Country Case Study on Sources and Sinks of Greenhouse Gases in Poland

Final Report

Global Environment Facility

UNEP

PREFACE

In accordance with Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC), all Parties are required to develop, periodically update, publish and make available to the Conference of the Parties, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol using comparable methodologies to be agreed upon by the Conference of the Parties.

A methodology for conducting such inventories was developed by the OECD Environment Directorate, the International Energy Agency (IEA), and the IPCC Working Group I Technical Support Unit and was proposed as the standard methodology as required under the Convention.

In order to test and further refine the method, the UNEP Atmosphere Unit, working in collaboration with the UNEP Global Environment Facility (GEF), implemented a series of nine complementary national studies using these "IPCC Guidelines for National Greenhouse Gas Inventories".

This report is one of the nine technical reports resulting from this effort. Based partly on this study and on a series of regional workshops sponsored by UNEP under the GEF funded programme and with the assistance of experts from a number of countries, an improved version of the IPCC Guidelines was prepared and approved at the Tenth Plenary Session of the IPCC in Nairobi (November 1994).

The First Conference of the Parties to the UNFCCC (Berlin, April 1995) also adopted the IPCC methodology as the recommended standard to be employed by all Parties in making their inventories in accordance with Article 4.

It is hoped that this report will assist other country study teams in the development and updating of future inventories of greenhouse gases.

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NATURAL RESOURCES AND FORESTRY
OF THE REPUBLIC OF POLAND

COUNTRY CASE STUDY ON SOURCES AND SINKS OF GREENHOUSE GASES IN POLAND

FINAL REPORT

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Entrusted by the Ministry of Environmental Protection, Natural Resources and Forestry with the role of Project Executive Agency, the National Foundation for Environmental Protection would like to express its recognition of, and gratitude for, the fruitful co-operation achieved with all those participating in the Project, and would seek to do this through the heads of the individual Subject Teams:

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- *Mr. M. Łaciński - carbon sequestered*
- *Dr. J. Bzowski - elaboration of computer model for GHGs estimation*

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PART O.

SUMMARY

0. Summary - A synthetic presentation of the Study

The Polish Study on Sources and Sinks of Greenhouse Gases in 1992 took in the estimation of emissions of the following gases recommended in the IPCC methodology:

- CO_2 - carbon dioxide,
- CH_4 - methane,
- N_2O - nitrous oxide,
- NO_x - oxides of nitrogen,
- CO - carbon monoxide,
- NMVOCs - non-methane volatile organic compounds.

The IPCC methodology recommended a structure of sources categories as presented below:

SOURCE/SINKS CATEGORIES

according to guidelines to National Inventories of Greenhouse Gases, Volume 1, Report Instruction IPCC/OECD Joint Programme, with adjustment to the Polish conditions

Note: Categories not reported in the Polish Study were marked by italic

****

1. ALL ENERGY

1.A. FUEL COMBUSTION

1.A.1 Energy & transformation industries

1.A.1. a Electricity generation

i Public electricity plants

ii Industrial electricity plants

1.A.1. b Combined Heat & Power Generation

i Public combined heat & power plants

ii Industrial combined heat & power stations

1.A.1. c District Heating

i Public heat plants

ii Industrial heat plants

iii Municipal heat plants

1.A.1. d Petroleum refining

1.A.1. e Production of solid fuels

1.A.1. f Other energy industries

1.A.2 Industry

1.A.2. a Iron & steel

1.A.2. b Non-ferrous metals

1.A.2. c Chemicals

1.A.2. d Pulp, paper & print

1.A.2. e Food processing, beverages and tobacco

1.A.2. f Other industries

1.A.3 Transport

1.A.3. a	Air transport		
	i	civil aviation	
	ii	other (private aviation, flying clubs, agricultural aviation)	
1.A.3. b	Road transport		
	i	private cars	
		i.a	four-stroke engines without catalytic converters
		i.b	two-stroke engines without catalytic converters
		i.g	engines with catalytic converters
	ii	motor vehicles with masses of up to 3500 kg	
		ii.a	four-stroke engines without catalytic converters
		ii.b	two-stroke engines without catalytic converters
		ii.g	engines with catalytic converters
	iii	motor vehicles with masses of more than 3500 kg	
		iii.a	heavy goods vehicles
		iii.b	buses
	iv	motorbikes	
	v	mopedes & autocycles	
	vi	tractors	
1.A.3. c	Rail transport		
1.A.3. d	Navigation on inland waterways		
1.A.3. e	Marine navigation		
	i	sea-going vessels	
	ii	fishing vessels	
1.A.3. f	Other types of transport		
	i	mobile technological machines	
	ii	other machines	
1.A.3. (2)	Transport - stationary sources		

1.A.4 Municipal management *(public/institutional)*

1.A.5 Residential sector

1.A.6 Agriculture and Forestry

1.A.7 Others

1.A.8 Traditional biomass burned for energy

1.B. Fugitive fuel emissions

1.B.1 Oil & Natural gas

1.B.1. a Oil system

- i extraction of oil
- ii transport
- iii oil refining & storage
- iv distribution of oil products
  - a wholesale distribution
  - b retail distribution

1.B.1. b Gas system

- i exploration
- ii processing
- iii transfer
- iv distribution

1.B.1 c Oil and gas production (when the two cannot be separated)

1.B.2 Coal mining

1.B.2 a Underground mining

- i mining activities - ventilation
- ii mining activities - desification
- iii post-extraction activities
- iv spoil heaps of post-production waste

1.B.2 b Open-cast mining

- i ventilation from deposits
- ii ventilation from rocks surrounding deposits
- iii post-extraction activities

****

2. INDUSTRIAL PROCESSES

2.A IRON & STEEL INDUSTRY

2.B NON-FERROUS METALS INDUSTRY

2.C INORGANIC CHEMICAL PROCESSES

2.D ORGANIC CHEMICALS PROCESSES

2.E NON-METALLIC MINERAL PRODUCTS

2.F OTHER

****

3. SOLVENT USE

3.A PAINT APPLICATION

3.B DEGREASING & DRY CLEANING

3.C CHEMICAL PRODUCTS MANUFACTURE/PROCESSING

3.D OTHER

****

4. AGRICULTURE

4.A ENTERIC FERMENTATION

4.A.1 Cattle
4.A.1 a Beef cattle
4.A.1 b Dairy cattle

4.A.2 Goats
4.A.3 Sheep

4.A.4 Pigs
4.A.5 Horses, *mules, asses*

4.A.6 *Buffalo*
4.A.7 *Camels & Lamas*
4.A.8 Other

4.B ANIMAL WASTES

4.A.1 Cattle
4.A.1 a Beef cattle
4.A.1 b Dairy cattle

4.A.2 Goats

4.A.3 Sheep

4.A.4 Pigs

4.A.5 Horses, *mules, asses*

4.A.6 *Buffalo*

4.A.7 *Camels & Lamas*

4.A.8 Other

4.C RICE CULTIVATION

4.D AGRICULTURAL SOILS

4.E AGRICULTURAL WASTE BURNING

4.F *SAVANNA BURNING*

4.G *OTHER*

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5. LAND USE

5.A. FOREST CLEARING

5.A.1 *Tropical*

5.A.1.a *Closed forest*

5.A.1.b *Open forest*

5.A.2 Temperate

5.A.3 *Boreal*

5.B CONVERSION OF GRASSLANDS TO AGRICULTURAL LANDS

5.C FOREST MANAGEMENT

5.C.1 *Tropical*

5.C.2 Temperate

5.C.3 *Boreal*

5.D *ABANDONMENT OF MANAGED LANDS*

****

6. WASTES

6.A LANDFILLS

6.B WASTEWATER

6.C *OTHER*

An overall estimation of net national emissions was obtained by consideration, research and estimation of the sources and sinks of the greenhouse gases in the six basic categories of the structure presented by the IPCC methodology (namely energy, industrial processes, solvent use, agriculture, land use and wastes). More than one year of intensive work by the research teams, co-ordinated by the Project Management Core Team, allowed for the working-out of national methodologies for the inventorying of greenhouse gases and thus constituted a valuable modification adjusting the IPCC methodology to the specifics of Polish conditions.

With the Study aim of maximal application of bottom-up methods, the detail in the categories under consideration is differentiated in relation to:

- the state of recognition in the course of research emission sources and sinks in the given categories,
- the possibility of the construction of a systemically-cohesive structure of categories,
- the availability of data on activity on the basis of reliable statistics,
- the possibility of selecting values for emission factors on the basis of Polish research (measurements, registers, balances of losses), or from Polish and foreign sources of data in the literature.

The final numerical results of inventorying calculations are presented on the following four levels of detail:

- an short summary report (Table 2),
- an extended summary report (Table 3),
- summary reports from each category (tables in Chapter C),
- detailed reports for each category (Tables 4-23, as well as tables in chapter C).

To the synthetic presentation of the Study results is attached Table 3 (Summary Report for National Greenhouse Gases Inventory) as an representative one.

- - - -

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORY (PART I) (Gg) — Table 3(1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2	CH4	N2O	NOx	CO	NMVOC
Total (Net)National Emission	359439.000	2473.920	50.200	1283.078	1609.474	644.864
1 All Energy (Fuel Combustion+Fugitive)	360988.057	821.323	5.794	1242.231	1494.971	415.878
1A Fuel Combustion	360926.728	28.638	5.794	1242.231	1494.971	376.801
1A1 Energy & Transformation Industries	223008.365	7.720	3.062	605.130	107.469	10.020
1A2 Industry (ISIC)	37259.165	10.408	0.286	135.302	41.436	23.312
1A3.1 Transport - Mobile Sources	29473.125	8.637	1.395	416.895	1282.997	333.848
1A3.2 Transport - Stationary Sources	1002.230	0.024	0	0.379	0.369	0.023
1A4 Commercial/Institutional	18.070	0.000	0.000	0.018	0.002	0.000
1A5 Residential	64933.003	1.616	0.871	39.069	25.196	2.502
1A6 Agriculture/Forestry	5232.770	0.232	0.166	45.439	37.502	7.096
1A7 Other						
1A8 Biomas Burned for Energy	4038.333	0.150	0.081	5.319	13.682	1.016
1B Fugitive Fuel Emission	·61.330	792.685	0	0	0	39.076
1B1a Oil System	52.784	0.517				33.789
1B1b Natural Gas System	8.545	163.672				5.288
1B2 Coal Mining		628.496				
2 Industrial Processes	10602.723	8.107	12.918	39.508	75.013	61.786
2A Iron and Steel	301.372	0.548	0	8.841	42.215	11.383
2B Non-Ferrous Metals	35.069	0	0	0.125	32.798	0.042
2C Inorganic Chemicals	1493.125	7.560	12.918	30.543	0	8.336
2D Organic Chemicals	0.085	0	0	0	0	12.811
2E Non-Metalic Mineral Products	7970.800	0	0	0	0	15.942
2F Other	802.271	0	0	0	0	13.271
3 Solvent Use	0	0	0	0	0	167.200
3A Paint Aplication	0	0	0	0	0	61.770
3B Degreasing and Dry Cleaning	0	0	0	0	0	21.845
3C Chemical Products Manufacture/Processing	0	0	0	0	0	6.750
3D Other	0	0	0	0	0	76.836

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORY (PART 2) (Gg)

Table 3(2)

GREENHOUSE GAS SOURCE AND SINK CATEGORIE	CO2	CH4	N2O	NOx	CO	NMVOC
4 Agriculture		703.607	31.487	1.338	39.431	
4A Enteric Fermentation		646.894				
4B Animal Wastes		55.586				
4D Agricultural Soils			31.430			
4E Agricultural Waste Burning		1.127	0.057	1.338	39.431	
5 Land Use & Forestry	-12151.780	0.004	0	0.001	0.059	
5A Forest Clearing & On-Site Burn.	244.273	0.004	0	0.001	0.059	
5B Grassland Conversion	5236.000					
5C Managed Forests	-17632.052					
5D Abandonment of Managed Lands						
6 Waste		940.878				
6A Landfills		844.433				
6B Wastewater		96.445				
6C Other						

0.1. Global Warming Potential

Data for the determination of global warming potential were taken from the short summary report (Table 2 Short Summary Report for National Greenhouse Gases Inventory).

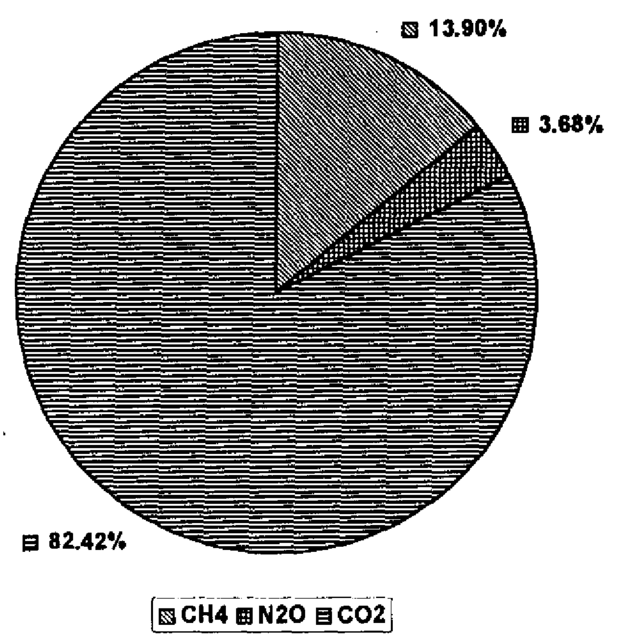
Applied in the calculation were factors for CO_2 equivalents of CH_4 and N_2O (100 years), in accordance with the publication entitled "Radiative Forcing of Climate Change 1994" (Report of the Scientific Assessment Working Group of IPCC, Summary for Policymakers). The results of the calculations are presented in Table I.

Table 1. Global Warming Potential (1992)

Gas	Emission [Gg]	CO_2 - Equivalent Factor	CO_2 - Equivalent [Gg]	Share of Total Emission [%]
CO_2	359439.00	1.00	359439.00	82.42
CH_4	2473.92	24.50	60611.00	13.90
N_2O	50.20	320.00	16064.00	3.68
Total			436114.00	100.00

The roles of CO_2, CH_4 and N_2O in terms of global warming potential are presented graphically in Fig. I.

Fig.I. Shares of CO_2, CH_4 and N_2O Emissions in Global Warming Potential (GWP), 1992



0.2. The Division of Global Warming Potential by Categories of Emissions and Sinks

The division of Global Warming Potential by categories was made using data from Table 2 in the Study Report (the short summary report). Data for the estimation of Gg emissions and sinks of CO_2, CH4 and N_2O are presented in Table II, along with their CO_2 equivalents.

