II. GHG INVENTORY IN THE NOVGOROD REGION

1. SUMMARY DATA

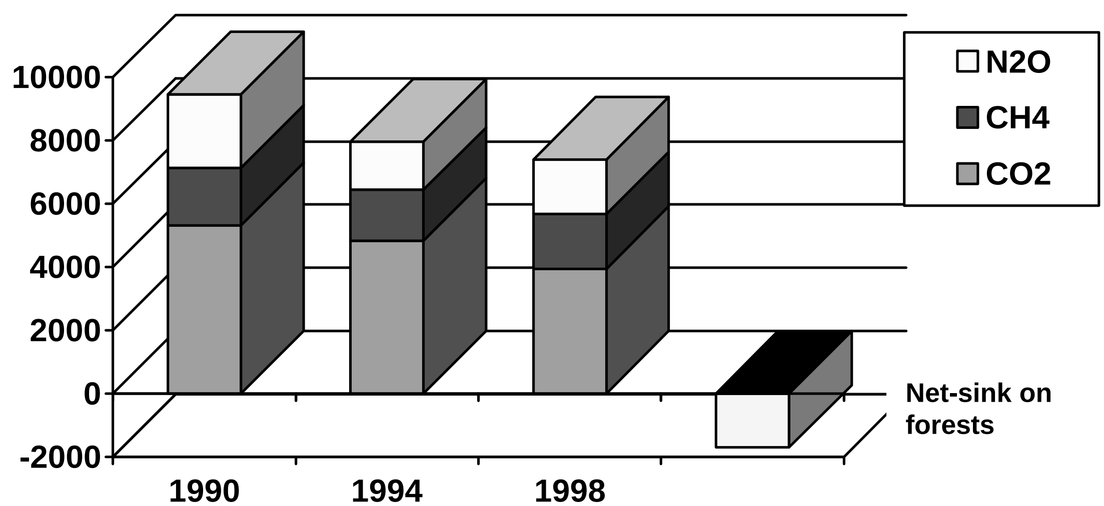
Total emission in the base year 1990 was estimated as 9464 Gg CO_2-eq. In the subsequent years it firstly was decreased rather fast to 8012 Gg CO_2-eq. in 1994 and then slowly decreased to 7397 Gg CO_2-eq.in 1998. In the result, total emission reduction in 1990-1998 is 22% (average value for Russia as a whole is significantly larger, about 30%). The GHG inventory was carried out for all of 9 years from 1990 to 1998. There were no sharp alterations or discrepancies from monotone reduction. In 1996 – 1998 reduction had minimum rate as 1 – 1.5% per year.

Currently the GHG emission in the Novgorod oblast is about 7.5 Gg CO_2-eq.(1998) or a little bit more than 0.3% of the total Russian emission, while the population is about 0.55%. It means that emission per capita is significantly less than Russian average value. Novgorod's emission per capita is about 9.5 t CO_2-eq.per year (1998), while Russian average is about 16 t CO_2-eq. This Novgorod's value is less than in many developed countries of the Northern zone, in particular it 10-20% less than in United Kingdom or Finland. On the other hand GDP per capita is significantly more in these countries. However, in any way, the oblast can be characterized by quite developed gas system and in general careful approach to heat.

Figure 2.1.1

Summary data on GHG emission in Novgorod oblast

Gg (th t) CO_2 - equivalent



The main emission reduction took place in 1990 – 1994, mainly due to CO_2, which contributes about 55% of all GHG emission (methane and N_2O 20-25% each). CO_2 emission is caused by fossil fuel combustion in energy purposes by 98% (1998). The second important factor was N_2O emission reduction due to decrease in agriculture production.

Methane emission is almost constant. However there was very significant redistribution of emissions among source categories. In 1990 waste contributed 45%, agriculture 35% and energy about 20% of all methane emission. In 1998 there are more modern system of waste utilization, which significantly improve ecological situation (first of all, in the capital of the region), however methane emission from waste became larger. Simultaneously number of cattle drop down sharply. Maintenance for gas pumps became better. In the result in 1998 contribution of waste became more – 75%, while energy – 10% and agriculture only 15% of all methane emission.

Table 2.1.1

Summary data on emission of the different GHG in Novgorod oblast

1990

Gg	GWP	CO_2-eq.	
5318	1	5318	CO_2
86.7	21	1821	CH_4
7.5	310	2325	N_2O
		9464	Sum
		-1318	Forests

1994

4831	1	4831	CO_2
76.6	21	1609	CH_4
5.1	310	1572	N_2O
		8012	Sum
		-3493	Forests

1998

3942	1	3942	CO_2
82.3	21	1729	CH_4
5.6	310	1727	N_2O
		7397	Sum
		-1710	Forests

Emissions of the «new gases» in Novgorod oblast: 1990 – 1996 only HFC-134a, emission was incerased from 21 kg/year in 1990 to 81 and 137 kg/year in 1994 and 1998 respectively. In 1997 and 1998 there also were emissions of HFC-125 (22 kg/year each year) and HFC-143a (18 kg/year each year). Total emission in CO_2-equivalent is about 0.2 Gg (1998).

Relatively large level of N_2O emission is caused by nitric acid production at the AKRON chemical plant. This plant currently emits up to 93% of all N_2O emission, in 1990 it's contribution was 80%. At present time agriculture production (including nitric fertilization) is decreased sharply and it's contribution into total N_2O emission became 4 times less (from 20 to 5%). In general N_2O emission in 1998 is slightly more than in 1995, but a quarter less than in the base year 1990.

Emissions of so-called “new gases” are estimated as about 150 kg (mainly HFC-134a in refrigerators, see Table above) or about 0.2 Gg of CO_2 equivalent. However there is clear tendency of their fast growth.

Table 2.2.2

Emissions of CO_2, CH_4 and N_2O in different sectors of economy

CO_2	Energy	Industry	Agriculture	Waste
1990	96.3%	3.7%		
1994	97.4%	2.6%		
1998	97.8%	2.2%		

CH_4	Energy	Industry	Agriculture	Waste
1990	20%		35%	45%
1994	15%		25%	60%
1998	10%		15%	75%

N_2O	Energy	Industry	Agriculture	Waste
1990	<1%	80%	20%	<1%
1994	<1%	90%	10%	<1%
1998	1%	93%	5%	1%

The CO_2 sinks and emissions in forests were also estimated in the inventory. It was obtained that CO_2 accumulation by young and fast pre-mature growing forests is more than logging and decomposition. It means that forests are CO_2 net-sink from the atmosphere. Volume of the CO_2 sink was estimated only rather approximately. It is caused as by specific features of the object – forests as by data accuracy and imperfections of the methodology (see results of the special Case Study below). It was estimated that sink is as large as from 1300 to 3500 Gg CO_2 per year or from 20 to 35% of all GHG emission of all other sectors of the regional economy.

The detail inventory data are presented below, IPCC module by module. The calculation worksheets of the IPCC software in Excel format are completely included in the Annex 2 to the given report (as electronic files only, it is caused by very large volume of the tables).

2. ENERGY – FUEL COMBUSTION

Short description of the regional energy sector

The energy sector is one of the largest sectors of Novgorod region economy. The electricity production in the region was rather stable during 1990-1998. As a result of the overall decline of industrial production by 48%, the share of electric power production increased up to about 17% of gross regional product. It should be mentioned that at the same time the fuel consumption in the region dropped down by 30%.

As many of the other regions of the European part of Russia, Novgorod region is not rich with the exhaustible fuel resources. There are no oil, gas or coal deposits in the region. The only regionally produced fuel resources are peat and firewood. Thus, the major part of primary fuel consumed in the region is imported from the other Russian regions. The secondary fuel (refinery products, etc.) is also imported in the region as there are no refineries located in Novgorod Oblast.

According to the Revised IPCC Guidelines, we used two approaches to greenhouse gas inventory: 1) Reference Approach, and 2) By major source categories.

Reference Approach

The greenhouse gas emissions inventory by Reference Approach was based on the aggregate fuel consumption data in Novgorod region (by type of fuel). In result, the estimates of CO_2, CH_4 and N_2O were obtained.

As it is shown on Figure 2.2.1, CO_2 emissions from the regional energy sector were declining since 1990. During the whole period of 1990-98 CO_2 emissions dropped down from 5120 to 3857 Gg CO2 or about 25%, which could be explained, first of all, by the significant reduction of fuel consumption in most of the industrial sectors of regional economy. The structure of fuel consumption has also substantially changed. As it can bee seen on Table 2.2.1, demand for almost all types of fuel declined during 1990-98, except the demand for peat and firewood however their share in total fuel consumption was rather small.

The aggregate emissions of CH_4 and N_2O during the whole inventory period were relatively small. Figure 2 illustrates that emissions of CH_4 varied from 1,3 to 1,7 Gg, and emissions of N_2O were in the range of 0,03-0,04 Gg annually.

Figure 2.2.1. CO_2 emissions from energy sources, Reference Approach (1990=100%).

