hexafluoride is also very high and amount 23900. this gas is generated during aluminum electrolyze process. Amount of PFCs and SF_6 emissions is not metered by special equipment but calculated taking into account technological parameters of production process. The Pavlodar Aluminum Plant produces alumina. Production of primary aluminum is planned for the nearest future. Therefore a new source of PFCs and SF_6 emissions may appear.

Isolation properties of SF_6 2,5 times higher than those of oxygen. The only SF_6 emission source in Kazakhstan may be commutation and distribution equipment in energy transportation systems. There is no data on SF_6 content in these equipment in statistical reporting, therefore the assessment may be performed only after additional researches. In 2001-2002 Kazakhstani energy company (KEGOK) procured and installed automatic interrupter. According to manufacturers data (EURELECTRICAL and CAPEL) each interrupter contain from 1 to 100 kg of sulfur hexafluoride. The service life of this equipment is 40 years. At present, gas leaks are almost impossible. Therefore SF_6 emissions in Kazakhstan estimated as zero.

8. ANALYSES OF KEY SOURCES IN 2004.

In this inventory, to define the key sources, we used IPCC methodology of Tier 1.

Table 8.1 – Analysis of key sources of GHG emissions by 2004 level.

IPCC source categories	GHG with direct greenhouse effect	Emissions in CO2-equ., Gg		% contribution to trend	Accumulated contribution
		Base year	Current year		
Fuel combustion : energy industry	CO_2	106,110	95,967	31.84	31.8
Fuel combustion : other sectors	CO_2	47,255	11,784	17.50	49.3
Fuel combustion : manufacturing industry	CO_2	71,954	30,164	14.14	63.5
Fugitive emissions: oil and gas	CO2	4,853	5,171	2.26	65.7
Fuel combustion: transport	CO_2	24,486	8,406	6.72	72.5
Use of limestone and dolomite	CO_2	0	3,455	3.54	76.0
Direct emissions from agricultural soils	N_2O	23,216	10,230	4.05	80.1
Production of iron and steel	CO_2	9,701	10,507	4.69	84.7
Solid waste	CH_4	1,999	4,494	3.35	88.1
Fugitive emissions: oil and gas	CH_4	7 413	3,696	0,85	7.5
Fugitive emissions: coal	CO2	23 289	10,901	3,41	96,6
Enteric fermentation	CH_4	13,730	6,510	1.93	93.2

The table 8.2 represents summary of GHG emission sources in Kazakhstan

Table 8.2 – Summary of GHG source categories analysis in 2004.

IPCC categories of sources	Direct greenhouse gases	Indicator of key category of sources (KCS)	Criteria of KCS identification
ENERGY ACTIVITY			
Fuel combustion			
Energy Industry	CO_2	Yes	Level, Trend
	CH_4	No	
	N_2O	No	
Manufacturing Industry	CO_2	Yes	Level, Trend
	CH_4	No	
	N_2O	No	
Transport	CO_2	No	Level, Trend
	CH_4	No	

	N_2O	No	
Other sources	CO_2	Yes	Level, Trend
	CH_4	No	
	N_2O	No	
Others	CO_2	Yes	Trend
	CH_4	No	
	N_2O	No	
Fugitive emissions			
Emissions at producing and processing coal	CH_4	Yes	Level
Emissions at refining oil and gas	CO_2	Yes	Level, Trend
	CH_4	Yes	Level
INDUSTRIAL PROCESSES			
Production of mineral matters			
Production of cement	CO_2	No	
Production of lime	CO_2	No	
Use of limestone and dolomite	CO_2	Yes	Level, Trend
Production and use of soda	CO_2	No	
Chemical industry			
Production of ammonia	CO_2	No	
Production of carbide	CO_2	No	
Emissions from other chemicals	CH_4	No	
Production of metals			
Production of iron and steel	CO_2	Yes	Level, Trend
Production of ferroalloys	CO_2	Yes	Trend
AGRICULTURE			
Enteric fermentation	CH_4	Yes	Level, Trend
Manure management	CH_4	No	
	N_2O	No	
Rice cultivation	CH_4	No	
Direct emissions from agricultural soils	N_2O	Yes	Level, Trend
Field burning of agricultural residues	CH_4	No	
	N_2O	No	
WASTE			
Solid waste disposal	CH_4	Yes	Level, Trend
	N_2O	No	
Wastewater handling	CH_4	No	
	N_2O	No	
Waste incineration	CH_4	No	
	N_2O	No	