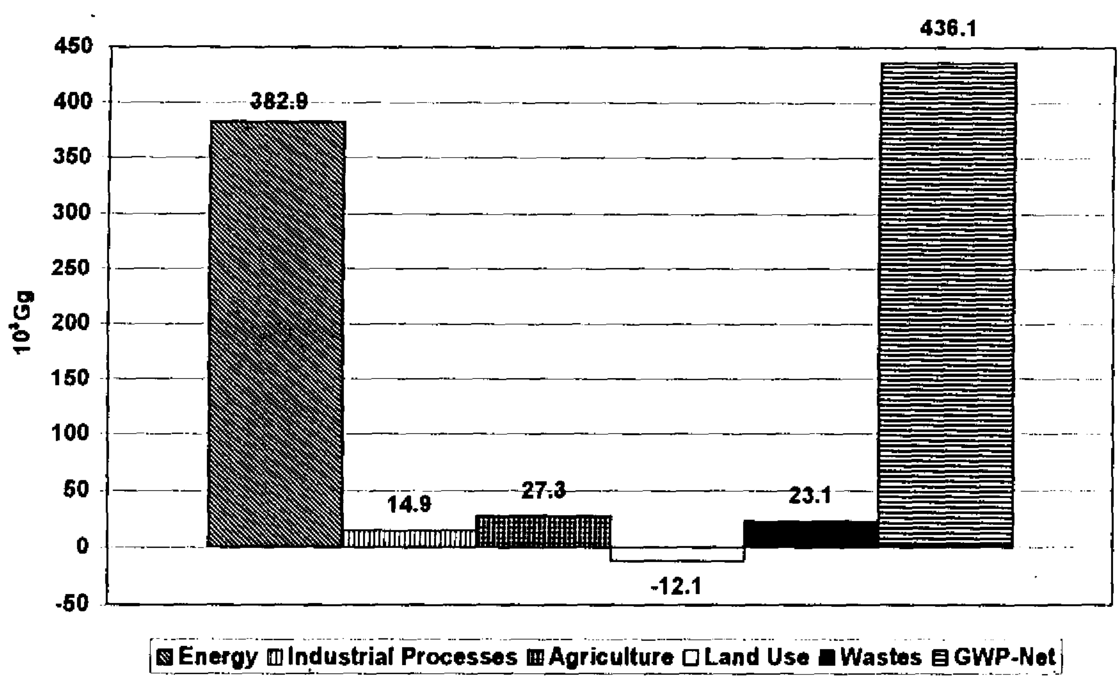
Table II. Shares of Emission Categories in Global Warming Potential (1992)

No.	Category	CO_2 [Gg]	CH_4 [Gg]	N_2O [Gg]	CO_2 - equivalent [Gg]
1	Energy	360988.10	821.30	5.80	382963.20
2	Industrial Processes	10602.70	8.10	12.90	14936.80
3	Solvent Use	NO	NO	NO	NO
4	Agriculture	NO	703.60	31.50	27314.20
5	Land Use	-12151.70	0.00	0.00	-12151.70
6	Wastes	NO	940.90	NO	23051.50
Total					436114.00

Note: NO means that there is no emission in this category.

Presented graphically in Fig. II is the Global Warming Potential by categories of emission and sink.

Fig.II. Global Warming Potential (GWP) According to Emission and Sink Categories



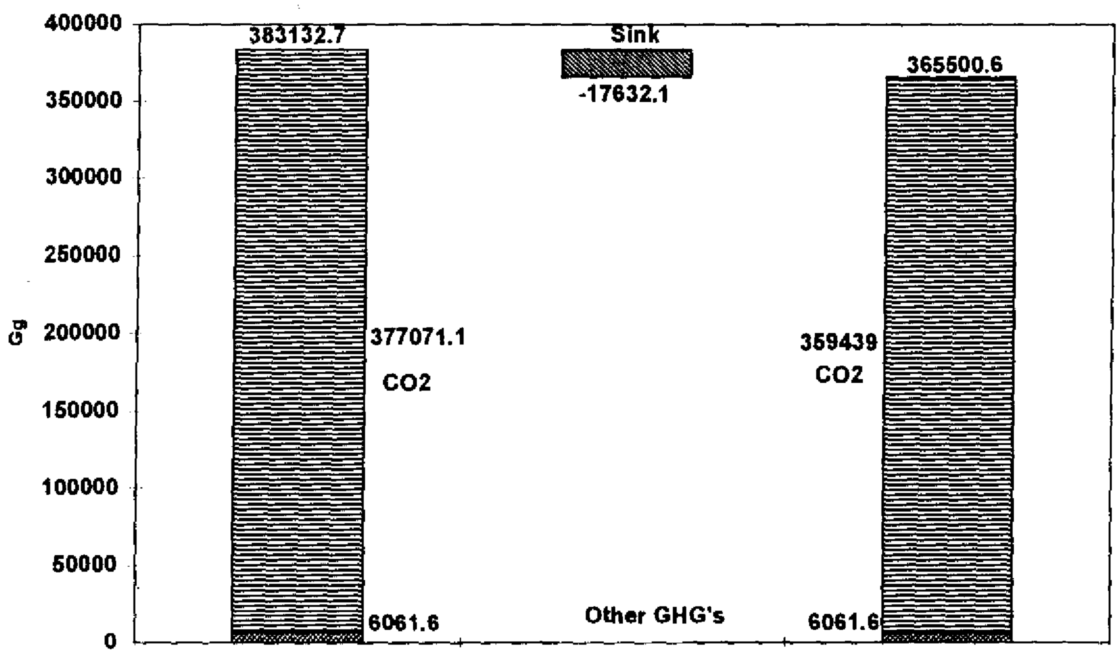
0.3. Analysis of emissions and sinks of greenhouse gases.

0.3.1. Total emissions.

In the direct emission of greenhouse gases, the value for the emission of CO_2 (377,071.1 Gg) represents 98.42% of the total, while, at 6061.6 Gg, the total for the other gases (CH_4, N_2O, NO_x, CO and NMVOCs) put together constitutes only 1.38 %. To graphical presention of the total direct emission, a diagram (fig. IIIa) was drawn with the following structure:

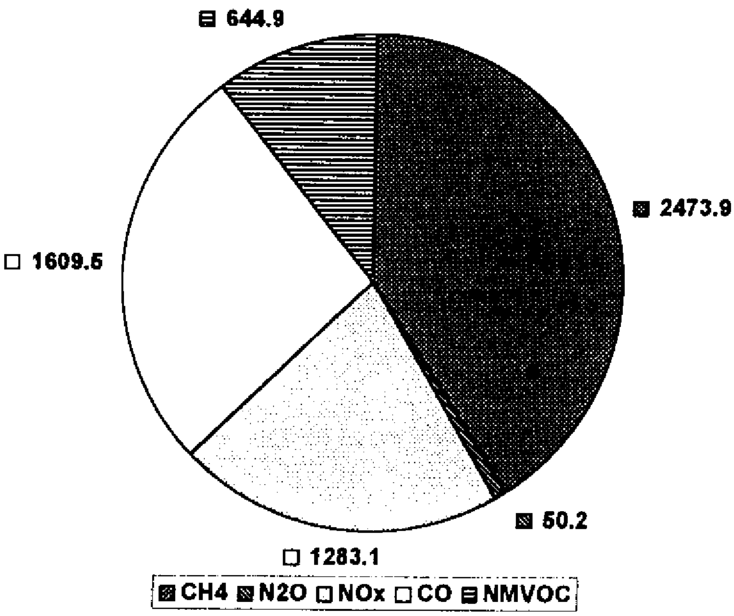
- a first column representing direct emissions of all the greenhouses gases estimated together with their precursors, and with a subdivision into CO_2 and other gases,
- a second column representing the estimated size of sinks for CO_2,
- a third column representing the direct emission of all gases after sinks have been deducted, with a subdivision into CO_2 and other gases.

Fig.IIIa. Total Emission of all Estimated GHG's in 1992, Taking Sink into Cosideration



For the graphical presentation of direct emission of greenhouse gases other than CO_2 (total 6061.6 Gg), Figure IIIb gives consideration to emissions of CH_4, N_2O, NO_x, CO and NMVOCs.

Fig.IIIb. CH_4, N_2O, NO_x and NMVOC Emissions in 1992 (emissions in Gg - total emission 6061.6Gg)

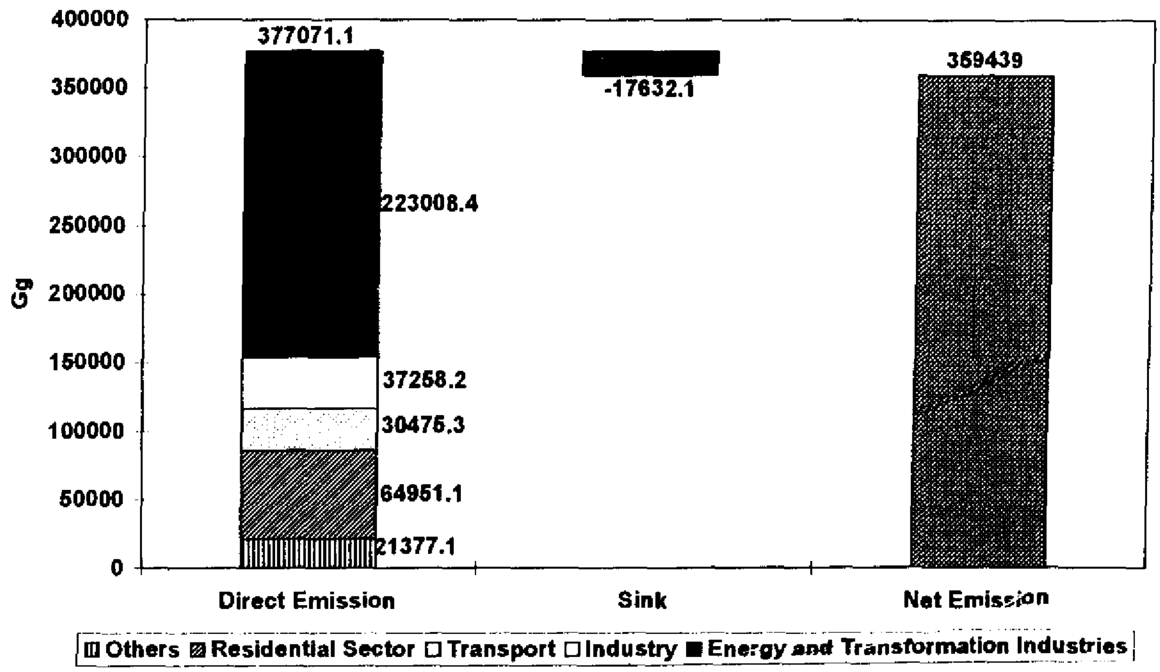


0.3.2. Analysis of emissions and sinks of CO_2

Direct emission of CO_2 is presented in Fig. IVa, which is arranged in the following way:

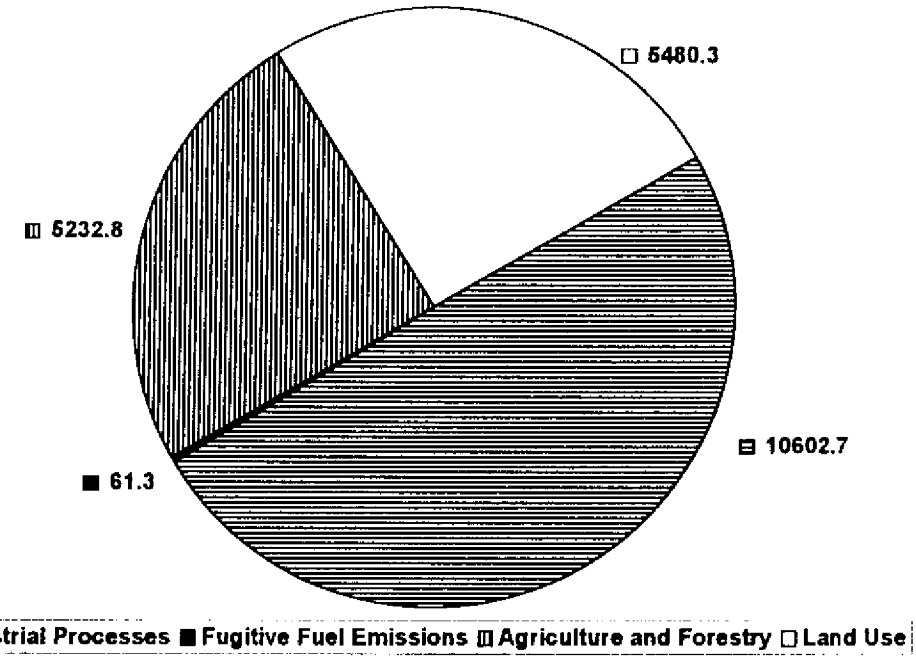
- the first column represents the direct emission of CO_2 ,
- the second column represents the estimated size of the sinks for CO_2;
- the third column illustrates the net emission of CO_2.

Fig.IVa. Direct CO_2 Emission Ordered by Categories and Net CO_2 Emission



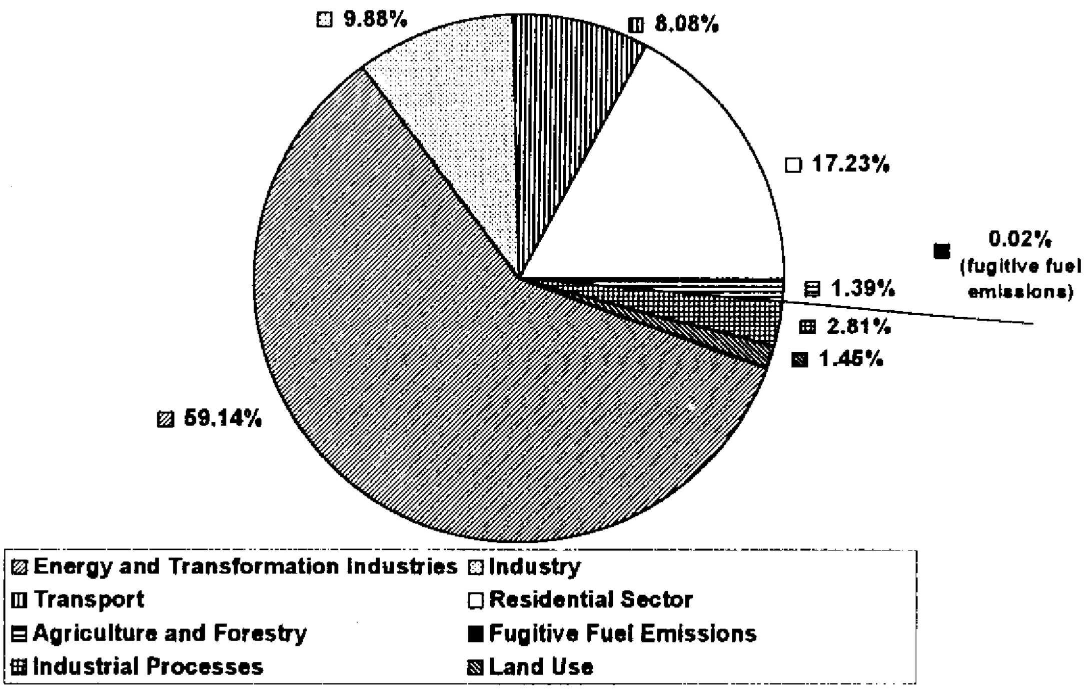
Emission estimated for group of categories occurred in first column of Fig. IVa as remaining (because of small value of emission), are presented in detail, with subdivision into different categories - in Fig. IVb - as supplement of information.

Fig.IVb. Direct CO_2 Emissions for Remaining Categories (emissions in Gg - total emission 21377.1Gg)



The percentage role of the direct emission of CO_2, ordered by categories are presented in the Fig.V

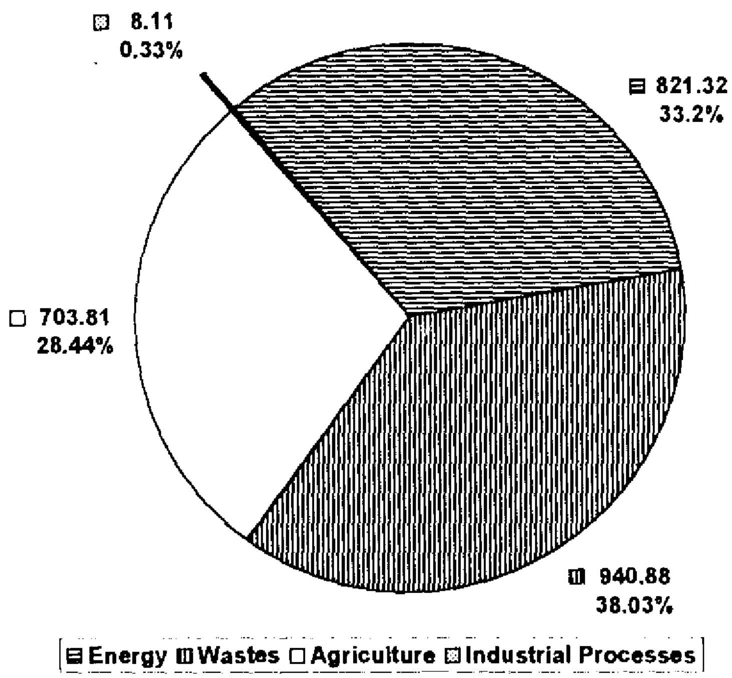
Fig.V. Direct CO_2 Emission contribution by Categories in Percentage



0.3.3. Emissions of CH_4

Fig. VIa. presents direct emissions of methane estimated in the categories considered and totalling 2473.92 Gg.