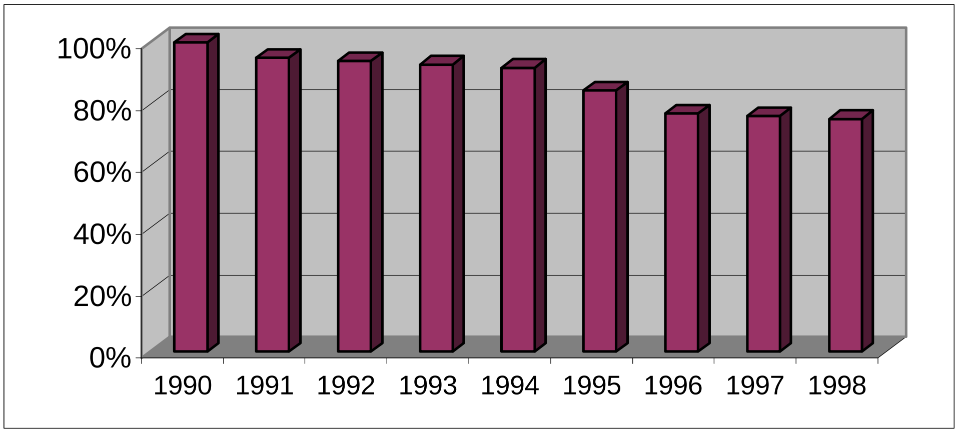


Table 2.2.1. Structure of fuel consumption in Novgorod region (TJ)

Fuel	**1990**	**1994**	**1998**
Gasoline	5936	6460	5569
Jet kerosene	401	42	8
Gas/Diesel oil	8926	6110	5369
Residual fuel oil	4726	2295	1009
Energetic coal	9379	6429	2956
Peat	224	1247	648
Natural gas (dry)	95034	92608	88193
Wood, wood waste	*2106*	*3637*	*2578*

Emissions inventory by major source categories

According to the classification proposed in the Revised IPCC Guidelines, adopted to Russian circumstances, the emissions estimation was done for the following major source categories: 1) large power and heat stations; 2) production of power and heat by non-energy enterprises; 3) transport including navigation, aviation, road and other transport; 4) residential sector including small heat stations and private residential sector; and 5) other stationary and mobile sources.

Large power and heat stations

The major part of the electric power is imported in Novgorod region, but around 20% of it is produced in the Oblast. The largest power and heat producer in the region is Novgorod TES-20. The main fuel types used for power and heat generation in TEC-20 are natural gas and coal, however the share of gas in total fuel consumption for 1990-1998 was around 85%. The share of this source in total emissions of CO_2 dropped from 22% to 18% during the inventory period (see Table 2).

Production of energy and heat by non-energy enterprises

This category of sources is presented in Novgorod Oblast by a number of large enterprises which use fuel for their own technological needs as well as for supplying power and heat to the nearby living districts. Amng them such enterprises as fertilizer producer “AKRON”, Borovichi fireproof materials factory, Uglovsky lime production factory could be distinguished. These enterprises emitted about 13% of total CO_2 emissions in the energy sector of Novgorod region in 1998.

Transport

The major transport sources of GHG emissions in Novgorod region are road transport and regional navigation. According to our estimates, the fuel consumption by road transport was increasing as a result of total number of automobiles registered in the region ((from 78,5 thousand in 1990 to some 140 thousand in 1998), however in domestic navigation the fuel consumption dropped down significantly due to reduction of cargo transportation from 5,5 to 0,97 mln tons and passenger transportation from 50 to 15 thousand persons per year. There was no international navigation bunker in the region during the inventory period. The share of these sources in total CO_2 emissions amounted to 18% in mobile transport and about 1% in navigation.

Domestic aviation in the region was consuming rather negligible amounts of fuel (jet kerosene and gasoline). Scheduled passenger flights in Novgorod region were carried out only till 1990 but the their number was small. After 1990 the regional aviation was used for agricultural and other purposes. There was no international aviation bunker in the region. Emissions by the rail transport were not estimated as there is no Railways Management District in the region.

Residential sector

The major sources of greenhouse gas emissions in the residential sector are the small heat stations (not included in large power and heat stations) and the private residential sector. Consumption of fuel in these two sources in 1990-98 was rather stable. The main types of fuel consumed in residential sector are energetic coal, residual oil fuel, peat and firewood, and in addition, private residential sector consumes large volumes of natural gas. The inventory showed that the share of this source of emissions is the largest – from 1990 to 1998 it increased from 38% up to 47% of total CO_2 emissions.

Other sources

Emissions from other stationary and mobile energy sources, which include agriculture, fishery, forestry and other sources, were not specified in the inventory as it requires much more additional data and, respectively, more resources for carrying our the detailed inventory. Thus we included emission from all non-specified sources in a special category of “Non-detailed source” which amounted to 3-13% of total CO_2 emissions in Novgorod Oblast.

Table 2.2.2. CO2 emissions estimation by major source categories (Gg of CO_2)

Source category		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	***1998 % of total emission by Reference approach***
Large power and heat stations		1112	1061	1067	1038	952	827	839	693	693	18%
Production of power and heat by non-energy enterprises		606	576	550	522	495	522	542	507	508	13%
Transport	Domestic aviation	32	31	22	13	3	1	1	1	1	0%
	Road	654	653	663	672	680	680	681	650	682	18%
	National navigation	133	127	65	62	60	50	42	44	47	1%
Residential sector	Small heat stations	78	74	124	173	223	253	219	284	279	7%
	Private residential sector	1850	1750	1781	1838	1956	1789	1494	1655	1544	40%
Total by specified sources		***4465***	***4272***	***4272***	***4318***	***4369***	***4122***	***3818***	***3834***	***3754***	***97%***
Total by non-specified sources		***655***	***593***	***542***	***440***	***334***	***202***	***132***	***74***	***103***	***3%***
Total by Reference approach		***5120***	***4865***	***4814***	***4758***	***4703***	***4324***	***3950***	***3908***	***3857***	***100%***

3. ENERGY- METHANE EMISSIONS FROM OIL AND GAS

There are several methane emission sources in the Novgorod region, among them gas pipelines which run through its territory (Serpukhov - St.Petersburg, Valdai - Chudovo, Valdai - Pskov - Riga), Nevskaya underground gas storage, and variuos consumers of fuel gas in energy sector, industry, servises, and household use. Emissions were estimated using *Tier 1* methodology and listed in the *Guidelines* default emission factors. Both technoligical emissions of methane and its leakages were taken into consideration.

Trend of CH_4 emission in the 1990 - 1998 period is shown by Fig. 2.3.1. Total emissions decreased from 12.3 Gg in 1990 to 6.5 Gg in 1998, because transit transmission of gas through the pipelines have diminished in the region. This took place mainly in 1990 - 1994. During the period considered emissions from gas accumulation and extraction by Nevskaya underground gas storage approximately doubled, because total volume of stored gas was increasing. Methane emissions associated with the end-use consumption remained approximately the same, at the level of 0.03 Gg/year.

Figure 2.3.1

Methane emission from natural gas activities (1990 - 1998)

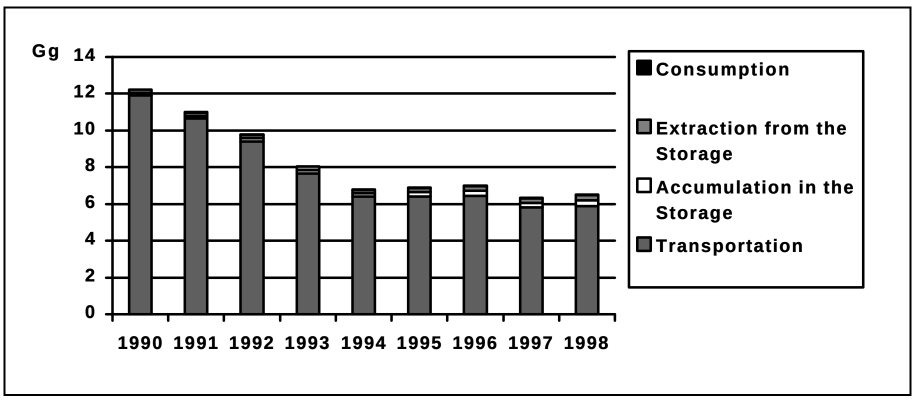


Table 2.3.1 shows *by source* distribution of methane emissions in the region. The leading source is gas transportation (pipelines) in 1998, as well, as in 1990, although share of emissions from gas accumulation and distribution in the total emission have increased by a factor of four.