Fig.VIa. CH_4 Emissions by Categories (emissions in Gg - total emission 2473.92 Gg)



Emissions of CH_4 in the different categories, are also presented by way of the following diagrams:

Fig. VIb.	-	energy, with a subdivision into fuel combustion and fugitive emissions,
Fig. VIc.	-	agriculture, with a subdivision into enteric fermentation, animal wastes and the agricultural waste burning,
Fig. VId.	-	wastes, with a subdivision into landfills and wastewaters.

Fig.VIb. CH_4 Emission in Energy Category (emissions in Gg - total emission 821.32Gg)

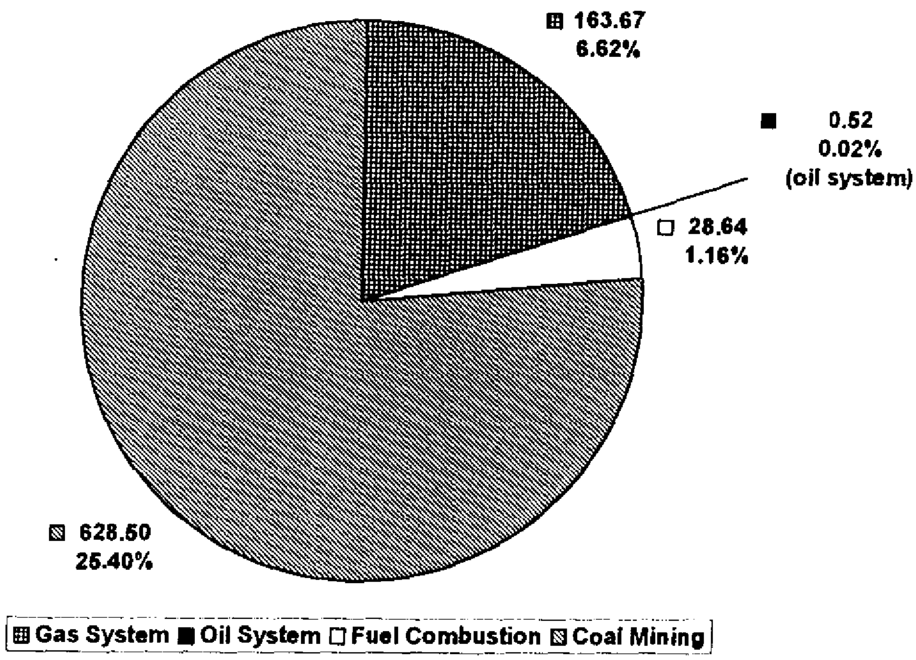


Fig.VIc. CH_4 Emission in Agriculture Category (emissions in Gg - total emission 703.61Gg)

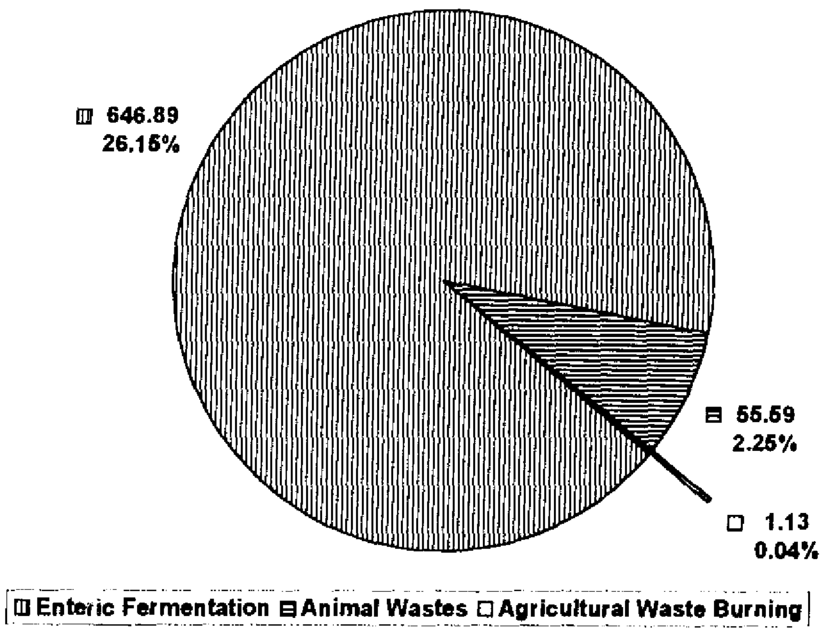
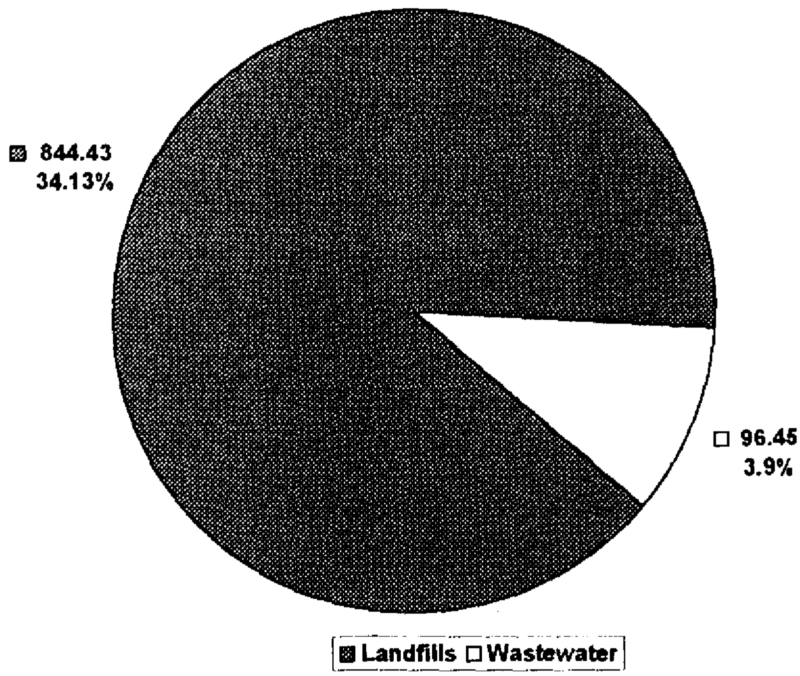


Fig.VId. CH_4 Emission in Wastes Category (emissions in Gg - total emssion 940.88Gg)



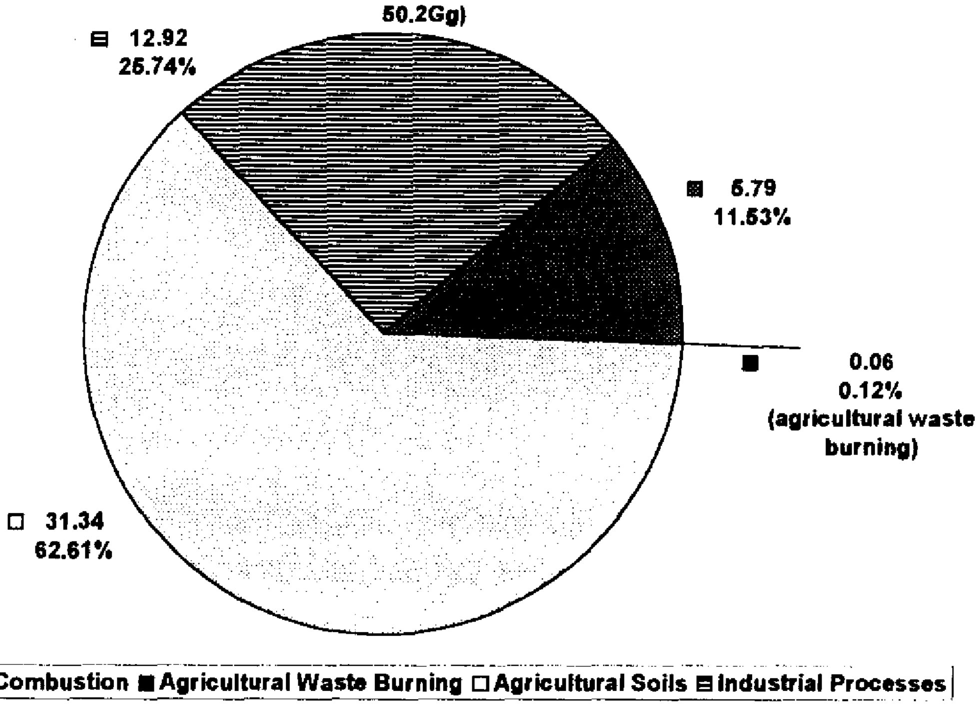
0.3.4. Emissions of N_2O

Emissions of nitrous oxide (total 50.2 Gg) were estimated in the following categories of emission sources:

- fuel combustion
- industrial processes,
- agricultural soils,
- agricultural waste burning.

The roles of the different categories are presented in Fig. VII.

Fig.VII. N_2O Emission Contribution by Categories (emissions in Gg - total emission 50.2Gg)



0.3.5. Emissions of NO_x

Emissions of oxides of nitrogen (total 1283.08 Gg) were estimated in the following categories of emission sources:

- fuel combustion,
- industrial processes,
- agricultural waste burning,
- forest clearing

Fig. VIIIa presents emissions of oxides of nitrogen in the aforementioned categories, with omission of emission originating from forest clearing (because of its small value).

Fig.VIIIa. NO_x Emission Contribution by Categories (emissions in Gg - total emission 1283.08Gg)

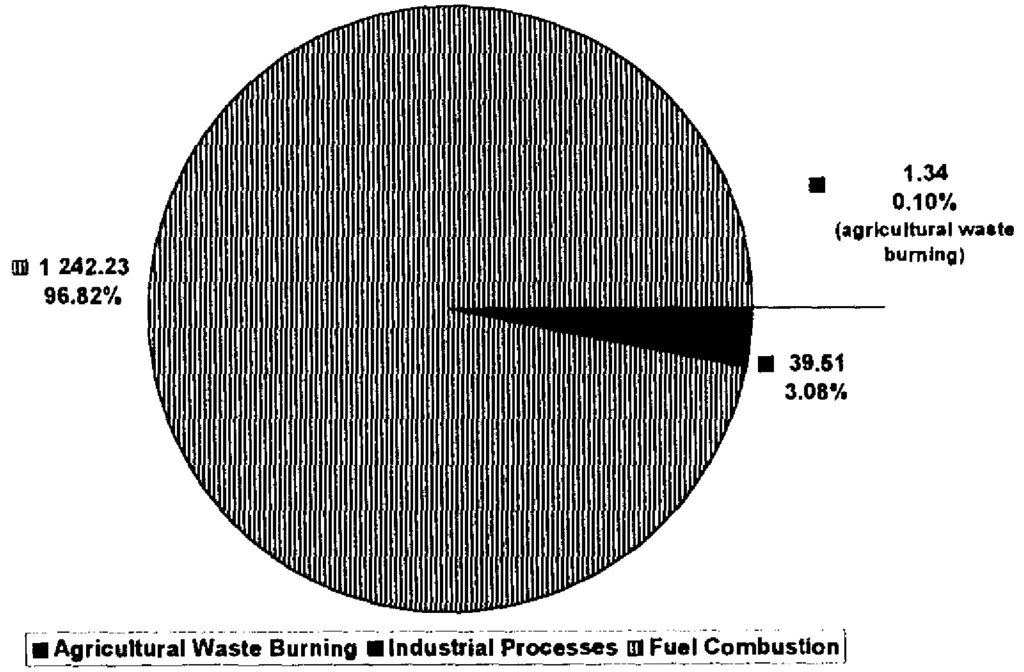
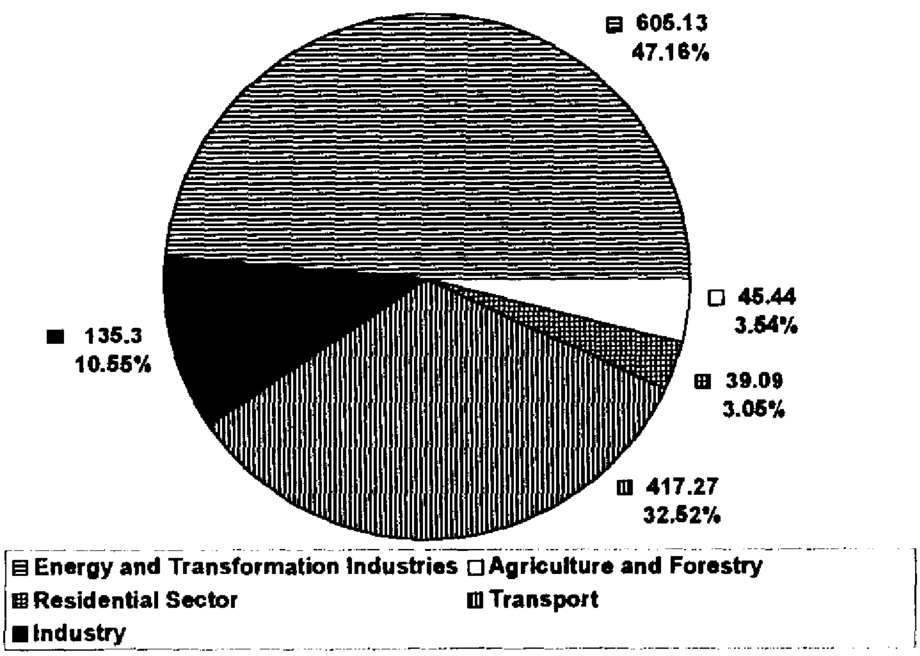


Fig. VIIIb shows in detail emissions of NO_x from fuel combustion, with a division into energy and its transformation, industry, transport, residential sector and municipal management, and agriculture & forestry.

Fig.VIIIb. NO_x in Fuel Combustion Category (emissions in Gg - total emission 1242.23Gg)



0.3.6. Emissions of CO

Emissions of carbon monoxide (total 1609.47 Gg) were estimated in the following categories:

- fuel combustion
- industrial processes
- agricultural waste burning,
- forest clearing

Fig. IXa presents emissions of carbon monoxide in the aforementioned categories, with omission of emission originating from forest clearing (because of its small value).

Fig.IXa. CO Emission Contribution by Categories (emissions in Gg - total emission 1609.47Gg)

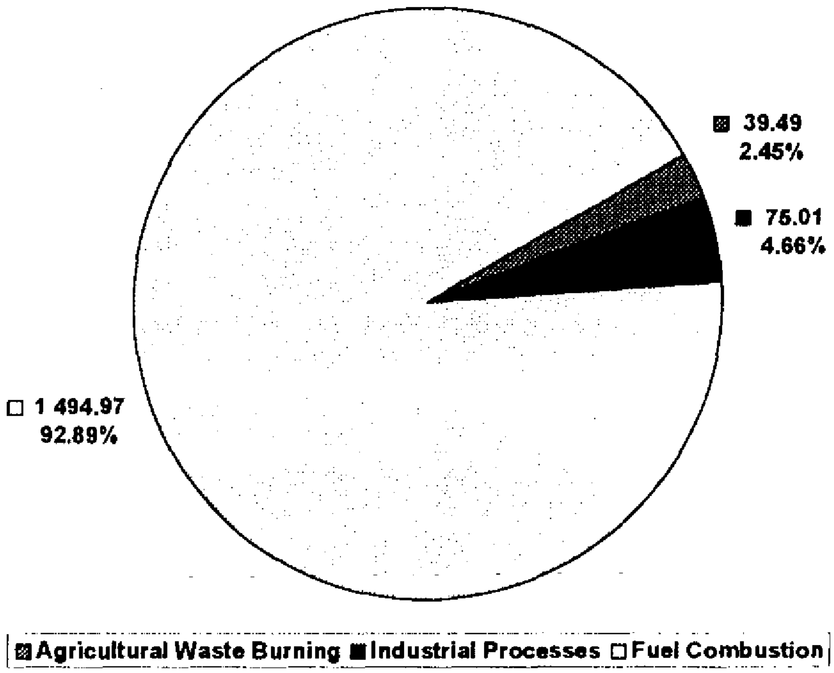
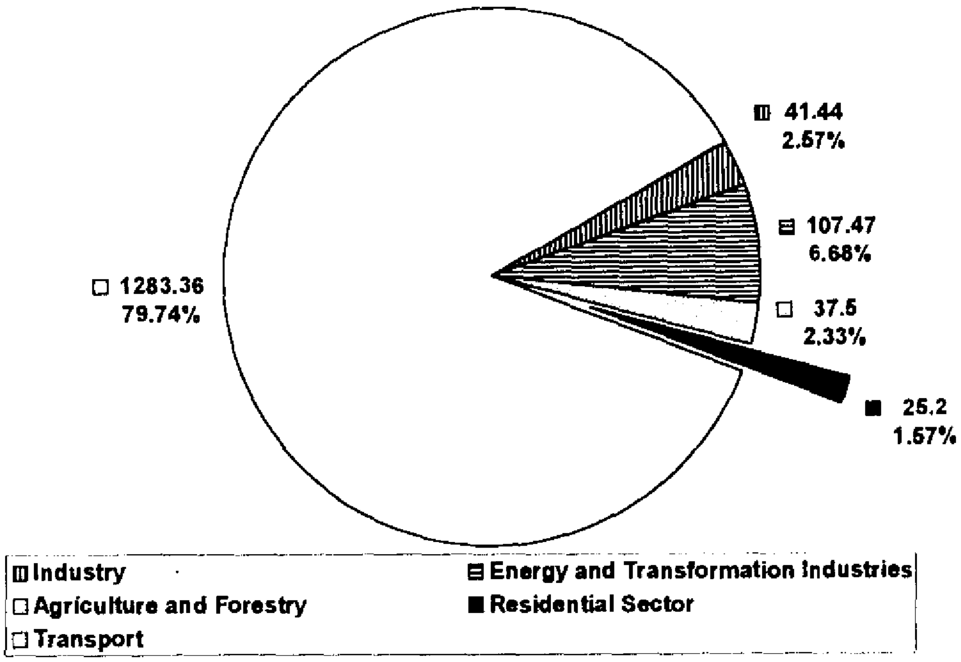


Fig. IXb shows in detail emissions of CO from fuel combustion, with a division into energy and its transformation, industry, transport, residential sector and municipal management, and agriculture & forestry.

Fig.IXb. CO Emission in Fuel Combustion Category (emissions in Gg - total emission 1494.97Gg)



0.3.7. Emissions of NMVOCs

Emissions of non-methane volatile organic compounds (total 644.86 Gg) were estimated in the categories:

- fuel combustion
- fugitive fuel emission
- industrial processes
- solvent use.

Fig. Xa presents emissions of NMVOCs in aforementioned categories.

Fig.Xa. NMVOC Emission Contribution by Categories (emissions in Gg - total emission 644.86Gg)

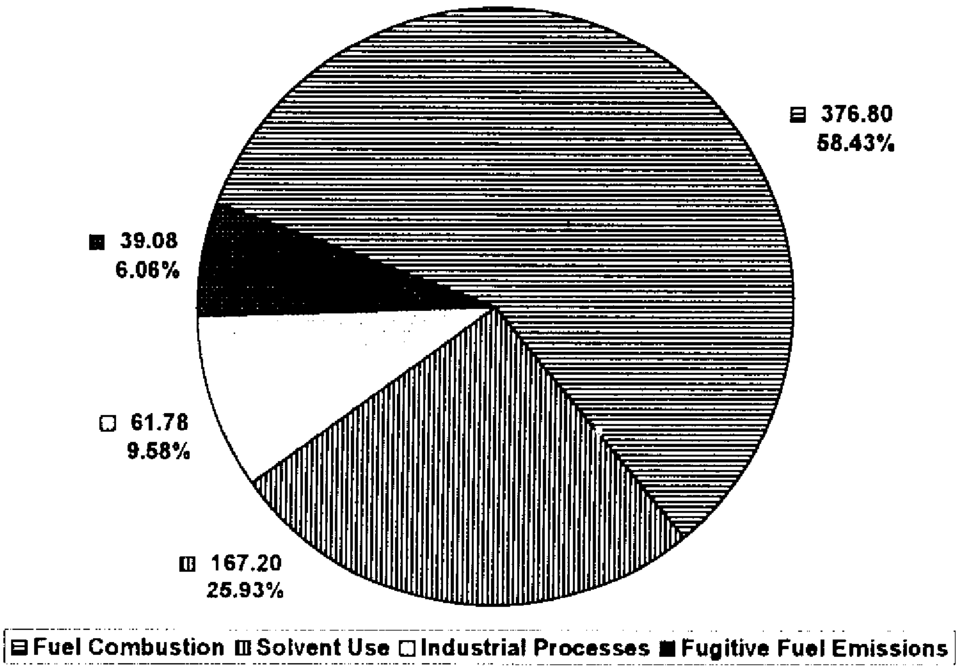
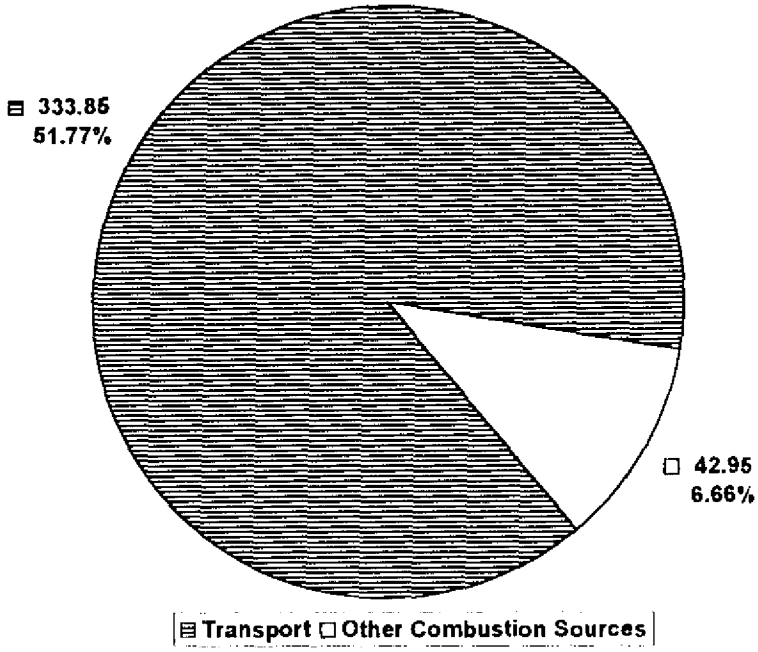


Fig. Xb presents the emissions of NMVOCs in detail from fuel combustion only, with a subdivision into transport and other sources of fuel combustion.

Fig.Xb. NMVOC Emission in Fuel Combustion Category (emissions in Gg - total emission 376.80 Gg)



0.4. Polish emission factors for greenhouse gases

Synthetic factors for the annual emissions of the different greenhouse gases are presented in the form of:

- emission factors for CO_2 per unit area of the country - $EF_{a,CO2}$
- emission factors for CO_2 per inhabitant - $EF_{inh,CO2}$

The assumption that the emission of CO_2 is representative of Poland's emissions of greenhouse gases is reasonable when it is recalled that emissions of other greenhouse gases amount to less than 2% of the total.

Table III presents the values for emission and emission factors for CO_2 for the years 1988, 1990 and 1992, with the source of the data given.

Table III. CO_2 Emission and Country CO_2 Emission Index

Source	Emission CO_2 [Gg]	$EF_{a,CO2}$ Index [Mg/km^2]	$EF_{inh,CO2}$ Index [Mg/mieszk.]
FEWE (IPCC), 1988	483700	1547.0	12.76
ATMOTERM (CORINAIR), 1990	414930	1303.4	10.64
NFEP (IPCC), 1992	359439	1152.0	9.36

PART A.
INTRODUCTION

A. Introduction

A.1. The bases of UNEP/GEF Project

In the 1980s, the results of scientific research concerning the observed and predicted negative effects of climatic change aroused the serious interest and disquiet of the specialist agencies of the United Nations.

Set up in 1988, under the auspices of the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO), was the International Panel on Climate Change (IPCC). This was to be a separate, specialist organizational structure which was to concern itself with the aforementioned matters.

Intensive work by IPCC led to the conclusion, in 1990, that "emissions associated with human activities have increased significantly the amounts of greenhouse gases in the atmosphere and are in consequence enhancing the greenhouse effect and giving rise to the warming of the Earth's surface". Noted in this way was the necessity for: the development of a system by which different countries could observe the climate, the improvement of climatic models and the international exchange of national data and international research.

The second World Climate Conference, organized at the end of 1990 by UNEP, WMO, UNESCO, FAO and other UN agencies, was to underline the need for international assessments of the levels of emissions and captures of greenhouse gases, recommending at the same time that this work be co-ordinated by IPCC. The Conference also revealed the general lack of information on the sizes and sources of emissions in developing countries. In consequence, it was agreed that the task of obtaining reliable, global measurements would require the granting of appropriate financial and technical resources to many countries.

The work done by the organizational structures (thematic working groups) of the IPCC gained valuable support from the Organization for Economic Co-operation and Development (OECD). In 1991, this organization held in Paris an international workshop commencing work on a unified methodology for the determination of emissions and sinks of greenhouse gases, as well as a reporting format that would be appropriate for use in all countries. Participating in the Paris workshop were more than 100 experts from 44 countries.

The main result of the workshop was agreement on methodological assumptions. It was also noted once again that there was a lack of information on levels of emissions of greenhouse gases from developing countries, and it was realized that this constituted a major barrier to international co-operation to reduce emissions. It was also recognized that the completion of the studies undertaken by a series of countries would make it easier for the problem to be solved, through the provision of more exact estimates of global emissions and the development of a basis for the exchange of data and the further refinement of methodologies.

In March 1991, the plenary session of IPCC gave its backing to the preliminary methodology drawn up in the course of the Paris workshop. There was also a restating of the opinion regarding the pre-eminent need for studies in developing countries. It was also recommended that country-based inventories of emissions be drawn up as an indispensable aid to further work.

On the basis of conclusions from the work done within the framework of the IPCC/OECD structure, UNEP and the Global Environment Facility took (in 1992) the decision to establish a special projects entitled "Country Case Studies for Sources and Sinks of Greenhouse Gases".

The co-operation of Poland in the work of UNEP-WMO and IPCC/OECD created a good base for the positive consideration of the declaration from the Ministry of Environmental Protection, Natural Resources and Forestry concerning the role of Poland in the UNEP Project. The Project now embraces 11 countries, of which Poland is one.

A.2. Polish participation in the work of IPCC/OECD

Poland has taken an active part in the action inspired by IPCC/OECD. Study work connected with the preliminary inventorying of sources and sinks of greenhouse gases in Poland was carried out in the years 1991-1992 and involved a series of study groups from various centres of scientific research. A considerable input was also provided by non-governmental organizations - the Foundation for the Efficient Use of Energy and the National Foundation for Environmental Protection.

The Ministry of Environmental Protection, Natural Resources and Forestry was the initiator and sponsor of those works, as the competent governmental agency.

The first inventory of emissions of greenhouse gases was drawn up in 1988 in accordance with the methodology of Polish experts, before the publication of the preliminary international methodology entitled " Estimation of GHG Emissions and Sinks, Final Report OECD/IPCC, August 1991". The inventory covered: the power supply industry, transport, agriculture and forestry, as well as landfill sites and sewage treatment plants.

The second inventory was undertaken in accordance with IPCC methodology contained in the aforementioned document. The inventory included estimations of the following emissions:

- of all greenhouse gases, on the basis of the activity of energetic sources involving combustion (1.A) and using the "top-down" method, with subdivision to the level of the sector restricted to transport (1A.3) - for which emissions were calculated using the "bottom-up" method;
- of fugitive fuels in system 1.B (involving coal) only;
- from industrial processes, but restricted to the production of cement (2.E);
- from agriculture, and with account taken of enteric fermentation (4.A), animal wastes (4.B), agricultural soils (4.D) and the burning of agricultural wastes (4.E);
- from wastes, albeit with consideration restricted to landfill sites (6.A).

The results of this inventory were not complete, on account of the discovered lack of applicable methodology for given sets of source category, and also on account of the failure to supply the emission factors and statistical data needed for the determination of the activity of particular sources of emission. Ignored completely were emissions from the use of solvents (3) and from changes in land use (5).

The synthetic results of the work and resulting research problems and conclusions were presented in three publications, which were produced for the needs of the Ministry of Environmental Protection, Natural Resources and Forestry by the Foundation for the Efficient Use of Energy:

1. The GHG Emissions Inventory for the Year 1988 in Poland, Final Report, FEWE (Foundation for the Efficient Use of Energy), December 1991.
2. "Uwarunkowania Inwentaryzacji Emisji i Wychwytu Gazow Cieplarnianych w Polsce w 1988 roku", ("The Conditioning of the Inventory of Emissions and Sinks of Greenhouse Gases in Poland in 1988"), FEWE, December 1991.
3. "Metodyka Oszacowania Emisji i Wychwytu Gazow Cieplarniarnych" ("A Methodology for the Estimation of Emissions and Sinks of Greenhouse Gases"), FEWE, December 1991.

The findings of the first inventory may be characterized as follows:

- figures were obtained for a significant number of emission sources, and these made it possible to estimate emissions for base year 1988, which was recognized as the reference year in negotiations on the stabilization and reduction of emissions in future years,
- drawn up on the basis of analysis of the IPCC methodology was a set of research problems for the needs of future inventories.

The research problems and conclusion resulting from the inventory were also presented by way of papers given in the international IPCC fora at Berkeley, U.S.A. (September 1992); Bracknell, U.K. (October 1992); Bratislava, Slovakia (October 1993) and Bonn, Germany (April 1994).

A further effect of the discussed activities was the making-available to Polish research centres of a Polish-language version of the "IPCC Methodology". This widened the group of researchers interested in the problems of inventorying greenhouse gases.

A.3. The United Nations Framework Convention on Climate Change

A significant result of the actions of UNEP, in co-operation with international organizations and governmental agencies, has been the drawing-up of the UN Framework Convention on Climate Change. This Convention was signed by many countries (including Poland), during the UN World Conference on Environment and Development at Rio in June 1992. Poland ratified the Convention in June 1994 and in so doing took on defined formal obligations whose realization has been recognized as a continuous process to be developed within the country.

Counted among the most important tasks to be carried out continuously are:

- periodic inventorying of emissions and captures of greenhouse gases (GHG), along with the broadest possible monitoring of them,
- actions to stabilize and progressively reduce emissions of GHG as conditioned by the developmental assumptions of the country.

The actual formal scope of Poland's obligations under the Framework Convention on Climate Change (FCCC) are to be established in the course of negotiations at the Conference of Parties to the Convention (CoP). The formal basis for the negotiation process at the CoP will be a national report made up of the following four parts:

A. General economic, social and political information which emphasizes the priorities for the development of the national economy, along with the submission of a characterization of sources and sinks of greenhouse gases and a highlighting of the role played by Poland in the global greenhouse effect.
B. An inventory of emissions and captures of greenhouse gases in reference year 1988 and in subsequent years.
C. A projection of emissions of greenhouse gases in the light of strategies for the development of the country and conditioned by scenarios for the limitation of these emissions.
D. A strategy for adapting society, the natural environment and the national economy to climatic change.