Table 2.3.1

Distribution of CH_4 emissions from natural gas activities, %

Source	1990	1998
Gas transportation	97.2	90.0
Accumulation in the gas storage	1.3	4.9
Extraction from the gas storage	1.2	4.6
End-use (consumer) waste	0.3	0.5
including industry and energy sector	0.2	0.3
Totals	**100.0**	**100.0**

The results would have been more precise if we had included detailed analysis of emissions from gas transportation. The methodology for such analysis is provided by *Tier 2* approach which is not included in the current version of *Guidelines*. It is known that most methane emissions associated with gas transportation originate at gas compressor stations, not at gas mains. However one of the two gas compressor stations in Novgorod region is not in use now, and the other operates only during the coldest part of winter when gas density increases because of the low temperatures. Consequently implementation of the *Tier 2* methodology (in particular, account for the compressor stations time-load factor) may result in lower estimated emission from the gas transportation and decrease of contribution this source to the total emission. However such a detailed analysis is beyond the scope of this study.

There are no oil extraction, transporting and refining facilities in the Novgorod region, therefore emissions associated with these activities were considered zero.

The uncertainty of the results is determined by peculiarities of methodology discussed above and uncertainties of emission coefficients, and considered relatively high.

4. INDUSTRIAL PROCESSES. USE OF SOLVENTS AND OTHER PRODUCTS

In accordance with general approach (see *Revised 1996 IPCC Guidelines)* this chapter contains inventory of:

- emissions from industrial processes and technologies,
- emissions form hydrofluorocarbons (HFC) use in the industry, commercial and residential sector.

The emissions associated with fossil fuel burning for electricity, heat and mechanical energy production (including emissions from transport) are not covered by this chapter. They are considered in the *Energy* chapter.

The Guidelines list 17 categories of industrial emission sources. In the Novgorod region have been identified and analyzed five of these:

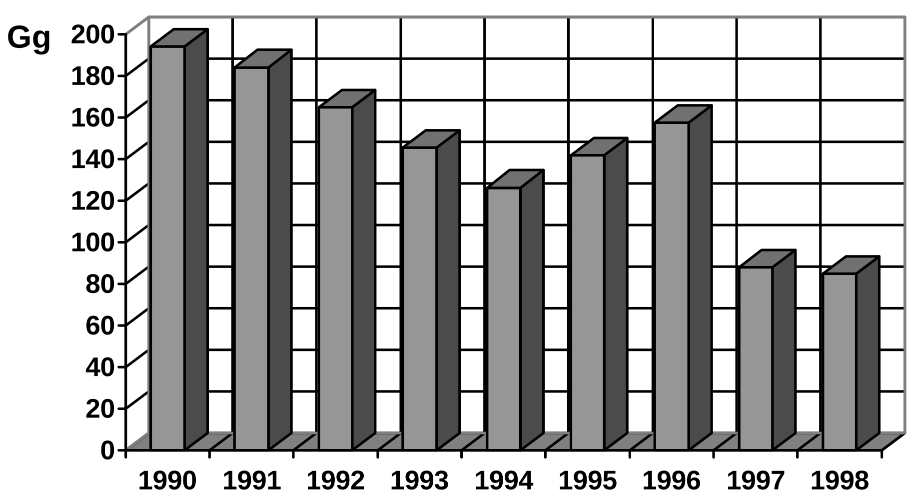
- Lime production (CO_2 emissions)
- Ammonia production (CO_2 emissions)
- Nitrous acid production (N_2O emissions)[1]
- Methanol production (CH_4 emissions)
- HFC emissions from industrial, commercial and household refrigerators.[2]

Altogether, this chapter includes all three “classic” greenhouse gases and a group of “new” GHGs - namely HFCs.

Emissions of CO_2 from lime production take place at Uglovsly lime combine in Uglovka settlement of Okulovsky district. The combine produces lime (CaO with less than 1% MgO admixture) for food, construction, chemical industries and metallurgy. CO_2 emissions are directly proportional to the volume of lime produced, which dropped from 361 th.t in 1990 to 158 th.t in 1998, as a result of financial difficulties at the consumers’ side. Figure 2.4.1 shows the trend of CO_2 emission at Uglovsly lime combine.

Figure 2.4.1

Emission of ÑÎ$_2$ from lime production



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[1] Considered in Chapter 2.12 of the *Guidelines* - “Production of other chemical substances”.

[2] Considered in Chapter 2.17 of the *Guidelines* - “Fluorocarbons and SF_6 use”.

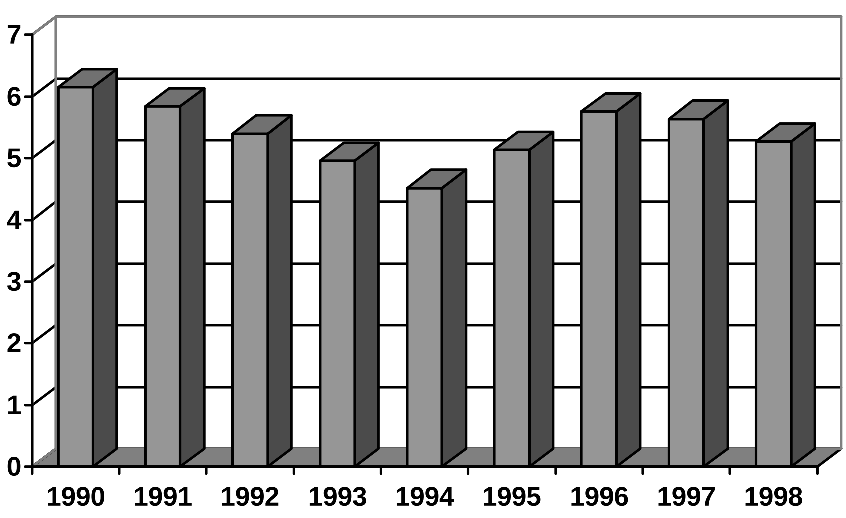
Emissions of CO_2 associated with ammonia production, take place at the ACRON combine in Novgorod, one of the biggest fertilizer producers in Russia. Emissions were calculated using *Tier 1a* methodology (see *Guidelines*). Natural gas consumption data were input in the calculations, 50% carbon content in the natural gas was assumed. Table 1 contains year-by-year data on CO_2 emission from this source. Emissions from ammonia production are higher by an order of magnitude than these from lime production and remained relatively stable during 1990 - 1998 .

In accordance with the *Guidelines*, we did not distinguish between direct CO_2 emission to atmosphere and recovered CO_2 used as raw material to produce various chemicals. Thus we assumed that captured CO_2 will anyway escape to the atmosphere in the relatively short time. However, during the discussion of the inventory results, ACRON experts have doubted of the correctness such an approach (*Razumov, 1999*). According to their information, large quantity of captured CO_2 is used for the production of carbamide - stable chemical which is used as fertiliser and decomposes (with CO_2 generation) only after application to soil. At the same time, the greater part of produced by the ACRON carbamide is exported (96% or about 290 th.t in 1998). Hence, the substantial part of CO_2 emission takes place outside the Novgorod region. Development of methodology, considering exports of carbamide and, possibly, other chemicals would allow to reduce emission uncertainty in the industrial sector. This problem deserves more detailed studying in the future.

JSC Acron also produces N_2O and CH_4 emissions. N_2O emissions (Fig.2.4.2) result from production of nitrous acid. The emission factor 7 kg N_2O per ton of HNO_3 was chosen, taking into account technological processes used (high pressure, catalytic cleaning of gas emissions). The ACRON experts suppose the emission factor to be somewhat less. The direct measurement of N_2O emission would allow to estimate emission factor and emission value more precisely.

Figure 2.4.2

N_2O emissions from production of nitrous acid, Gg.



Methane emissions from methanol production are given by Table 2.4.2.

To estimate HFC emissions, methodology of *Tier 2* was used based on data on total amount of HFCs contained in equipment of Novgorod region.

Table 2.4.2

Methane emission from methanol production, Gg.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Emission	0.2	0.19	0.17	0.16	0.15	0.15	0.13	0.11	0.14

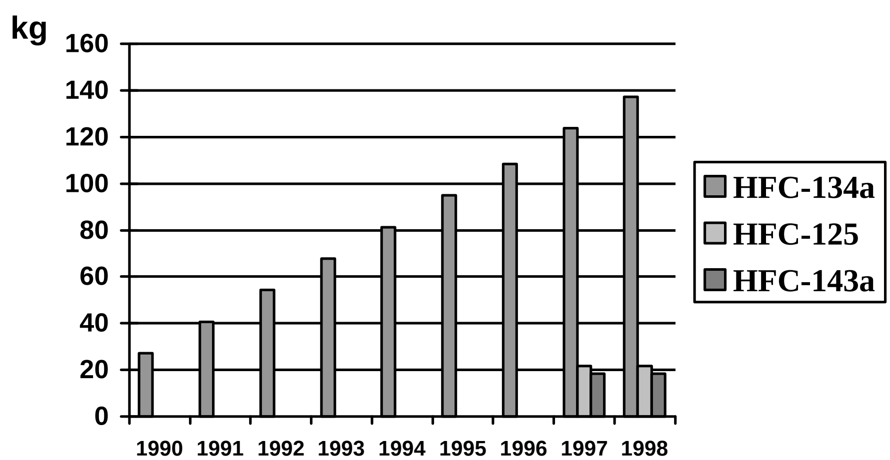
We input the following data:

- each household refrigerator contains on average 0.15 kg, and each commercial refrigerator contains 0.40 kg of HFC-134a (R-134a)
- the share of refrigerators containing R-134a increased linearly from 8% in 1990 to 40% of total number in 1998 as a result of replacement the elder types. Total number of refrigerators in use was estimated by the experts because exact data not available.
- during the period considered three big industrial refrigerators started operation at Cherkizovsky meat combine in Valdai town. These refrigerators use the mixture of 52% HFC- 143a, 44% of HFC-125 and 4% of HFC-134a. Total volume of freezing agent is about 4200 kg. It is likely that other industrial refrigerators were in operation during this period, including refrigerating railway cars and trucks but the data are not available.

We took 1% per year as the leakage factor for all types of refrigerators and neglected emissions associated with equipment withdrawal and disposal because the refrigerator lifetime is more than 10 years and HFC-filled refrigerators are not yet withdrawn. Emission trend is shown on Fig. 2.4.3.

Figure 2.4.3

HFCs emission trends (1990 - 1998)

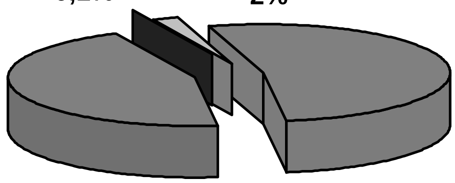


HFC emissions from household and industrial air condition equipment were not estimated because data are not available.

Figure 2.4.4 shows distribution CO_2-equivalent of greenhouse gas emissions by source category in 1998 (to calculate CO_2-equivalents, the IPCC global warming potentials for 100-year time horizon were used).

Figure 2.4.4

Contribution of sources to the total emission



Greenhouse gas emissions from solvents and other product use

Emissions of N_2O use for anesthesia were estimated in this category.

In accordance with *Guidelines*, Module 3, information on N_2O supplies for medical use was collected. All N_2O supplied during the year was assumed to be released to the atmosphere in the same year. Emissions remained stable during 1990 - 1998 (see Table 2.4.3).

Table 2.4.3

Emissions of N_2O used for anesthesia, Gg.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Emission	0.015	0.015	0.015	0.015	0.015	0.016	0.016	0.014	0.014

5. AGRICULTURE

The area of Novgorod region is 5450.1 thousand hectares (ha). As for 1990, the agricultural lands occupied 840.8 thousand ha. That is 15.4% of the total area of the region. In 1998, the agricultural lands were by 1.5 thousand ha less than in 1990. Arable lands constitute about 60%, and hay-lands and pastures - 38% of the agricultural lands in the region. Almost 390 agricultural enterprises and 163 individual farms were registered in the region in 1990. However, in 1998, the number of enterprises decreased to 52, whereas the quantity of farms raised to 1831. In 1990-98 total agricultural employers were 44.1 and 24.5 thousand respectively. According to *Revised 1996 IPCC Guidelines* (1997), the greenhouse gasses to be reported under agricultural module include methane (CH_4) and nitrous oxide (N_2O). The methane is produced owing to enteric fermentation and manure management of domestic livestock. Emissions of nitrous oxide occur from various systems of animal and poultry waste management systems, and agricultural lands, where organic and mineral fertilizers are applied, agricultural residues are plowed in, and nitrogen fixing plants accumulate nitrogen. Besides, anthropogenic nitrogen deposits on agricultural lands from the atmosphere. Agricultural residue burning may serve additional source of anthropogenic greenhouse gas emissions, but this type of activity does not occur over the territory of Novgorod region, and therefore, it was not included in the calculations.

Activity data for greenhouse gas emission calculations

Based on the *Revised 1996 IPCC Guidelines* (1997), the following activity data was used for greenhouse gas (GHG) regional inventory within the Module 4 “Agriculture”:

- Total amount of mineral nitric fertilizers annually applied to agricultural crops of the region recalculated for 100% of active matter.
- Domestic livestock and poultry population subdivided to the following categories:
    - ✓ dairy and non-dairy cattle,
    - ✓ swine,
    - ✓ sheep,
    - ✓ goats,
    - ✓ horses, and
    - ✓ summary poultry for the region.
- Annual regional data on waste management systems used for collection, storage, and application of manure from animals and poultry and nitrogen content there.
- Pulses and soybeans produced in the region in dry weight after processing.
- Total regional production of other agricultural crops except soybeans and pulses recalculated to dry weight after processing.
- The area of organic soils annually cultivated within the region.

Table 1 presents description of typical waste management systems for collection, storage, and use of manure from animals and poultry that are classified according to *Revised 1996 IPCC Guidelines* (1997) and adapted to country specific conditions.

Table 2.5.1.

The typical systems for animal and poultry manure management (animal waste management systems, AWMS) classified according to *Revised 1996 IPCC Guidelines* (1997) and adapted to country specific conditions.

Type of animal waste management system	Brief description of AWMS
Anaerobic lagoon	These are flush systems that use water to remove manure. Mainly they are applied at large swine-breeding farms. Diluted with water manure deposits in sedimentation tanks from 30 to 200 days. In case of isolated water supply, the water from sedimentation tanks is used on recycled basis. If no isolated water supply is present, the sewage is used for fertilization.
Liquid systems	These are built in land isolated concrete tanks, where manure is stored for 6 and more months before application to fields. During storage water can be added to manure.
Daily Spread	The manure is collected in solid phase with the use of different devices (conveyers, scrapers, etc.) and are regularly (as a rule daily) taken and spread over the fields.
Solid Storage and Drylot	The manure is collected daily in solid phase with the use of scraping. However, it is not carried to the fields immediately but stored in especially designed depositories during a rather long period (several months) before use. This term can be also applied for fenced enclosures, where animals are kept for a certain period. The manure there dries on the surface and is periodically collected and transported to special depositories.
Pasture Range and Paddock	No specific activities on manure collection, management, and use are applied. The manure is not removed from the place, where it was produced.
Manure used as Fuel	This type of animal waste management is not specific for the territory of Russian Federation.
Other System	The other animal waste management systems include bioenergy devices to obtain biogas and biological manure treatment to produce biohumus and albuminous forage and other methods.

Table 2.5.2 displays summary data on domestic livestock and poultry population in agricultural enterprises, farms, and private sector of Novgorod region. Table 2.5.3 presents the data on annual production of pulses, soybeans, and other agricultural crops within the region in dry weight after processing. Besides, the table presents information on application nitric mineral fertilizers in Novgorod region. The values of fertilizers are recalculated for the active matter.

Table 2.5.2.

The summary population of domestic livestock and poultry in Novgorod region (1000 heads, for poultry - 1000 units)

Livestock categories	Population units	Years								
		1990	1991	1992	1993	1994	1995	1996	1997	1998
Cattle as a whole and	1000 heads	352.2	339.8	317.3	277.6	248.4	212.0	194.5	168.0	141.6
Dairy cattle	1000 heads	140.5	137.0	135.8	122.6	116.4	106.4	98.8	86.5	75.1
Swine	1000 heads	226.3	226.4	203.2	176.1	163.4	139.4	100.1	77.0	62.9
Sheep and goats	1000 heads	83.6	78.9	81.8	80.3	78.0	71.7	68.7	61.9	52.5
Separately sheep	1000 heads	63.2	59.7	61.9	60.8	59.2	54.4	52.0	46.9	39.7
Horses	1000 heads	6.8	6.7	5.4	5.4	5.3	4.9	4.4	3.9	2.5
Poultry	1000 units	3831.7	3781.9	3048.2	3029.9	2955.6	2083.8	1291.1	1068.3	1169.1

Table 2.5.3.

The annual production of pulses, soybeans, and other agricultural crops (in dry weight after processing) and application of nitric mineral fertilizers within the territory of Novgorod region.

Parameters	Units	Years								
		1990	1991	1992	1993	1994	1995	1996	1997	1998
Agricultural crop production (except pulses and soybeans)	1000 t	950.2	937.8	755.9	751.4	743.8	827.4	911.0	780.3	486.3
Production of pulses and soybeans	1000 t	0.5	4.9	0.4	0.4	0.3	0.6	0.8	0.4	0.2
Application of nitric mineral fertilizers	1000 t	30.5	29.6	20.0	17.1	7.0	7.0	3.1	3.1	1.7

The data for 1990, 1994, and 1996 to 1998 were taken from publications of Novgorod Regional Committees for Agriculture and Food Production and for Statistics (Social and Economy Situation..., 1995; Summary Data..., 1996; The Agriculture of Novgorod Region, 1997, and others). The data on livestock and swine population for 1991-1993 and 1995 were taken from national statistical data (The Agriculture in Russia, 1998). Individual populations of sheep and goats were calculated from national statistical data according to the ratio between summary population of animals for current and previous years. Populations of horses and poultry for the years 1991 to 1993 were calculated based on indices of physical agriculture production given in national statistics (The Agriculture in Russia, 1998). The data for 1995 were taken as average between 1994 and 1996.