With the aim of ensuring effective co-ordination of study and organizational work in the field under consideration, the Minister of Environmental Protection, Natural Resources and Forestry called into being a Centre for the Protection of the Climate in 1992. In co-operation with interested institutions and organizations, this Centre worked on a plan for a Country Study under the title of "A Strategy for the Reduction of Emissions of Greenhouse Gases in Poland and for Adapting Polish Society and the Polish Economy to Climate Change". This Study embraced 3 major themes:

- a Country Study of Sources and Sinks of Greenhouse Gases in Poland (realized within the framework of the UNEP/GEF Project),

- a Strategy for the Limitation of Emissions and for Adaptation (realized in co-operation with the US Department of State),

- Methodological Research and Monitoring (domestic works).

PART B.

A GENERAL PRESENTATION OF THE POLISH STUDY

B. A general presentation of the Polish Study

B.1. Aims of the UNEP/GEF project

The aim of the long-term master project from UNEP is to understand the role of emissions and captures of greenhouse gases in nature and human life, as well as to define strategies and technologies which - when implemented in national plans - will have the effect of minimizing the harmful effects of excessive emissions of greenhouse gases.

The direct aims of the project are:

- to develop the inventorying of emissions of greenhouse gases at the level of countries,
- to improve the system for the collection and gathering of data on the sizes and sources of emissions,
- to strengthen the links between countries and international organizations concerned with climatic change and its causes,
- to improve a unified international methodology for the evaluation of emissions and captures of greenhouse gases,
- to give possibilities for the governments of different countries to make use of data on the sizes of estimated emissions as well as the methodological and organizational conclusions constituting the results of the Project, in the process of developing the national strategies and technologies which will minimize emissions of greenhouse gases.

An important further aim of the project is to grant consultative and financial help for country studies.
The following aims are to be considered among the most important to be attained as the study for the needs of Poland was drawn up:

A. The production of the inventory, including:
- the application of the third version of the IPCC methodology [3] in the inventorying of the 1992 emissions and captures of greenhouse gases in Poland;
- the modification of the supplied methodology for some studied categories of emission source, in order to approximate Polish conditions more closely;
- the augmentation of the set of Poland-specific emission factors;
- the improvement of the methods for the determination of the activity of different emission sources on the basis of national statistics;

- the compilation of a list of new research problems to be investigated in order to increase the reliability of inventories in successive years (a routine task incumbent upon Poland as a Party to the Framework Convention on Climate Change);
- The drawing-up of new methods for the collection, organization and storage of statistical data for each of the categories of emission source.

B. In accordance with the IPCC principles for reporting, the utilization of the results of the inventory in the shaping and implementation of the State Ecological Policy, as well as in the negotiation process within the framework of the FCCC,

C. The supply of the information base to the research team working on a strategy for the reduction of emissions of greenhouse gases and a strategy for adaptation in the future up to the year 2030.

D. Investigation of the range of possibilities for using the CORINAIR methodology in the inventorying of greenhouse gases in accordance with the requirements of the IPCC.

E. The working-out of a computer model for the inventorying of emissions of greenhouse gases and for the reporting of the inventory in accordance with IPCC principles.

F. The creation of a network of research centres and individual experts which may develop research and produce expert opinions in fields associated with the inventorying of emissions and sinks of greenhouse gases for the needs of the respective reports involved in the implementation by the State authorities of the Framework Convention on Climate Change ratified by Poland.

B.2. A strategy for the implementation of the Study

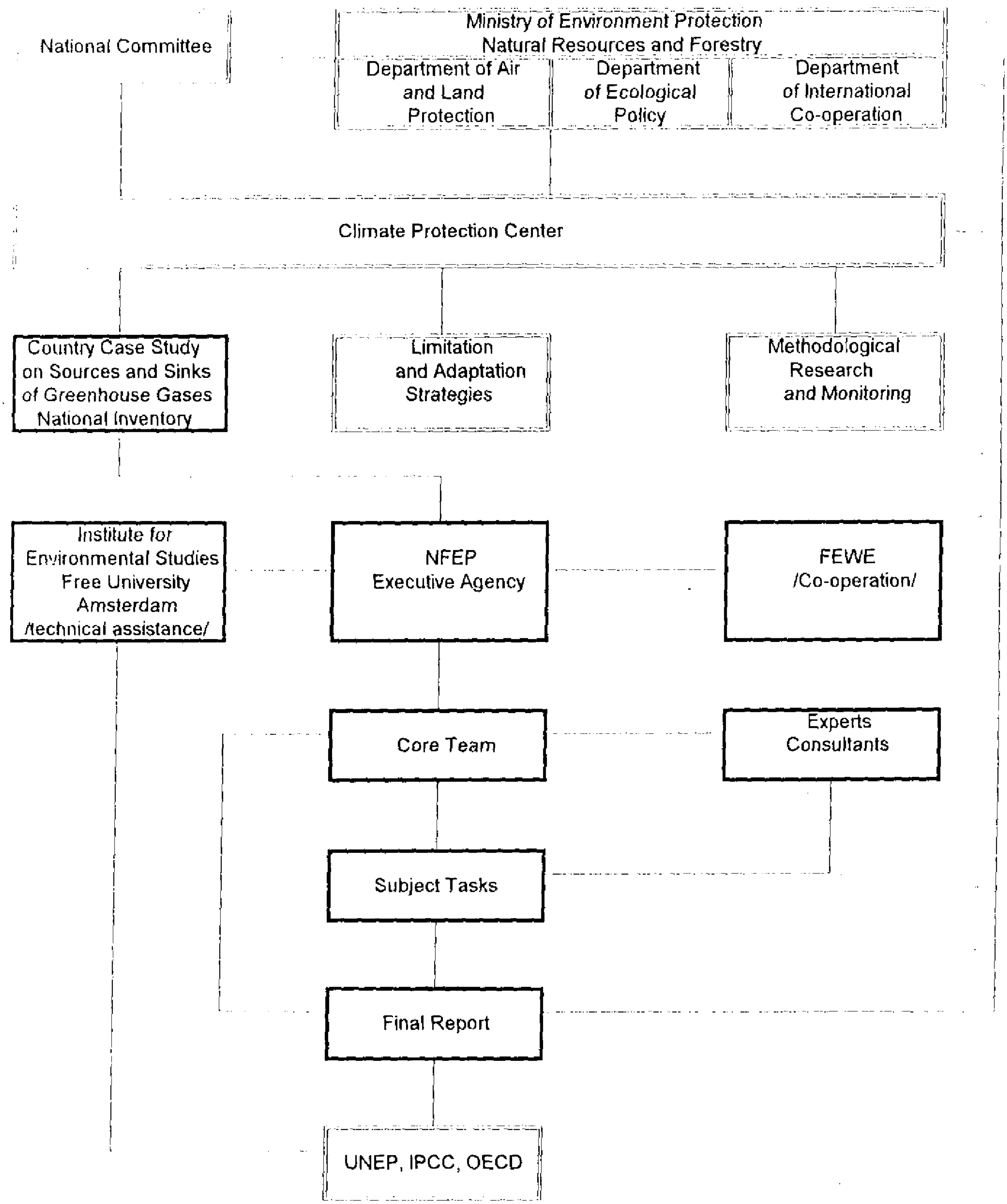
As a consequence of the positive results of co-operation to date between the National Foundation for Environmental Protection and UNEP (in the Polish Study of Biological Diversity), as well as the experience of the Foundation in relation to emission sources and the protection of the air, the Ministry of Environmental Protection, Natural Resources and Forestry entrusted NFEP with the function of executive agency for the Country Study of Sources and Sinks of Greenhouse Gases in Poland.

Considering the great national and international significance of the task entrusted to it, NFEP worked with the Ministry, the Polish Centre for the Protection of the Climate and the Foundation for the Efficient Use of Energy to undertake a series of preparatory actions at the beginning of 1993. To be mentioned as the tasks of greatest significance in the preliminary period are:

- the creation of a team to co-ordinate the study and organizational work,
- the determination of the division of topics and part-tasks against the background of the OECD/IPCC methodology, and the creation of a structure for the execution of the project through the interesting and selection of Polish institutions as well as specialists in the required fields,
- the drawing-up of a Project Proposal,
- the concluding of the appropriate national and foreign agreements.

The general organizational structure of the Project is presented in the appended schematic representation (figure 1).

PROJECT LOGISTIC STRUCTURE



The Project Proposal gained a positive evaluation from the Institute for Environmental Studies of the Free University in Amsterdam, which UNEP had tasked to serve as consultant and co-ordinator in the realization of the Polish Project. An equally-positive opinion was given by UNEP and the consequence was the Memorandum of Understanding reached with the Ministry of Environmental Protection, Natural Resources and Forestry in relation to the Country Study of Sources and Sinks of Greenhouse Gases in Poland. This document made possible the completion of the preparatory work undertaken previously.

A certain obstacle to the activities of the Project Direction Team in this phase was the need to adjust the programme structure presented in the Project Proposal in order that it would come into line with the IPCC methodology for inventories of emissions of greenhouse gases which had been modified in the meantime. The recommended methodology introduced significant changes to the categories of emission source. This required both detailed verification of the scope of the different thematic tasks agreed upon as well as the updating of the stepwise timetable for their realization. In the time-consuming process of negotiation resulting from it, as well as in substantive and formal agreements, a major element was the organization of a "workshop" concerning program-related, methodological and organizational aspects. Also provided for in this phase was the co-ordination of part-tasks against the background of the substantive connections between the different tasks.

The point of entry and basis of the strategy for the implementation of the study was the programme of research work and divisions of them worked on by the Project Core Team. The strategy for implementing the Study was based upon a logistic procedure for the co-ordination of the issues linked with the subjects being researched in the different categories of emission.

In accordance with the substantive and organizational guidelines laid down by the Project Core Team, each study team drew up a plan and timetable for its research in line with the research aims and tasks of the Study.

Methodological and inventorying work was carried out between November '93 and April '94 within the framework of all the tasks. Information on methodological modifications presented by the different research teams was continually updated in works on the mathematical model for the calculation of emissions in different source categories and on the procedures for summing results in accordance with IPCC recommendations.

Unanticipated difficulties arose with the presentation of a new improved version of the IPCC methodology, volumes I and II of which arrived in February and volume III in March. These times were intended to constitute the final phases of the methodological work. Failing in this case was the co-ordination of the deadline for the IPCC work with the deadline requirements of UNEP in relation to the Country inventory studies. The only possible solution was the introduction by the research teams of additional studies aiming to set the worked-out modifications against the new guidelines of IPCC.

June 1994 saw the completion of the work connected with the estimation of levels of emission, as well as the working-out of guidelines concerning the modification of the system of inventorying work and methodological aspects.

The National Workshop entitled "The Emission of Greenhouse Gases in Poland" took place in Warsaw on 21 September, and was the first wider forum for the working presentation of the aims, substantive and organizational structures and results within the framework of the Study. The discussion and conclusions of the Workshop provided very valuable input for the final phase of the work on the draft final report.

An important element of the strategy for the implementation of the Study was the decision to review and analyse the results of each stage of the work, which were presented in succession by all the research teams, in the form of interim reports.

The assessment of interim and final results of the work of the different research teams was carried out in accordance with the following criteria:

1. the overall level of concordance between the methods applied and those of the IPCC;
2. the level of concordance between the structures of categories, subcategories and sources applied and the structure set out by the IPCC;
3. the estimated scope of the use made of the IPCC's calculation procedures;
4. the reliability of determinations of activity in the categories under consideration;
5. the identification of those areas in which research had been done specifically to meet the needs of the Study;
6. the maximal use of Polish emission factors;
7. the application of comparative analysis of the results obtained with those set out in the literature;
8. the appropriateness of the selection of foreign emission factors in the description of Polish conditions;
9. the state of organization of the Polish and foreign sets of emission factors employed in the inventory;
10. the suitability of the obtained interim results for the inventories carried out by other teams;
11. the purposefulness of the identification and choice of research topics to improve on the IPCC methodologies for the sake of future inventories.

B.3. Institutions and individuals involved in the execution of the Study

Directly or indirectly involved in the execution of the Country Case Study on Sources and Sinks of Greenhouse Gases in Poland were the following Ministries and governmental agencies:

- The Ministry of Environmental Protection, Natural Resources and Forestry, as represented by three departments:

  A. The Department of Air and Land Protection - which helped to establish the programme of research for the Project, as well as accepting it.

  B. The Department of International Cooperation - which was involved with matters both substantive and formal, in relation to the co-operation with UNEP and with other international organizations within the U.N. system.

  C. The Department of Ecological Policy - involved in ongoing consultations with regard to links with the State Ecological Policy.

- The Ministry of Industry and Trade - which made available sets of otherwise-lacking data on activity in the power supply industries and other industries.

- The Ministry of Agriculture and the Food Economy - which made available detailed data on the rearing of livestock and on the national stock of agricultural machinery.

- The Ministry of Transport and the Maritime Economy - which made available data from its institutes.

- The Main Statistical Office - for the use of its publications as well as selected resources of information which have not been published.

The organization of the study as a whole was in the hands of a Project Core Team made up of:

1. Mieczyslaw Metler, Project Manager, National Foundation for Environmental Protection,
2. Edward Radwanski, Project Scientific Leader,
3. Maciej Sadowski, Supervisor of the Project authorized by the Ministry of Environmental Protection, Natural Resources and Forestry, director of the Climate Protection Centre,
4. Adam Lackowski, Deputy Project Manager, National Foundation for Environmental Protection.
5. Aleksandra Wiszniewska, Project Activities Officer, National Foundation for Environmental Protection.

The main goals of the activities of the Project Core Team, and especially of the Project Scientific Leader, were to ensure:

- the development by the research team - in selected categories and subcategories of emission source - of the most in-depth research possible in relation to the activity of sources, emission factors and the correctness of estimations made,
- that the results of calculations of emissions made by the team were subject to verification,
- that the presentation and calculation of datasets was in accordance with the structure of categories and subcategories of emission source recommended by IPCC on the basis of the interim results from research teams,
- the presentation of aggregated results on the reporting forms required by the IPCC methodology,
- the use of the computer models created for the summary presentation of the inventory and for the production of the required tables showing interim results for different categories and subcategories of emission, as well as for other reports required by the IPCC methodology.

The realization of the Project brought together a significant professional potential in the form of the Project Core Team, the consultants and specialists making up the different research teams and the technical and administrative personnel involved in the co-operation. In total, the Project involved more than 150 people.

On behalf of UNEP consultative assistance, which extended to both methodological and organizational guidance, was provided by Mr. Jan F. Feenstra of the Institute of Environmental Studies of the Free University of Amsterdam.

The research tasks of the Project were performed or aided by the institutions and individuals given in Table 1, which is organized by IPCC category of emission source or sink. The name of the leader of each research team is given first.

Table 1. Executors of Research Tasks

No.	Category	Executing and supporting institutions	Executors
1.	Energy	Foundation for Energy Efficiency (FEWE)	Radwański E. (scientific supervision)
1.A.1.a,b,c.	Power plants, Heat-and-power plants, Heat plants	Energy Information Center (CIE) - Warsaw	Kumanowski M., Dębski B., Radovic V.
1.A.1.d.e.f.	Petroleum Refining, Solid Fuel Transformation, Other Energy Industries	FEWE - Katowice	Wojtulewicz I., Maroń I., Pasierb S., Pyka M.
1A.2.(a-f).	Industry	FEWE -Katowice	Wojtulewicz I.,Maroń I., Pasierb S., Pyka M.
1.A.3.(a-f).	Transport	Institute of Motor-car Transport - Warsaw	Radzimirski S. with team
1.A.4.5.6	Municipal Management (commercial/institutional), Residential, Agriculture/Forestry	FEWE - Katowice	Wojtulewicz I., Maroń I., Pasierb S., Pyka M.
1.B.1.a.	Fugitive emission from the oil system	Foundation "Progress and business" - Kraków	Żebrowski M., Ziembla W., Krasowski Z., Marek W., Posłuszny K., Serafin R.
1.B.1.b.	Fugitive emission from the gas system	Institute of Gas Mining - Krakow	Steczko K., Dudek J., Froński A., Pałkowska H., Rachwalski J., Schuster T., Schuster T., Starzyska J,
1.B.2	Fugitive emission from the coal system	Center of the Fundamental Problems on Mineral Raw Materials and Energy Economy- Polish Academy of Sciences- Kraków	Gawlik L., Suwała W., Nieć M., Grzybek J., Pytal J., Kuzak R.
2.	Other industrial production processes	FEWE - Warsaw	Radwański E., (scientific supervision)
2.A.B.F.	Iron & steel, non-ferrous metals & others	FEWE - Katowice	Wojtulewicz I., Maroń I., Pasierb S.
2.C.D.E.	Inorganic chemistry, organic chemistry, non-metal mineral products	Institute of Ecology of Industrialized Areas - Katowice	Fudała I. Hławiczka S., Cenowski M., Dyduch B., Borowska M.