Similar to the population of horses and poultry, annual production of agricultural crops for 1991-1993 was calculated with the use of indices of physical agriculture production (The Agriculture in Russia, 1998), whereas the value for 1995 was taken as average between the appropriate values for 1994 and 1996. Nitric fertilizers applied in the region in 1991-1993 and 1995 were determined based on the data on average sales within the country recalculated for 1 ha of arable lands that are given in national statistics (The Agriculture in Russia, 1998).

The calculation of greenhouse gas emissions

Methane (CH_4) and nitrous oxide (N_2O) emissions from agriculture of Novgorod region were calculated according to *Revised 1996 IPCC Guidelines* (1997). Default emission factors were used for calculation CH_4 emissions from domestic livestock and poultry. To make the appropriate calculation of N_2O emissions, it is necessary to determine a portion of animals and poultry that are kept and correspondingly produce certain amount of nitrogen under specific animal waste management systems (AWMS). The latter forms basis for calculations of bulk nitrogen excretion for definite AWMS.

Table 2.5.4 presents nitrogen excretion from domestic livestock and poultry excrement. For adult (mature) cattle, swine, and poultry nitrogen excretion was calculated based on All-Union Guidelines for Technology Projecting of Manure Management Systems (1981, 1986), which provide mean rates of nitrogen content and output from manure. Average value for chicken, turkey, and duck excrement were used for poultry estimates. Nitrogen excretion for other animals was taken from *Revised 1996 IPCC Guidelines* (1997) as default values for Eastern Europe.

Table 2.5.4.

Nitrogen excretion from domestic livestock and poultry (kg/animal/year)

Categories of domestic livestock and poultry					
Non-dairy cattle[a]	Dairy cattle[a]	Poultry[b]	Sheep[c]	Swine[a]	Others[c]
65.4	74.5	1.7	16	24.4	25

[à]The data are given for adult animals regardless age structure of herd. *Source:* All-Union Guidelines for Technology Projecting of Manure Management Systems (1986);

[b] Average value for chicken, turkey, and ducks. *Source:* All-Union Guidelines for Technology Projecting of Manure Management Systems (1981);

[ñ] Default data for Eastern Europe. *Sources:* Ecetoc (1994), Vetter et. al. (1988), Steffens and Vetter (1990).

Nitrous oxide emission depend on animal waste management systems applied in the region and summary population of domestic livestock and poultry kept under specific AWMS. There is no anaerobic lagoons in the Novgorod region. Liquid AWMS are used at *Ermolino* livestock farm and *Novgorodsky* swine-breeding farm. Up to 1996 *Ermolino* was non-dairy cattle feeding farm. For the rest farms manure management systems correspond to "solid storage and drylot" according to *Revised 1996 IPCC Guidelines* (1997). Sometimes manure is stored at unorganized sites that can be referred as "solid storage and drylot" as well, because there are no fallow in Novgorod region and manure is not spread daily there.

The year-to-year variations in non-dairy cattle and swine population dynamics at *Ermolino* and *Novgorodsky* farms are as follows:

Year	*Ermolino* livestock farm (non-dairy cattle feeding), 1000 heads	*Novgorodsky* swine-breeding farm, 1000 heads
1990	14.0	49.0
1991[a]	13.8	48.4
1992[a]	11.1	39.0
1993[a]	11.1	38.8
1994	9.3	45.0
1995[a]	6.8	37.0
1996	4.2	29.0
1997	0	24.5
1998	0	15.0

[a] Non-dairy cattle and swine population for the years 1991-1993 was determined based on the indices of physical agriculture production given in national statistics (The Agriculture in Russia, 1998), whereas the population for 1995 was taken as average between the values for 1994 and 1996.

Summer pasturing of domestic animals (dairy and non-dairy cattle, sheep, goats, and horses) is typical for agricultural enterprises, farms, and private sector of Russia. In that case the manure produced by animals is treated according to "pasture range and paddock" category of the *Revised 1996 IPCC Guidelines* (1997). Hence, within one-year period the same categories of animals could be kept under different animal waste management systems (AWMS) according to *Revised 1996 IPCC Guidelines* (1997). In private estates poultry is kept outdoors in summer daytime. Therefore, poultry excrement is not collected during the daytime but remains at the place, where it was produced. Therefore, it can be considered as the manure of "pasture range and paddock" category according to the *IPCC Revised Guidelines* (1997). Consequently, in accordance to *Revised 1996 IPCC Guidelines* (1997) 3 animal waste management systems can be identified in Novgorod region in 1990-1998:

- liquid AWMS,
- solid storage and drylot, and
- pasture range and paddock.

Weather conditions determine duration of summer pasturing of dairy and non-dairy cattle, sheep, goats, and horses. But in general it starts on May 20 and lasts till October 1. Its daily duration is 10 hours for cows (from 7.00 to 19.00 except 2 hours for milking, when cows are brought to farms). For non-dairy cattle, sheep, and horses summer pasturing lasts for 12 hours (from 7.00 to 19.00). Consequently, the duration of summer pasturing is 55.8 days for cows and 67 days for other domestic animals, if recalculated for 24-hour day period. That is 15.3 and 18.4% of annual time correspondingly. Thus regional population of cows spends 15.3% of the year period outdoors (field pasturing) and 84.7% indoors. Non-dairy cattle, sheep, and horses spend 18.4% of year period over field pastures and 81.6% indoors (farms). If assume that nitrogen evenly excrets from manure of domestic animals and poultry within the whole year period, 15.3% of population of cows is kept under conditions, when their manure remains on pastures and paddock, whereas 84.7% of the population is kept in farms, and their manure is referred to solid storage and drylot AWMS. Similar approach can be applied for sheep, goats, and horses.

There is no swine pasturing in Novgorod region. Liquid AWMS for swine manure are applied by *Novgorodsky* swine-breeding farm only. The rest swine population is kept in farms, feedlots and other indoor constructions. That corresponds to solid storage and drylot AWMS (Table 1). Consequently two types of AWMS were applied for swine-breeding in the region within the period from 1990 to 1998. These are: (1) liquid and (2) solid storage and drylot AWMS according to *Revised 1996 IPCC Guidelines* (1997).

As shown above, from 1990 to 1996 part of non-dairy cattle was kept at *Ermolino* livestock farm, where liquid AWMS were used. Manure of the rest dairy and non-dairy cattle and other livestock was collected in solid state (solid storage and drylot) otherwise was left on pastures (pasture range and paddock). The percentage ratio 18.4% for pasture range and paddock AWMS (summer pasturing) and 81.6% for solid storage and drylot (indoor keeping) should be applied for the whole regional livestock population except the non-dairy cattle that was kept in *Ermolino* farm. Similar approach can be applied for calculation nitrogen excretion from poultry in private estates and farms that is kept outdoors during summer time, so part of manure remains at the place, where it was produced. If assume that duration of summer pasturing for poultry is 12 hours (from 7.00 to 19.00), the correction factors are 0.184 and 0.816 respectively for summer pasturing and indoor keeping. That corresponds to 18.4 and 81.6% of the year period.

In large enterprises poultry is permanently kept indoors and the manure is collected in solid form. Therefore, regional population of poultry must be subdivided into portions that are kept in large enterprises and private estates and farms. The part kept in private estates and farms must be treated as described above. The values obtained must be summarized to get final factors to be used for calculation of nitrogen excretion from the appropriate AWMS.

Portions of domestic livestock and poultry kept with the use of specific animal waste management systems were calculated separately for each inventory year based on total animals and poultry population and the above correction factors. Results of calculations are given in appropriate reporting tables. Tables 5 and 6 present summary N_2O and CH_4 emissions from agricultural sector of Novgorod region.

Assessment of accuracy of the calculations

The accuracy of the calculations depends on precision of activity data, correction coefficients, and emission factors. The activity data was obtained from regional and national statistics, that are of a high rate exactness (as a rule, the deviation is no more than 5%). Correction factors were determined based on activity data and therefore, they should be of rather high precision as well. Emission factors were taken from the *Revised 1996 IPCC Guidelines* (1997). Their accuracy is 20%. Therefore, it is possible to conclude that the accuracy of the estimates obtained is about 20%.

Table 2.5.5.