3.	Use of solvent	FEWE - Warsaw	Radwański E., (scientific supervision)
3.A.B.C.D.	Use of paints, Degreasing and Chemical Cleaning, The Production of Chemical Products	Institute of Ecology of Industrialized Areas - Katowice	Fudała I., Hławiczka S., Cenowski M., Dyduch B., Borowska M.
4.A.B.	Enteric fermentation, animal wastes	Institute of Zootechny- Kraków - Babice	4.A. Pilarczyk A., Okoński J., Wierny A., Matuszewska E., Kraszewski J., Herbut E. 4.B. Pilarczyk A., Dyrcz S., Kieć W., Wrona I., Kaczor A.
4.C.	Agricultural soils	Academy of Agriculture - Faculty of Agricultural Chemistry- Warsaw	Mercik S., Moskal S., Stępień W.
4.E.	Agricultural waste burning	Academy of Agriculture - Faculty of Plant Physiology	Nalborczyk E., Łoboda T., Pietkiewicz S.
5.	Land use and forestry	FEWE - Warsaw	Radwański E., (Scientific Supervision)
5.A.2., 5.B., 5.C.2.	Forest clearing, conversion of grassland, Timber cutting and Forest management	Institute for the Cultivation and Fertilizing of Land - Puławy	Górski T., with team
6.	Wastes	FEWE - Warsaw	Radwański E., (Scientific Supervision)
6.A.B.	Landfills, waste waters	Institute of Environmental Protection-Warsaw	Kachniarz M., Mihułka M.
	Sequestered carbon in industrial products	Production-Implementation Center "Ecochem"-Szczecin	Łaciński M., Bądzyńska K.
	Computer model for the estimation of emission of Greenhouse Gases	FEWE -Warsaw	Bzowski J.,Radwański E.,

B.4. The overall results of the inventory

The inventory of 1992 emissions and sinks of greenhouse gases was drawn up on the basis of research within the framework of a UNEP project, and was designed for a number of purposes - and not only to allow comparative analysis with values for emissions and sinks in other years and with the results gained using methods other than the latest version of the IPCC methodology. Listed below are other attainments of the Study, including some which are even of greater significance than the 1992 results themselves for the development of (and Polish role in) the FCCC process:

- the improvement of Polish calculational instruments for the inventorying of emissions,
- the enhancement of the correctness of determinations of activities resulting in emission, which has been made using the available Polish statistical information for the categories of emission source studied,
- the determination, and enhancement of the reliability, of the values of the emission factors used, by way of the "bottom-up" method applied in the study, and on the basis of research or analysis in selected source categories which took account of the influence of technology and the type of fuel in combustion processes, as well as the parameters defining the methods of consumption of other sources of emission,
- the establishment of databases of emission factors organized in relation to categories of emission source and ready for use in the next inventory,
- the creation, for each of the different source categories, of research teams whose appraisals - checked in the course of the realization of the project - made international co-operation possible,
- the creation and application of a computer model for calculating the inventory and for carrying out reporting in line with the recommendations of IPCC,
- the provision of proposals for improving the methods of collection, organization and storage of the statistical data serving in the inventorying of emissions and sinks in each of the studied categories of emission source,
- work on new research tasks with a view to the future improvement of the inventorying of greenhouse gases in Poland.

B.5. Presentation of the main overall results from the 1992 inventory.

Reference should be made to Table 1 in part B, chapter 3 of the present study (entitled "A Descriptive Presentation of the Study"). Given in this table, by IPCC structural category of emission source, are the tasks of the different research teams within the Study. It follows from the data presented in the table that only 3 research teams were occupied exclusively with the problems of a separate category of emission source. The cases in question were category 3 - the Use of Solvents, category 5 - Land Use and Forestry, and category 6 - Wastes.

The remaining research teams had tasks concerned with selected subcategories which were allotted by the Core Team on the basis of two guidelines:

- the qualifications of the research teams,
- the fullest possible concordance of the study as a whole with the structure of categories of emission source defined by the IPCC methodology.

The substantively- and numerically-verified results of the inventory as a whole are presented in Table 2 as a Short Summary Report for the National Inventory of Greenhouse Gases. In line with the requirements of the IPCC methodology, zero values in particular positions for categories or subcategories do in principle reflect the fact that emissions of the greenhouse gas concerned did not physically occur.

Presented in Table 3 is the Summary Report for the National Inventory of Greenhouse Gases -. The Table is organized by aggregate category (numbers 1-6), by subcategory (e.g. 1.A.1 etc.) and by introduced subcategories specific to the Polish study, namely:

- 1.A.3.2. - Transport - Stationary Sources,
- 1.B.1.a. - the Oil System,
- 1.B.1.b. - the Natural Gas System.

The justification for introducing these sub-categories is discussed later in the report.

Sub-category (1.A.8). - the Combustion of Biomass for Energy - is included in frames in Table 3, in order to separate it in the manner required by the balancing procedure.

The summary report (Tables 2, 3) is augmented by the following tables relating to defined categories and subcategories of emission source:

- Table 4 - Emissions from the Energetic Combustion of Fuel (1.A), ordered by sector and by aggregated types of fuel;
- Table 5 - Fugitive Emissions from the Oil and Gas Systems (1.B.1) - includes emissions from the production (1.B.1.a.i), transport (1.B.1.a.ii) and refining (1.B.1.a.iii) of oil, as well as from the production of gas (1.B.1.b.i), and from its "consumption" (1.B.1.b.ii), which was taken to mean processing, transmission, storage and distribution. Gas in this context referred not only to natural gas but also to coke-oven gas which was included in this category of emission;
- Table 6 - Fugitive Emissions from the Distribution of Oil-related Products (1.B.a.iv)- included emissions from the wholesale and retail distribution of petrol and diesel This influenced the activity value making up the sum of wholesale and retail activity.
- Table 7 - Fugitive Emissions from the Mining of Coal (1.B.2), as separated into underground and open-cast mining (1.B.2.b and 1.B.2.a respectively);

- Table 8 - Emissions from Industrial Processes (2), organized by technological processes in the different branches of industry;
- Table 9 - The Use of Solvents (3). The emissions presented are organized into The Use of Paints (3A), Degreasing and Dry Cleaning (3B), The Manufacture and Processing of Chemical Products (3C) and other uses of solvents;
- Table 10 - Emissions of CH_4 from Enteric Fermentation and Animal Wastes (4A and 4B), drawn up by type of animal;
- Table 11 - Emissions of N_2O from Agricultural Soils - organized according to the artificial fertilizers or manure used, and the roles of leguminous plants and the mineralization of soils;
- Table 12 - Emissions from the Burning of Agricultural Wastes - drawn up according to type of plant, and for the gases CH_4, N_2O, NO_x and CO;
- Table 13 - Emissions of CO_2 from the Burning of Above-ground Forest Biomass on and off site in the course of the clearing of forests (5.A.1) - organized in relation to broadleaved and coniferous species;
- Table 14 - Emissions of CH_4, N_2O, NO_x and CO from the On-Site Burning of Forest Biomass in the course of the clearing of forests (5.A.2);
- Table 15 - Emissions of CO_2 from the Decay of Above-ground Forest Biomass in the course of the clearing of forests (5.A.3);
- Table 16 - Emissions of CO_2 from Forest Soils in the course of the clearing of forests (5.A.4)
- Table 17 - Total CO_2 Emissions in the course of the clearing of forests (5A);
- Table 18 - Emissions of CO_2 from the Conversion of Meadows into Cultivated Land (5B) - with calculations made assuming an annual factor of 0.02 for the release of elemental carbon from soils;
- Table 19 - Annual Growth Increment from Managed Forests (5.C.1.);
- Table 20 - Annual Harvest of Timber (5.C.2);
- Table 21 - Net Emissions of CO_2 from Managed Forests (5.C);
- Table 22 - Emissions of CH_4 from Dumps for Solid Wastes (6.A)
- Table 23 - Emissions of CH_4 from Sewage Works (6.B).

Along with the tables for the different categories and subcategories (Tables 4-23), the summary tables 2 and 3 constitute the official presentation of the Polish inventory of those 1992 emissions and sinks of greenhouse gases for which the availability of statistical data made more detailed consideration possible. The following chapters successively present - by category or subcategory of source/sink - the research work done within the framework of the UNEP Project entitled "A Country Case Study on Sources and Sinks of GHG in Poland".

SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORY (Gg)

Table 2

GREENHOUSE GAS SOURCE AND SINK CATEGORIE	CO2	CH4	N2O	NOx	CO	NMVOC
Total (Net)National Emission and Sinks	359439.000	2473.920	50.200	1283.078	1609.474	644.864
1 All Energy (Fuel Combustion+Fugitive)	360988.057	821.323	5.794	1242.231	1494.971	415.878
A Fuel Combustion	360926.728	28.638	5.794	1242.231	1494.971	376.801
B Fugitive Fuel Emission	61.330	792.685	0	0	0	39.076
2 Industrial Processes	10602.723	8.107	12.918	39.508	75.013	61.786
3 Solvent Use	0	0	0	0	0	167.200
4 Agriculture	0	703.607	31.487	1.338	39.431	0
A Enteric Fermentation	0	646.894	0	0	0	0
B Animal Wastes	0	55.586	0	0	0	0
C Agricultural Soils	0	0	31.430	0	0	0
D Agricultural Waste Burning	0	1.127	0.057	1.338	39.431	0
5 Land Use & Forestry	-12151.780	0.004	0.000	0.001	0.059	0
6 Waste	0	940.878	0	0	0	0

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORY (PART I) (Gg) — Table 3

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO2	CH4	N2O	NOx	CO	NMVOC
Total (Net)National Emission	359439.000	2473.920	50.200	1283.078	1609.474	642.017
1 All Energy (Fuel Combustion+Fugitive)	360988.057	821.323	5.794	1242.231	1494.971	415.878
1A Fuel Combustion	360926.728	28.638	5.794	1242.231	1494.971	376.801
1A1 Energy & Transformation Industries	223008.365	7.720	3.062	605.130	107.469	10.020
1A2 Industry (ISIC)	37259.165	10.408	0.286	135.302	41.436	23.312
1A3.1 Transport - Mobile Sources	29473.125	8.637	1.395	416.895	1282.997	333.848
1A3.2 Transport - Stationary Sources	1002.230	0.024	0	0.379	0.369	0.023
1A4 Commercial/Institutional	18.070	0.000	0.000	0.018	0.002	0.000
1A5 Residential	64933.003	1.616	0.871	39.069	25.196	2.502
1A6 Agriculture/Forestry	5232.770	0.232	0.166	45.439	37.502	7.096
1A7 Other						
1A8 Biomas Burned for Energy	4038.333	0.150	0.081	5.319	13.682	1.016
1B Fugitive Fuel Emission	61.330	792.685	0	0	0	39.076
1B1a Oil System	52.784	0.517				33.789
1B1b Natural Gas System	8.545	163.672				5.288
1B2 Coal Mining		628.496				
2 Industrial Processes	10602.723	8.107	12.918	39.508	75.013	61.786
2A Iron and Steel	301.372	0.548	0	8.841	42.215	11.383
2B Non-Ferrous Metals	35.069	0	0	0.125	32.798	0.042
2C Inorganic Chemicals	1493.125	7.560	12.918	30.543	0	8.336
2D Organic Chemicals	0.085	0	0	0	0	12.811
2E Non-Metalic Mineral Products	7970.800	0	0	0	0	15.942
2F Other	802.271	0	0	0	0	13.271
3 Solvent Use	0	0	0	0	0	164.354
3A Paint Aplication	0	0	0	0	0	61.770
3B Degreasing and Dry Cleaning	0	0	0	0	0	21.845
3C Chemical Products Manufacture/Processing	0	0	0	0	0	3.904
3D Other	0	0	0	0	0	76.836

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORY (PART 2) (Gg) — Table 3

GREENHOUSE GAS SOURCE AND SINK CATEGORIE	CO2	CH4	N2O	NOx	CO	NMVOC
4 Agriculture		703.607	31.487	1.338	39.431	
4A Enteric Fermentation		646.894				
4B Animal Wastes		55.586				
4D Agricultural Soils			31.430			
4E Agricultural Waste Burning		1.127	0.057	1.338	39.431	
5 Land Use & Forestry	-12151.780	0.004	0	0.001	0.059	
5A Forest Clearing & On-Site Burn.	244.273	0.004	0	0.001	0.059	
5B Grassland Conversion	5236.000					
5C Managed Forests	-17632.052					
5D Abandonment of Managed Lands						
6 Waste		940.878				
6A Landfills		844.433				
6B Wastewater		96.445				
6C Other						

1 A Energy Fuel Combustion Activities (Part 1) — Table 4

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	Emissions Estimates						AGGREGATE EMISSION FACTORS					
Sector Specific Data	A Apparent Consumption (PJ)	B (Gg of full mass of pollutant)						C (kg(pollutant)/GJ) C=B/A					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1 A Fuel Combustion Activities	3978.91	360926.73	28.638	5.794	1242.231	1494.971	376.801	90.710	0.007	0.001	0.312	0.376	0.095
Oil	552.24	40699.49	9.000	1.580	484.787	1331.015	341.516	73.700	0.016	0.003	0.878	2.410	0.618
Gas	301.73	16800.24	10.378	0.030	91.710	3.779	22.437	55.679	0.034	0.000	0.304	0.013	0.074
Coal	3071.15	302180.67	8.979	4.077	660.140	145.842	11.442	98.393	0.003	0.001	0.215	0.047	0.004
Biomass	40.63	4038.33	0.150	0.081	5.319	13.682	1.016	99.396	0.004	0.002	0.131	0.337	0.025
Other	13.16	1246.33	0.130	0.026	0.276	0.653	0.390	94.726	0.010	0.002	0.021	0.050	0.030
1 A 1 Energy and Transformation Activities	2334.58	223008.37	7.720	3.062	605.130	107.469	10.020	95.524	0.003	0.001	0.259	0.046	0.004
Oil	95.26	7062.22	0.164	0.047	19.178	1.547	0.592	74.135	0.002	0.000	0.201	0.016	0.006
Gas	22.15	1215.81	0.029	0.002	1.930	0.400	0.030	54.881	0.001	0.000	0.087	0.018	0.001
Coal	2195.27	213484.01	7.266	2.969	581.998	91.761	8.790	97.247	0.003	0.001	0.265	0.042	0.004
Biomass	8.74	913.47	0.131	0.017	1.748	13.108	0.218	104.532	0.015	0.002	0.200	1.500	0.025
Other	13.16	1246.33	0.130	0.026	0.276	0.653	0.390	94.726	0.010	0.002	0.021	0.050	0.030
1 A 2 Industry(ISIC)	401.00	37259.16	10.408	0.286	135.302	41.436	23.312	92.917	0.026	0.001	0.337	0.103	0.058
Oil	20.62	1615.53	0.035	0.012	6.783	9.425	0.068	78.333	0.002	0.001	0.329	0.457	0.003
Gas	121.43	6643.60	10.128	0.012	81.872	2.113	22.028	54.712	0.083	0.000	0.674	0.017	0.181
Coal	258.94	29000.04	0.246	0.261	46.646	29.898	1.216	111.994	0.001	0.001	0.180	0.115	0.005
Biomass													
Other													