Summary methane emission from agricultural sector of Novgorod region (Gg)

The methane emission source categories	Years								
	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total for agricultural sector	**27,223**	**26,344**	**24,774**	**21,874**	**19,860**	**17,151**	**15,586**	**13,459**	**11,400**
A Enteric Fermentation	**24,305**	**23,488**	**22,161**	**19,556**	**17,729**	**15,351**	**14,091**	**12,206**	**10,328**
1. Cattle	23,236	22,454	21,164	18,611	16,820	14,532	13,362	11,571	9,807
2. Sheep	0,506	0,478	0,495	0,486	0,474	0,435	0,416	0,375	0,318
3. Goats	0,102	0,096	0,100	0,098	0,094	0,087	0,084	0,075	0,064
4. Horses	0,122	0,121	0,097	0,097	0,095	0,088	0,079	0,070	0,045
5. Swine	0,339	0,340	0,305	0,264	0,245	0,209	0,150	0,116	0,094
6. Poultry	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
B Manure Management	**2,918**	**2,857**	**2,613**	**2,318**	**2,131**	**1,800**	**1,495**	**1,252**	**1,072**
1. Cattle	1,690	1,633	1,541	1,356	1,226	1,061	0,976	0,845	0,717
2. Sheep	0,012	0,011	0,012	0,012	0,011	0,010	0,010	0,009	0,008
3. Goats	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002
4. Horses	0,009	0,009	0,008	0,008	0,007	0,007	0,006	0,005	0,003
5. Swine	0,905	0,906	0,813	0,704	0,654	0,558	0,400	0,308	0,252
6. Poultry	0,299	0,295	0,238	0,236	0,231	0,163	0,101	0,083	0,091

Table 2.5.6.

Summary nitrous oxide emission from agriculture of Novgorod region (Gg)

The nitrous oxide emission source categories	Years								
	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total for agricultural sector	**1,227**	**1,195**	**0,844**	**0,752**	**0,436**	**0,461**	**0,365**	**0,326**	**0,196**
A Enteric Fermentation									
B Manure Management	**0,001**	**0,001**	**0,001**	**0,001**	**0,001**	**0,001**	**0,0005**	**0,0004**	**0,0004**
Anaerobic	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Liquid Systems	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Solid Storage and Dry Lot	0,001	0,001	0,001	0,001	0,001	0,001	0,0005	0,0004	0,0004
Other (please specify)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
D Agricultural Soils	**1,226**	**1,194**	**0,843**	**0,752**	**0,435**	**0,460**	**0,3640**	**0,3251**	**0,1955**
F Field Burning of Agricultural Residues	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**

6. LAND USE CHAGE AND FORESTRY

The Land Use Change and Forestry module of the *Revised 1996 IPCC Guidelines* (1997) is currently under revision. However, regional greenhouse gas inventory will be incomplete, if emissions and sinks of carbon dioxide ($C0_2$) in forest sector and land use change are not included in the regional assessments. It was decided to make appropriate estimations with the use of former methodology that is presented in the *Revised 1996 IPCC Guidelines* (1997). It must be noticed that as it stands in the *Revised 1996 IPCC Guidelines* (1997), this methodology is not fully consistent with land use and forest management practices currently applied in Russian Federation. Therefore, only separate steps and formulas were used for calculations. That resulted in filling only a few Reporting Tables. Particularly the emissions and sinks in forest sector were calculated based on changes in wood biomass due to harvesting practices and annual increment. Total biomass and area conversion of grasslands were used for emission and sinks estimates due to land use change, and the data on lime delivery to Novgorod region was used for calculating $C0_2$ emissions from soil liming. The section on accuracy assessment gives a detailed description of problems relevant to inconsistency of former Land Use Change and Forestry module with national land use and forest management practices.

Activity data for greenhouse gas emission calculations

Based on the *Revised 1996 IPCC Guidelines* (1997), the following activity data is required for greenhouse gas (GHG) regional inventory within the Land Use Change and Forestry:

- Total area of forested lands.
- Average annual increment of timber.
- Regional forest management practices including types of cuttings applied.
- Annual changes in areas of forested and other lands.
- Biomass reserves in forests and grasslands.
- The regional data on liming.

In Russian Federation state inventory of forest stock is performed once in 5 years. Therefore, forest inventory data for January 1, 1998, 1993, and 1998 were used to assess changes in forested areas of Novgorod region for the period from 1990 to 1998. For intermediate years changes in the areas were obtained by interpolation the values of previous and subsequent years. The greenhouse gas emissions and sinks were estimated based on total data of forested lands that are under the authority of various ministries, agencies, and organizations (Federal Forestry Service, Ministry of Agriculture and Food Production and others). Table 2.6.1 presents the data on areas of forests in Novgorod region. Bold figures mark forest inventory data that took place during the period under consideration. As follows from Table 2.6.1, the area of forests decreased from 1990 to 1993. Evidently it is because part of forested lands was transformed into non-forest territories. But form 1993 to 1998 the area of forest increased by 6.5 thousand hectares. That is almost 1.3 thousand hectares annually.

Table 2.6.1.

The changes in forest areas in Novgorod region within the period from 1990 to 1998.

Year	Area of forests, thousand hectares
1990	3475.2
1991	3475.1
1992	3474.6
1993	**3474.4**
1994	3475.7
1995	3477.0
1996	3478.3
1997	3479.6
1998	**3480.9**

Total average increment of basic coniferous, hardwood, and softwood species were used for assessment carbon sinks in the forests of Novgorod region. It is well known that total average increment of forest stands corresponds to their annual mean increment within the whole period of development (Tretyakov et al., 1952). Therefore, that is the most representative feature of forest biomass accumulation dynamics. Table 2.6.2 displays values of total average increment of the basic tree species in Novgorod region according to State Forest Inventory data of 1988, 1993, and 1998.

Table 2.6.2.

The total average increment of basic tree species in Novgorod region (according to the data of State Forest Stock Inventory).

Year	The value of total average increment, million m^3
1988	5.22
1993	7.64
1998	6.85

As follows from Table 2.6.2, there was a significant increase in biomass in the forests of Novgorod region till 1993, whereas after 1993 the increment of wood biomass slightly decreased. Annual increment of wood biomass for interim years was calculated by interpolation forest stock inventory data from Table 2.6.2. Figures obtained were recalculated for 1 hectare and transformed into tones of dry matter with the use of conversion factors proposed by Isaev et al. (1993). These are given in Table 2.6.3.

Table 2.6.3.

Conversion factors for woody biomass, t of dry matter/î^3 (from Isaev et al., 1993)

Tree species	Age group of the forest stand			
	Young	Middle aged	Premature	Mature and overmature
Pine	0.887	0.667	0.672	0.637
Spruce	1.190	0.793	0.734	0.759
Birch	0.756	0.781	0.770	0.786
Aspen	0.767	0.630	0.682	0.605

So far as age composition of regional forests is rather even, average for all age groups value of conversion factor was used for calculations. The basic regional tree species are:

pine -	28%
spruce -	19%
birch -	33%
aspen -	16%
alder -	4%

Therefore, mean weighted conversion factor was calculated with regard to the input of each tree species. The value of the factor is 0.76 t/m^3. Table 2.6.4 presents resulting values of annual increment within the period from 1990 to 1998 recalculated to t/ha.

Table 2.6.4.

The annual increment of forests over the territory of Novgorod region within the period from 1990 to 1998.

Year	Increment, t/ha
1990	1.35
1991	1.46
1992	1.57
1993	1.67
1994	1.63
1995	1.60
1996	1.56
1997	1.53
1998	1.50

The following types of cuttings are applied over the territory of Novgorod region:

- clear cuttings;
- management cuttings;
- reconstruction cuttings; and
- other cuttings.

The exact data on areas of cutting and scales of timber harvested are available for 1994, 1995, 1996, and 1998. The figures for other years were calculated by extrapolation of existing values of harvesting with regard to annual allowable cut set over the area. The obtained data on wood harvesting are given in Table 2.6.5.

It must be noticed that the calculations for the period from 1990 to 1993 seem to underestimate the real scales of wood harvesting. According to our expert estimations, the scales of harvesting for these years were higher (put in brackets). However, in subsequent calculations we used results of extrapolation instead the expert estimates.

Table 2.6.5.

Wood harvesting in Novgorod region within the period from 1990 to 1998.

Year	Scales of wood harvesting for various cuts, thousand m^3			
	Clear cuttings	Management cuttings	Reconstruction cuttings	Other cuttings
1990	2183.0 (3300)*	419.0	4.6	118.0
1991	2183.0 (3000)*	419.0	4.6	118.0
1992	2183.0 (2900)*	419.0	4.6	118.0
1993	2183.0 (2700)*	419.0	4.6	118.0
1994	2135.4	358.8	4.5	132.1
1995	2248.0	452.0	4.0	115.0
1996	1932.0	406.0	9.0	109.0
1997	2183.0	419.0	4.6	118.0
1998	2415.1	459.2	1.0	115.3

* Our expert estimate of scales of wood harvesting is given in brackets.

Table 2.6.6 presents total scales of clear, management, and other cuttings over the territory of Novgorod region for the period from 1990 to 1993.

Table 2.6.6.

The areas of wood harvesting over the territory of Novgorod region within the period from 1990 to 1998.

Year	The area of wood harvesting, thousand ha
1990	39.914
1991	39.914
1992	39.914
1993	39.914
1994	41.518
1995	43.472
1996	36.294
1997	39.914
1998	38.373

Based on the data on wood harvesting in Novgorod region and Assortment and Trading Tables, total scale of timber cut including wood residues in t of dry matter were calculated for 1 ha (Tretyakov et al., 1952; Assortment and Trading Tables, 1978). The figures obtained are given in Table 2.6.7.