1 A Energy Fuel Combustion Activities (Part 2)

Table 4

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	Emissions Estimates						AGGREGATE EMISSION FACTORS					
Sector Specific Data	A Apparent Consumption (PJ)	B (Gg of full mass of pollutant)						C (kg(pollutant)/GJ)					
								C=B/A					
		CO2	CH4	N2O	NOx	CO	NMVOC	CO2	CH4	N2O	NOx	CO	NMVOC
1 A 3.1 Transport - Mobile Sources	401.21	29473.13	8.637	1.395	416.895	1282.997	333.848	73.460	0.022	0.003	1.039	3.198	0.832
Oil	400.85	29437.10	8.636	1.395	416.776	1282.963	333.830	73.436	0.022	0.003	1.040	3.201	0.833
Gas													
Coal	0.36	36.03	0.001	0	0.119	0.033	0.017	100.069	0.002	0.000	0.329	0.093	0.048
Biomass													
Other													
1 A 3.2 Transport - Stationary Sources	10.18	1002.23	0.024	0.014	0.379	0.369	0.023	98.451	0.002	0.001	0.037	0.036	0.002
Oil													
Gas	0.17	9.25	0.000	0.000	0.008	0.001	0.000	55.030	0.001	0.000	0.050	0.008	0.002
Coal	10.01	992.98	0.024	0.014	0.370	0.367	0.023	99.179	0.002	0.001	0.037	0.037	0.002
Biomass													
Other													
1 A 4 Commercial/Institutional	0.20	18.07	0.000	0.000	0.018	0.002	0.000	91.264	0.002	0.001	0.091	0.012	0.002
Oil	0.01	1.11	0.000	0.000	0.002	0.000	0.000	79.095	0.003	0.001	0.120	0.015	0.002
Gas	0.03	1.46	0.000	0.000	0.001	0.000	0.000	56.087	0.001	0.000	0.050	0.008	0.002
Coal	0.16	15.50	0.000	0.000	0.015	0.002	0.000	98.131	0.002	0.001	0.096	0.013	0.002
Biomass													
Other													
1 A 5 Residential	768.93	64933.00	1.616	0.871	39.069	25.196	2.502	84.446	0.002	0.001	0.051	0.033	0.003
Oil	1.84	104.36	0.003	0.000	0.092	0.015	0.004	56.778	0.001	0.000	0.050	0.008	0.002
Gas	157.75	8918.84	0.221	0.016	7.888	1.262	0.379	56.536	0.001	0.000	0.050	0.008	0.002
Coal	577.79	55909.81	1.374	0.792	27.557	23.351	1.330	96.765	0.002	0.001	0.048	0.040	0.002
Biomass	31.55	3091.06	0.019	0.063	3.533	0.568	0.789	97.989	0.001	0.002	0.112	0.018	0.025
Other													

1 A Energy Fuel Combustion Activities (Part 3)

Table 4

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	Emissions Estimates						AGGREGATE EMISSION FACTORS					
Sector Specific Data	A Apparent Consumption (PJ)	B (Gg of full mass of pollutant)						C (kg(pollutant)/GJ)					
								C=B/A					
		CO2	CH4	N2O	NOx	CO	NMVOC	CO2	CH4	N2O	NOx	CO	NMVOC
1 A 6 Agriculture/Forestry	62.81	5232.770	0.232	0.166	45.439	37.502	7.096	83.305	0.004	0.003	0.723	0.597	0.113
Oil	33.64	2479.174	0.163	0.125	41.956	37.065	7.021	73.687	0.005	0.004	1.247	1.102	0.209
Gas	0.21	11.295	0.000	0.000	0.010	0.002	0.000	55.099	0.001	0.000	0.050	0.008	0.002
Coal	28.62	2742.300	0.069	0.040	3.434	0.429	0.066	95.818	0.002	0.001	0.120	0.015	0.002
Biomass	0.35	33.806	0.000	0.001	0.039	0.006	0.009	97.989	0.001	0.002	0.112	0.018	0.025
Other													
1 A 7 Other													
Oil													
Gas													
Coal													
Biomass													
Other													

1 B 1 Fugitive Fuel Emissions (Oil and Gas)

Table 5

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES			AGGREGATE EMISSIONS FACTORS		
	Fuel Quantity (PJ)	CH4 (Gg)	CO2 (Gg)	NMVOC (Gg)	CH4 (kg/GJ)	CO2 (kg/GJ)	NMVOC (kg/GJ)
1 B 1 a Crude Oil (Total)	1912.71	0.517	52.784	13.129	0.000	0.028	0.007
i Production	8.36	0.517	52.784	0.397	0.062	6.315	0.048
ii Transported	1376.30	0	0	3.757			0.003
iii Refined	528.05	0	0	8.974			0.017
1 B 1 b Gas (Total)	345.99	163.672	8.545	5.288	0.473	0.025	0.015
i Production	113.87	7.451	0.025	0.261	0.065	0.000	0.002
ii Consumption	345.99	156.222	8.520	5.026	0.452	0.025	0.015
1 B 1 c Oil/Gas Joint (Total)							
Production							

1 B 1.a.IV Fugitive Fuel Emissions (Distribution of Oil Products)

Table 6

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES	AGGREGATE EMISSION FACTORS
Consumption of Oil Products	Fuel Quantity PJ	NMVOC (Gg)	NMVOC (kg/GJ)
Gasoline	402.43	18.488	0.046
Diesel oil	472.89	2.172	0.005

1 B 2 Fugitive Fuel Emissions (Coal Mining)

Table 7

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES			AGGREGATE EMISSIONS FACTORS	
Coal Mining	Production (Tg)	Total CH4 (Gg CH4)	Production (Gg CH4)	Post Processing (Gg CH4)	Production (kg CH4/Mg)	Post Processing (kg CH4/Mg)
1 B 2 a Surface	66.85	0.852	0.852	0.000	0.013	0.000
b Underground	116.18	627.644	507.071	120.573	4.365	1.038

Minimum Data Tables 2 Industrial Processes

TABLE 8

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	Emissions Estimates						AGGREGATE EMISSION FACTORS					
Sector Specific Data	A Production quantity (t)	B Full Mass of Pollutant (Gg)						C Polutant per tonne of product (kg / t)					
								C=B/A					
		CO	CO2	CH4	N2O	NOx	NMVOC	CO	CO2	CH4	N2O	NOx	NMVOC
2 INDUSTRIAL PROCESSES	58416548	75.013	10602.72	8.107	12.918	39.508	61.786	1.284	181.502	0.139	0.221	0.676	1.058
A Iron and Steel	9865000	42.215	301.37	0.548	0	8.841	11.383	4.279	30.550	0.056	0.000	0.896	1.154
B Non-Ferrous Metals	585200	32.798	35.07	0	0	0.125	0.042	56.045	59.927	0	0	0.213	0.072
Aluminium Production	43600	3.318	35.07	0	0	0.037	0.000	76.090	804.34	0	0	0.850	0.004
Other	541600	29.480	0	0	0	0.088	0.042	54.431	0	0	0	0.162	0.078
C Inorganic Chemicals	8297180	0	1493.13	7.560	12.918	30.543	8.336	0	179.956	0.911	1.557	3.681	1.005
Nitric Acid	1388300	0	0	0	4.72	30.543	0	0	0	0	3.400	22.000	0
Fertilizer Production													
Other	6908880	0	1493.13	7.560	8.198	0.00	8.336	0	216.117	1.094	1.187	0	1.207
D Organic Chemicals	1063568	0	0.08	0	0	0	12.811	0	0.080	0	0	0	12.046
Adipic Acid													
Other	1063568	0	0.08	0	0	0	12.811	0	0.080	0	0	0	12.046
E Non-Metallic Mineral Products	14426000	0	7970.80	0	0	0	15.942	0	552.530	0	0	0	1.105
Cement	11900000	0	5950.00	0	0	0	11.900	0	500.000	0	0	0	1.000
Lime	2526000	0	2020.80	0	0	0	4.042	0	800.000	0	0	0	1.600
Other													
F Other (ISIC)	24179600	0	802.27	0	0	0	13.271	0	33.18	0	0	0	0.549

Minimum Data Tables 3 Solvents

Table 9

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES	AGGREGATE EMISSION FACTORS
Specific Data	A Quantity Consumed (Gg)	B Full Mass of Pollutant (Gg)	C Pollutant per tonne of Product (Mg/Mg)
			C=B/A
		NMVOC	NMVOC
3 SOLVENT USE		164.354	
A Paint Application	123.54	61.770	0.500
B Degreasing and Dry Cleaning	25.61	21.845	0.853
C Chemical Products Manufacture/Processing	406.44	3.904	0.010
D Other	38418.00	76.836	0.002

In the last row of collumn A - population

MINIMUM DATA TABLES 4 AGRICULTURE

4 A & B Enteric Fermentation & Animal Wastes

Table 10

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES		AGGREGATE EMISSIONS FACTO	
	A	B		C	
Sector Specific Data	Number of Animals	Enteric Fermentation	Animal Wastes	Enteric Fermentation	Animal Wastes
	(mln)	(Gg CH4)		(kg CH4 per animal)	
				C=(B/A)	
4 AGRICULTURE					
A&B Enteric Fermentation & Wastes	121.13	646.894	55.586	5.341	0.459
1 Catle	7.94	581.419	16.753	73.186	2.109
i Beef	3.74	184.964	4.565	49.432	1.220
ii Dairy	4.20	396.455	12.188	94.336	2.900
2 Goats					
3 Sheep	1.87	16.618	0.355	8.889	0.190
4 Pigs	21.78	32.666	31.142	1.500	1.430
5 Horses/Mules/Asses	0.90	16.191	1.250	18.000	1.390
6 Other	88.64	0.000	6.086	0.000	0.069

4 D Agricultural Soils

Table 11

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSIONS ESTIMATES	Aggregate Emissions Factor(s)	
Sector Specific Data	A Amount of nitrogen applied in fertilizer and manure (Mg N)	B Area Cultivated (ha)	C (Gg N2O)	D Nitrogen dioxide released per tonne N applied (kg N2O/Mg N)	E Amount of biological fixation of nitrogen (Mg N)
Fertilizers	688000	1 800000	.466	12.506	53 8.800
Manure	5199	1 800000	9.398	1 .081	5989. 61
Papilionaceous	152830	1698000	2.400	15.814	1528.300
Mineralization	810600	1 800000	11.168	15.814	8106.000
		Total	31.430		

4.E Agricultural Waste Burning

TABLE 12

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSIONS ESTIMATE				Aggregate Emissions Factor(s)			
Sector Specific Data	A Annual Burning of Crop Residues (kt dm)	B Carbon Fraction (t/t dm)	C Full Mass of Pollutant (Gg)				D Pollutant per tonne of dry matter (kg/t dm)			
			CH4	N2O	NOx	CO	CH4	N2O	NOx	CO
E. Agricultural Waste Burning	377.37		1.127	0.057	1.338	39.431	0.003	0.000	0.004	0.104
1. Wheat	41.35	0.485	0.134	0.003	0.072	4.682	0.003	0.000	0.002	0.113
2. Rye	24.94	0.480	0.080	0.001	0.034	2.793	0.003	0.000	0.001	0.112
3. Barley	13.64	0.457	0.042	0.001	0.024	1.453	0.003	0.000	0.002	0.107
4. Oats	5.91	0.470	0.019	0.000	0.011	0.648	0.003	0.000	0.002	0.110
5. Triticale	9.93	0.485	0.032	0.001	0.016	1.125	0.003	0.000	0.002	0.113
6. Cer.mix	11.45	0.730	0.036	0.001	0.021	1.264	0.003	0.000	0.002	0.110
7. Mill.buck.	0.09	0.450	0.000	0.000	0.000	0.010	0.003	0.000	0.002	0.105
8. Maize	0.24	0.471	0.001	0.000	0.001	0.026	0.003	0.000	0.002	0.110
9. Leg.ed.	0.12	0.450	0.000	0.000	0.001	0.012	0.003	0.000	0.005	0.105
10.For.leg	0.43	0.450	0.001	0.000	0.002	0.045	0.003	0.000	0.005	0.105
11.Potato	149.10	0.423	0.420	0.033	0.778	14.702	0.003	0.000	0.005	0.099
12 Sugar beet	0	0.407	0.000	0.000	0.000	0.000	0	0	0	0
13.Rape	41.84	0.450	0.126	0.003	0.073	4.393	0.003	0.000	0.002	0.105
14 Other oil	0.90	0.450	0.003	0.000	0.002	0.095	0.003	0.000	0.002	0.105
15 Flax straw	0.00	0.450	0.000	0.000	0.000	0.000	0.003	0.000	0.002	0.105
16 Hemp straw	0	0.450	0.000	0.000	0.000	0.000	0	0	0	0
17.Tobacco	0.05	0.450	0.000	0.000	0.000	0.005	0.003	0.000	0.005	0.105
18 Hop	0.04	0.450	0.000	0.000	0.000	0.004	0.003	0.000	0.004	0.105
19.Root oth.	0	0.407	0.000	0.000	0.000	0.000	0	0	0	0
20.Meadow hay	0.09	0.450	0.000	0.000	0.000	0.010	0.003	0.000	0.005	0.105
21 Pasture hay	0.05	0.450	0.000	0.000	0.000	0.005	0.003	0.000	0.005	0.105
22.Legum hay	0.00	0.450	0.000	0.000	0.000	0.000	0.003	0.000	0.005	0.105
23 Clover & alfalfa hay	0.04	0.450	0.000	0.000	0.000	0.004	0.003	0.000	0.007	0.105
24 Other hay	0.02	0.450	0.000	0.000	0.000	0.002	0.003	0.000	0.007	0.105
25. Cabbage	0	0.450	0.000	0.000	0.000	0.000	0	0	0	0
26.Onion	0	0.450	0.000	0.000	0.000	0.000	0	0	0	0
27.Carrot	0	0.450	0.000	0.000	0.000	0.000	0	0	0	0
28.Red beet	0	0.450	0.000	0.000	0.000	0.000	0	0	0	0
29.Cucumber	0.09	0.450	0.000	0.000	0.001	0.009	0.003	0.000	0.008	0.105
30.Tomato	1.65	0.450	0.005	0.000	0.010	0.183	0.003	0.000	0.006	0.111
31.Oth.ground	0.36	0.450	0.001	0.000	0.002	0.038	0.003	0.000	0.006	0.105
32.Green v	0.14	0.450	0.002	0.000	0.004	0.056	0.011	0.000	0.026	0.394
33.Apples	37.07	0.450	0.111	0.006	0.142	3.892	0.003	0.000	0.004	0.105
34 Pears	2.22	0.450	0.007	0.000	0.008	0.233	0.003	0.000	0.004	0.105
35.Plums	4.63	0.450	0.014	0.001	0.018	0.486	0.003	0.000	0.004	0.105
36 Sour cherries	5.62	0.450	0.017	0.001	0.021	0.590	0.003	0.000	0.004	0.105
37.Sweet cherries	1.23	0.450	0.004	0.000	0.005	0.129	0.003	0.000	0.004	0.105
38 Other hort. fries	0.33	0.450	0.001	0.000	0.001	0.035	0.003	0.000	0.004	0.105
39.Strawberies	0.17	0.450	0.000	0.000	0.001	0.017	0.003	0.000	0.004	0.105
40 Raspberries	2.27	0.450	0.007	0.000	0.009	0.238	0.003	0.000	0.004	0.105
41 Current	17.25	0.450	0.052	0.003	0.066	1.812	0.003	0.000	0.004	0.105
42 Goosberries	3.65	0.450	0.011	0.001	0.014	0.383	0.003	0.000	0.004	0.105
43 Other berries	0.49	0.450	0.001	0.000	0.002	0.051	0.003	0.000	0.004	0.105