Table 2.6.7.

Total scale of wood harvesting in the Novgorod region.

Year	Withdrawal of biomass, t/ha
1990	56.7
1991	56.7
1992	56.7
1993	56.7
1994	52.0
1995	53.0
1996	56.2
1997	56.7
1998	66.6

The portion of wood residues left for decay over cutting areas was taken as 16% of total timber harvest (Tretyakov et al., 1952; Assortment and Trading Tables, 1978).

The data on areas and biomass reserves for grasslands were taken from Novgorod branch of State Land Stock Projecting and Research Enterprise under the State Committee for Land Stock of Russia.

Burnt lime and lime powder were applied for soil liming in Novgorod region. They were produced by the local joint stock company *Uglovsky Lime Production Enterprise*. The data on summary regional delivery of burnt lime and lime powder by *Uglovsky Lime Production Enterprise* are given in Table 2.6.8. It was assumed that annual deliveries of lime products correspond to their annual soil input. Besides, both categories of products were summarized together and considered as limestone ($CaCO_3$).

Table 2.6.8.

The summary delivery of lime powder and burnt lime in Novgorod region.

Year	Delivery, t
1990	332268
1991	225244
1992	178220
1993	101196
1994	24173
1995	18047
1996	11921
1997	11455
1998	11393

The deliveries of limestone for 1991-1993 and 1995 were calculated by extrapolation of the data on deliveries for 1990, 1994, and 1996-1998.

Calculation of greenhouse gas emissions

Despite the current revision of appropriate module of the *Revised 1996 IPCC Guidelines* (1997), regional emissions and sinks of greenhouse gas due to land use change and forestry were calculated in accordance to the former methodology. Results of calculations are given in appropriate reporting tables.

Based on geographical position, the forests of Novgorod region were considered as “mixed broadleaf coniferous forest”. The amount of traditionally used fuel wood and other wood use (Sheet 2 of 3, Worksheet 5-1) were assumed equal 0, because all forest management practices in the region are centralized and registered.

The information on land conversion necessary for assessment annual changes in forest and grassland communities were taken from the data of Novgorod Regional Forestry Administration, State Inventory of Forest Stock, and Novgorod branch of State Land Stock Projecting and Research Enterprise. In case of decrease in land area (conversion to other types of land use), the biomass after land conversion was assumed 0. However, in the reverse case the biomass before conversion was assumed 0. The biomass for mixed boreal forests was taken as a mean value from appropriate table of default values given in the *Revised 1996 IPCC Guidelines* (1997).

Carbon loss due to biomass burning on site and off site (Sheets 2 and 3 of 5, Worksheet 5-2) were not estimated, so far as harvesting residues are not burnt in the region. They are left to decay over the cut areas. The portion of residues was taken 16% of total scale of wood harvesting (Sheet 4-5, Worksheet 5-2). Duration of complete decomposition of the residues was assumed 1 year. Emission of other greenhouse gasses except CO_2 (Sheet 1 of 1, Worksheet 5-3) were not calculated, because harvesting residues are not burnt in the forests of the region.

The data on conversion of non-forest lands to forests within the latest 20-year period were used for filling the Sheet 1 of 3, Worksheet 5-4. It was assumed that spruce forest plantations were developed over formerly non-forest lands. It was impossible to fill Sheet 2 of 3, Worksheet 5-4, because after the 20-year period the territories converted to forested lands are already treated as forest stock.

The regional changes in soil carbon reserves are mainly associated to soil erosion and humus wash-out. Therefore, netto changes in carbon are equal 0 (Sheet 1 of 4, Worksheet 5-5). The agrotechnics applied over the region are perfect enough, and they do not cause CO_2 atmospheric emission from cultivated lands. Besides, no virgin lands have been cultivated in Novgorod region within the recent 20 years. Consequently, Sheets 1of 1, Worksheet 5-5A (supplementary), and 2 of 4, Worksheet 5-5, cannot be applied for Novgorod region. Summary regional CO_2 emission and sink owing to land use change and forestry are given in Table 9. The Fig. 1 presents temporary dynamics of carbon dioxide sinks caused by the general changes in forest biomass and due to regional land use change and forestry.

Assessment of accuracy of the calculations

The accuracy of the calculations depends on precision of activity data and conversion factors. The exactness of State Forest Stock Inventory is about 20%. The annual allowable cut and the scales of harvesting are calculated with the same accuracy. Land conversion and other land use changes are registered with similar precision, whereas the limestone delivery data are of significantly higher accuracy. The conversion factors were taken from the *Revised 1996 IPCC Guidelines* (1997) and other reference sources. Their accuracy is also about 20%.

However, the structure of reporting tables applied in the *Revised 1996 IPCC Guidelines* (1997) lacks of objective reflection of changes in land use, land use change, and forestry. Thus, the Worksheets 5-2 and 5-3 follow clash-burn clearing land use system that foresees decrease in forested lands due to subsequent increase of agricultural fields. This system is not applied in Russia. Cut residues are not burnt on site and off site in the Novgorod region. All forest management activities associated with wood withdrawal are centralized, registered and documented. Meanwhile no methodology is provided to consider wild forest fires neither for the areas of burnt forest, nor for the scales of damaged wood. It is recommended to account burnt wood through increment decrease. But this method has rather high uncertainty and low accuracy. Besides, it is impossible to follow the changes in land use for more than 20-year period (Worksheet 5-4), because after that period new territories are included in appropriate categories of land management, and their subsequent inventory is performed under these generalized land management categories.

The investigations within the frames of Country Study show that in Russian Federation netto changes in soil fertility are equal 0. The technology of cultivation and other types of land treatment do not cause emission of greenhouse gasses. The losses of humus from upper soil layer are associated to mechanical transfer (wash-out and soil erosion). Therefore, Sheets 1 and 2 of 4, Worksheet 5-5, and Worksheet5-5A (supplementary) are not valid for Russia.

Table 2.6.9.

Carbon dioxide emissions and sink due to land use change and forestry in Novgorod region (Gg)

Carbon dioxide emission and sink categories	1990		1991		1992		1993		1994	
	CO_2 emissions	CO_2 removals	CO_2 emissions	CO_2 removals	CO_2 emissions	CO_2 removals	CO_2 emissions	CO_2 removals	CO_2 emissions	CO_2 removals
Total Land-Use Change and Forestry	**0,000**	**-1 317,907**	**0,000**	**-2 052,362**	**0,000**	**-2 785,625**	**0,000**	**-3 455,913**	**0,000**	**-3 493,017**
A Changes in Forest Woody Biomass Stocks	**0,000**	**-2 107,490**	**0,000**	**-2 808,054**	**0,000**	**-3 507,427**	**0,000**	**-4 143,825**	**0,000**	**-4 116,477**
B Forest and Grassland Conversion	**663,850**		**663,850**		**663,850**		**663,850**		**633,288**	
1. Boreal Forests	663,850		663,850		663,850		663,850		633,288	
2. Grasslands/Tundra	0,000		0,000		0,000		0,000		0,000	
C Abandonment of Managed Lands		**-20,464**		**-20,464**		**-20,464**		**-20,464**		**-20,464**
1. Boreal Forests		-20,464		-20,464		-20,464		-20,464		-20,464
2. Grasslands/Tundra		**0,000**		0,000		0,000		0,000		0,000
D CO2 Emissions and Removals from Soil	**146,198**	**0,000**	**112,307**	**0,000**	**78,417**	**0,000**	**44,527**	**0,000**	**10,636**	**0,000**

Carbon dioxide emission and sink categories	1995		1996		1997		1998	
	CO_2 emissions	CO_2 removals	CO_2 emissions	CO_2 removals	CO_2 emissions	CO_2 removals	CO_2 emissions	CO_2 removals
Total Land-Use Change and Forestry	**0,000**	**-2 817,262**	**0,000**	**-3 511,372**	**0,000**	**-2 618,223**	**0,000**	**-1 710,675**
A Changes in Forest Woody Biomass Stocks	**0,000**	**-3 480,583**	**0,000**	**-4 094,471**	**0,000**	**-3 266,648**	**0,000**	**-2 444,878**
B Forest and Grassland Conversion	**675,845**		**598,319**		**663,850**		**749,655**	
1. Boreal Forests	675,845		598,319		663,850		749,655	
2. Grasslands/Tundra	0,000		0,000		0,000		0,000	
C Abandonment of Managed Lands		**-20,464**		**-20,464**		**-20,464**		**-20,464**
1. Boreal Forests		-20,464		-20,464		-20,464		-20,464
2. Grasslands/Tundra		0,000		0,000		0,000		0,000
D CO2 Emissions and Removals from Soil	**7,941**	**0,000**	**5,245**	**0,000**	**5,040**	**0,000**	**5,013**	**0,000**

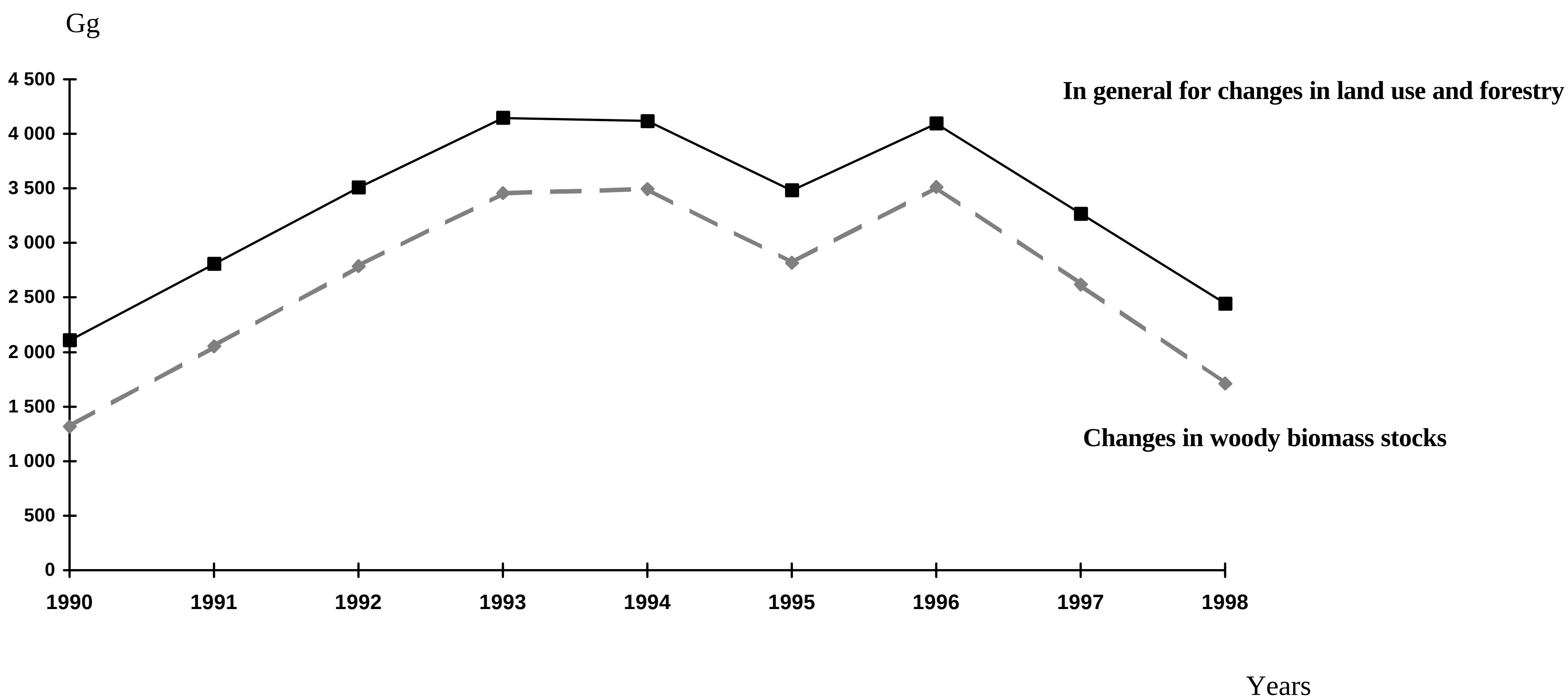


Fig. 2.6.1. Temporary dynamics of carbon dioxide sinks in forestry and due to land use change over the territory of Novgorod region.

Consequently, the structure of reporting tables of the *Revised 1996 IPCC Guidelines* (1997) is mainly oriented at extensive economy that supposes progressive decrease in the areas of forested lands together with subsequent increase in the areas of cultivated lands that are managed in away that leads to soil fertility exhaustion. This system is not valid for the territory of Russian Federation. Therefore, the methodology proposed in the *Revised 1996 IPCC Guidelines* (1997) is not fully consistent for conditions of Russian Federation. That results in incomplete filling of Worksheets and significantly reduces accuracy of the estimates.

Special investigations are required that enable precise accounting all emission sources and sinks of greenhouse gasses in forest sector and due to land use change. It is recommended to develop a detailed assessment of woody and non-wood biomass reserves with regard to the species composition, growth conditions, and other factors that specify structural and functional properties of boreal forests. The detailed investigations of underground biomass of forests and grasslands are also required as well as the estimates of biomass loss due to different types of forest fires. Of course, these investigations were not included in the present project. However, the estimates of greenhouse gas emissions and sinks in Novgorod region are rather rough without appropriate implementing of the above activities.

7. WASTE

In accordance with the *Revised 1996 IPCC Guidelines* this chapter contains:

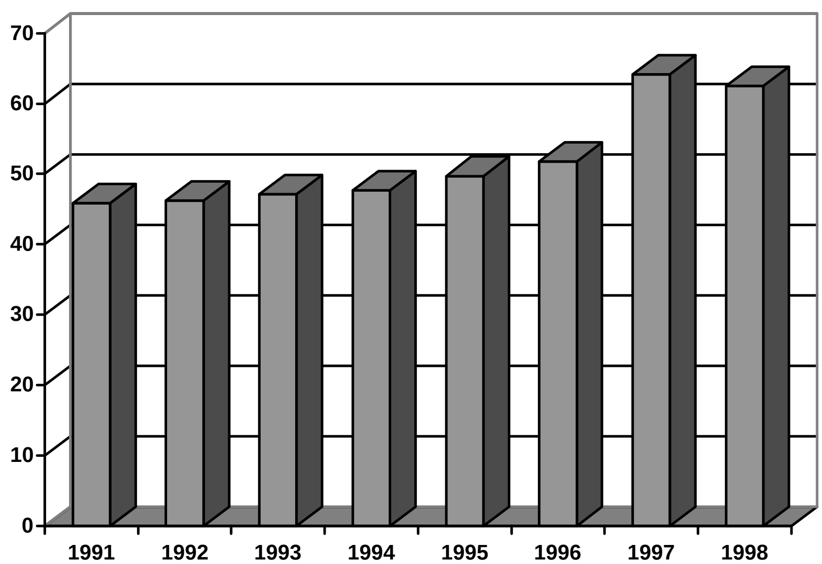
- Methane emissions from solid waste disposal in landfills;
- Methane emissions from wastewater treatment and sediment treatment;
- N_2O emissions from human sewage.

Methane emissions from solid waste disposal sites were calculated using data on total volume of solid waste disposed. The data were obtained from Novgorod state enterprise "Novgorodjilcommuneservice". Solid waste density was taken 0.21 t/m^3. The share of organic carbon was taken from the *Guidelines*, 17%. We considered the following landfills as "managed" (as defined by the *Guidelines*): Borovichi landfill, Novgorod landfill, Staraya Russa landfill. These landfills accounted for 70 % (in 1998) to 80% (in 1990) of total volume of waste disposed. All other landfills were considered non-managed.

According to the *Guidelines*, CH_4 emissions were calculated based on total volume of waste disposed each year. Methane emissions from waste disposed in the previous years, as well, as delay of methane generation from waste disposed in the current year was not taken into account. Implementation of methodologies taking account of these processes can decrease the uncertainty.

Figure 2.7.1

Methane emissions from solid waste disposal, Gg.



As can be seen from Fig.2.7.1, methane emissions increased from 45 Gg/year in 1990 to 64 Gg/year in 1998.

Table 2.7.1 shows methane emissions from wastewater and sludge treatment. The volume of these emissions is lower by two orders of magnitude than methane emissions from solid waste disposal in landfills. To calculate these emissions we used the population statistics of Novgorod region, default emission factors and parameters (see *Guidelines*), as well as expert estimates. More accurate definition of these coefficients will decrease the uncertainty of estimates (in particular, more detailed information is needed on emissions from aerobic waste water treatment systems, digesters use, accounting for incomplete treatment).

Table 2.7.1

Methane emissions from wastewater and sludge treatment, Gg.

Ãîä	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ýìèññèÿ	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.54	0.54

N_2O emissions from human sewage was calculated using population data and proteine consumption rate (which was estimated at 30 kg/person per year). Emission appeared to be constant during 1990 -1998 within accuracy of calculation.

Table 2.7.2

Emission of N_2O from human sewage, Gg.

Ãîä	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ýìèññèÿ	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06

Table 2.7.3 shows contribution of sources to the total 1998 GHG emission from waste (in CO_2-equivalent). To obtain CO_2-equivalents of emissions, the IPCC global warming potentials (GWPs) for 100-year time horizon were used (GWP_{CH4}=21, GWP_{N2O}=310).

Table 2.7.3

Contribution of emission sources to the total emission, %

Source	Solid waste	Liquid waste	Human sewage
Contribution ti the total emission	97.8	0.8	1.4

The share of methane in total emission was 98.6%, the share of N_2O was 1.4% (1998).