MINIMUM DATA TABLES 5 LAND USE CHANGE AND FORESTRY

5 A 1 Forest clearing:CO2 Release from Burning of Aboveground Biomass

Table 13

SOURCE AND SINK CATEGORIES			ACTIVITY DATA			EMISSIONS ESTIMATES	AGGREGATE EMISSIONS FACTOR
			A Area Cleared (k ha)	B Total Biomass Change (kt dm)	C Quantity of Biomass Burned (kt dm)	D Quantity of CO2 Released (Gg CO2)	E Emissions Factor (Gg CO2/kt dm burned)
							E=D/C
Temperate	Evergreen	Primary					
		Secondary	0.490	46.550	8.798	14.517	1.650
		Sub-Total	0.490	46.550	8.798	14.517	1.650
	Deciduos	Primary					
		Secondary	0.120	15.960	2.873	4.740	1.650
		Sub-Total	0.120	15.960	2.873	4.740	1.650

5 A 2 On-Site Burning of Cleared Forests

Table 14

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSIONS ESTIMATE				Aggregate Emissions Factor(s)			
Sector Specific Data	A Carbon Release (Gg)	B Nitrogen Release (Gg)	C Emissions Estimates (Gg)				D Aggregate Emissions Ratios (Gg/Gg)			
							D=C/A		D=C/B	
			CH4	CO	N2O	NOx	CH4	CO	N2O	NOx
On-Site Burning of Cleared Forests	0.253	0.003	0.004	0.059	0.000	0.001	0.016	0.233	0.011	0.257

5 A 3 Forest clearing: CO_2 Release from Decay of Aboveground Biomass

Table 15

SOURCE AND SINK CATEGORIES			ACTIVITY DATA			EMISSIONS ESTIMATES	AGGREGATE EMISSIONS FACTOR
			A 10-Year Average Area Cleared (k ha)	B 10-Year Average Actual Loss of Biomass (kt dm)	C Average Quantity of Biomass to Decay (kt dm)	D CO_2 Emissions (Gg CO_2)	E Emissions Factor (Gg CO_2/kt dm)
							E=D/C
Temperate	Evergreen	Primary					
		Secondary	0.5	47.5	2.375	3.919	1.650
		Sub-Total	0.5	47.5	2.375	3.919	1.650
	Deciduos	Primary					
		Secondary	0.1	13.3	0.665	1.097	1.650
		Sub-Total	0.1	13.3	0.665	1.097	1.650

5 A 4 Forest clearing:Soil Carbon Release

Table 16

SOURCE AND SINK CATEGORIE		ACTIVITY DATA		EMISSIONS ESTIMATES	AGGREGATE EMISSION FACTOR
		A Average Annual Forest Converted to Pasture or Crops over 25 years	B Soil Carbon Content of Land Before Clearing (t C/ha)	C CO2 Released from soil (Gg CO2)	D Aggregate Emissions Factor from Soil Carbon (Mg/ha)
					D=C/A
Temperate	Evergreen	0.8	120	176.00	220
	Deciduos	0.2	120	44.00	220

5 A TOTAL CO_2 EMISSIONS FROM FOREST CLEARING Table 17

CATEGORY	EMISSIONS (Gg)
CO_2 from Burning of Cleared Biomass	19.257
CO_2 from Decay of Cleared Biomass	5.016
CO_2 from Soil Carbon Release	220.000
TOTAL	244.273

5 B Grassland Conversion (Annual CO2 Emissions)

Table 18

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSIONS ESTIMATES	AGGREGATE EMISSIONS FACTOR
Sector Specific Data	A Area Converted (25 Year Total) (k ha)	B Average Carbon Content Of Soil (Gg C/ha)	C CO2 Emission Estimates (Gg)	D Average Emission Factors (Mg/ha)
Conversion of grasslands to cultivated lands	1020	0.07	5236.000	5.133

5 C 1 Managed Forest: Annual Growth Increment

Table 19

SOURCE AND SINK CATEGORIES			ACTIVITY DATA	EMISSIONS/ REMOVALS ESTIMATE	AGGREGATE REMOVALS FACTORS
			A Area of managed Forest (k ha)	B Carbon Removal (Gg C)	C Carbon Removal Factor (Mg C/ ha)
					C=B/A
Temperate	Plantations				
		Loblolly Pine	5	0.90	0.180
	Commercial	Evergreen	6960	7830.00	1.125
		Deciduos	1740	2818.80	1.620
			Number of Trees 1000	Carbon Removal (Gg C)	Carbon Removal Factor (Mg C/ 1000 trees)
					C=B/A
Afforestation Programs			670000	30.15	0.045
Village & Farm Trees			88000	435.60	4.950

5 C 2 Managed Forests: Harvest

Table 20

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES	AGGREGATE EMISSION FACTOR
	A Amount of Biomass Harvested (kt dm)	B Carbon Emission/Removal Estimates (Gg C)	C Carbon Emission Factors (Mg C/t dm)
			C=B/A
Commercial Timber + Fuelwood	14014.91	6306.71	0.450
Fuelwood			
Other			

Table 21

5 C 3 Managed Forests: Net Emissions/Removals (Summary)

CATEGORY	Emissions/Removals
	CO_2 (Gg)
Total Growth Increment	-40756.65
Total Harvest	23124.60
Net Emissions(+) or Removals(-)	-17632.05

MINIMUM DATA TABLES 6 WASTE

6 A Waste: Landfills

Table 22

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSIONS ESTIMATES	Aggregate Emissions Factor(s)	
Waste Type	A Total MSW (kg per year)	B Landfilled Cultivated (Gg)	C CH4 Emissions (Gg)	D Emission Factor (kg CH4/kg MSW landfilled)	E Qty of CH4 recovered (kg CH4)
				D=C/B	
A Landfills		9400	844.433	0.090	

6 A Waste: Sewage Treatment

Table 23

SOURCE AND SINK CATEGORIES	ACTIVITY DATA		EMISSIONS ESTIMATES	Aggregate Emissions Factor(s)	
Waste Type	A Quantity BOD in Wastewater (Gg)	B Quantity of CH4 anaerobically digested (Gg CH4)	C CH4 Emissions (Gg)	D Emission Factor (kg CH4/kg BOD)	E Qty of CH4 recovered (Gg CH4)
				D=C/B	
B Wastewater Industrial	3315.70	397.884	87.194	0.220	0.340
Municipal	350.43	42.048	9.251	0.220	
C Other					
		Razem	96.445		

PART C.

A DETAILED PRESENTATION OF THE RESULTS OF THE STUDY

C. A DETAILED PRESENTATION OF THE RESULTS OF THE STUDY

Introduction

The detailed presentation will embrace the following discussion and information:

- a characterization of emission sources and sinks;
- the methodological approach to estimation;
- determination of the completeness of estimations in the categories and subcategories, and the ways in which they have been collected together;
- sources of information;
- the scope of work done specially for the needs of the study;
- assessment of the quality of the estimation;
- the scope of the documentation possessed and introduced into the report;
- guidelines for the collection of information for future inventories and the ways of storing it;
- an outline of the research to be done to enhance the reliability of national inventories drawn up in the future;
- conclusions regarding the IPCC methodology.

The detailedness of the presentation was geared to the characteristic of categories and subcategories of emission sources.

C.1. Emissions from all energy (from the combustion of fuel and fugitive)- (1)

The inventory and related research tasks embraced all categories of emission source (1.A.1. through to 1.A.6, as well as 1.B.a.b. to 1.B.2).

C.1.1. Energy and transformation industries (1.A.1.)

C.1.1.1. Emissions from stationary sources producing electrical energy and heat (1.A.1.a. - Electricity Generation, 1.A.1.b - Combined Heat and Power Generation, 1.A.1.c - District Heating)

In Poland, it is only hydro-electric plants which produce electrical energy only. All the other plants are thermal power stations which produce heat at the same time as electricity. It is for this reason that Poland's commercial power plants are included amongst heat and power plants (1.A.1.b) along with other industrial heat and power plants. Thus, in accordance with agreements reached with international organizations, heat and power plants (1.A.1.b) are the only element to be separated out in Poland's energy balance.

C.1.1.1.1. Heat and Power Plants (1.A.1.b)

Operational in Poland are 55 commercial combined heat-and-power plants as well as 205 industrial ones.

Public combined heat and power plants (1.A.1.b.i)

Five of the 55 public combinated heat and power plants (CHP) are fired by brown coal and the remainder by hard coal. The secondary fuel (utilised mainly for plant restarting) in most of them is fuel oil or diesel oil, except for three plants which make use of natural gas or coke-oven gas as a secondary fuel and one which uses liquid waste fuel. The overall consumption of different fuels in this category of emission source is summarized in Table 24.

The inventory was drawn up by means of the "bottom-up" method, with account being taken of:

- the consumption of each type of fuel;
- the choice of emission factor in relation to the type of fuel and the technology of combustion - this was made possible by prior work on the consumption of fuels by reference to each combustion technology and for each combined heat and power plant [3];
- the estimation of emissions of all the greenhouse gases (CO_2, CH_4, N_2O, NO_x, CO and NMVOCs).

The estimation of emissions was complete because the "bottom-up" method was used. In drawing up the inventory, the research teams made use of data from the 10 sources of information contained in [3], (including the IPCC, RADIAN, USEPA, CORIN, CIE and the Foundation for the Effective Use of Energy [4] and [5]) as well as from sets of primary data gathered in the Main Statistical Office in the form of statistical reporting sheets from the individual heat-and-power plants. These sheets had full data on: the consumption of fuels, the low heat value of the fuels used, the energetic balance of conversions, as well as information on the technologies of combustion, the emission of particulates and gases, and many other data useful in the selection of values influencing the emissions estimated by experts. The tasks of the research team focussed on the analysis of the completeness and reliability of data, as well as on the use of a coherent method for the balancing and calculation of emissions. The reliability of the results of estimations of emissions was considered to be high.

The summary results from the calculation of emissions arranged by type of fuel and consumption are presented in Table 24 (table 11[3]), along with emission factors . The Team Report [3] contained the following tables which were the basis for the summary table:

- the consumption of fuels by type (table 1 [3]),
- emission factors for all the greenhouse gases in accordance with type of fuel and technology of combustion (table 7 [3]),
- the consumption of fuels by type and technology of combustion (table 8 [3]).

Given in the Team Report [3] was an outline of the research activities undertaken with a view to enhancing the reliability of the results of future inventories and periodic verification of data concerning the values of emission factors. The outline of the research problems included:

- the making of obligatory measurements of emissions from larger combined heat-and-power stations (at first periodically and later continuously);
- the carrying-out of chemical analyses of fuels and the products of combustion,
- the augmentation of data bases concerning technologies of combustion, the characteristics of boilers and the distribution of loads;
- for each object, the determination - on the basis of research - of the values of emission factors for particular greenhouse gases.

To make estimations of emissions from public combined heat-and-power plants more efficient, and to increase the reliability of these estimations, the team presented a schematic representation of a system for the collection of data, together with the submission of a list of essential data and the way in which these had been processed and stored. It went on to propose that the Energy Information Center (CIE) should work on these tasks, within the framework of formal co-operation with the Main Statistical Office (GUS).

No recommendations were made regarding changes to the IPCC methodology.

Table 24. (1.A.1.b.i) Public CHP (Combined Heat and Power Generation)

FUEL TYPE	Consupmtion	Emission (Mg)						Aggregate Emission Factors (kg /GJ)					
	GJ	CO 2	CH 4	N 2 O	NO x	CO	NMVOC	CO 2	CH 4	N 2 O	NO x	CO	NMVOC
LIQUID FUELS	7611438	588056.8	7.9	4.6	1858.8	114.2	16.9	77.26	0.0010	0.0006	0.2442	0.0150	0.0022
Olis	6438521	497484.2	4.5	3.9	1624.2	96.6	13.5	77.27	0.0007	0.0006	0.2523	0.0150	0.0021
Fuel oil	6317227	488691.8						77.36					
Diesel oil	121294	8792.3						72.49					
Liquid wastes	1172917	90572.7	3.4	0.7	234.6	17.6	3.4	77.22	0.0029	0.0006	0.2000	0.0150	0.0029
GAS FUELS	250102	13965.5	0.0	0.0	37.5	4.8	0.1	55.84	0.0001	0.0001	0.1500	0.0190	0.0004
Natural gas	250102	13965.5	0.0	0.0	37.5	4.8	0.1	55.84	0.0001	0.0001	0.1500	0.0190	0.0004
SOLID FUELS	1390542282	139846219.8	866.0	1946.8	440961.3	21335.6	1732.1	100.57	0.0006	0.0014	0.3171	0.0153	0.0012
Hard coal	845705970	79340243.9	539.1	1184.0	299304.0	13707.8	1078.3	93.82	0.0006	0.0014	0.3539	0.0162	0.0013
Brown coal	544835487	60505942.2	326.9	762.8	141657.2	7627.7	653.8	111.05	0.0006	0.0014	0.2600	0.0140	0.0012
Coke gas	825	33.7	0.0	0.0	0.1	0.0	0.0	40.86	0.0001	0.0001	0.1300	0.0190	0.0004
TOTAL	**1398403822**	**140448242**	**874**	**1951**	**442858**	**21454**	**1749**	**100.43**	**0.0006**	**0.0014**	**0.3167**	**0.0153**	**0.0013**

Industrial combined heat-and-power stations (1.A.1.b.ii)

Poland has 205 such plants, and these are divided among the branches of industry in the following way:

- the coalmining industry - 12
- extractive industries - 3
- the food industry - 79
- the textile industry - 19
- the papermaking industry - 15
- the coking industry - 3
- oil refining - 6
- the chemical industry - 37
- the building ceramics industry - 1
- the steel industry - 7
- the metals industry - 10
- the industry making means of transport - 5
- other industries - 2

The overwhelming majority of these heat-and-power plants burn hard coal, with only 3 using brown coal as a primary fuel, and 5 fuel oil or diesel oil. Secondary fuels vary from sector to sector and are:

* coke-oven gas (used in coalmining and the steel industry),
* blast-furnace (gas in the steel industry),
* refinery gas (in refineries)

and other liquid waste fuels in relation to the technologies used in the sector.

The inventory was drawn up using the "bottom-up" method and presents the consumption of fuel, the selection of emission factors and the values for emissions of the different greenhouse gases in table 25 (table 12 [3]). The methodology employed ensured that the estimations of emissions were complete.
The Team Report [3] contained the following partial tables:

- the use of fuels by type (table 2 [3])
- the use of fuels by type and technology of combustion (table 9 [3])

The research team used the same set of information sources as had been described for public heat-and-power plants (1.A.1.b.i), as well as data from the original information sheets. The results obtained from the estimations should be considered reliable.

Summary results for the calculation of emissions, ordered by branch of industry, and accompanied by overall consumption and aggregate emission factors are presented in table 26 (table 17 [3])

The aforementioned guidelines for improving methods of data-collection in future inventories for public plants (1.A.1.b.i) apply also to industrial plants, as does the outline of research matter leading to the enhanced reliability of inventories.

Table 25. (1.A.1.b.ii) Industrial CHP (Combined Heat and Power Generation)

FUEL TYPE	Consumption	Emission (Mg)						Aggregate Emission Factors (kg/GJ)					
	GJ	CO 2	CH 4	N 2 O	NO x	CO	NMVOC	CO2	CH4	N 2O	NO x	CO	NMVOC
LIQUID FUELS	45817370	3510297.2	40.0	24.9	10473.5	708.1	94.1	76.61	0.0009	0.0005	0.2286	0.0155	0.0021
Oils	39299944	3039626.6	28.9	23.6	9497.8	589.5	83.0	77.34	0.0007	0.0006	0.2417	0.0150	0.0021
Fuel oils	39184545	3031261.5						77.36					
Diesel oils	115399	8365.0						72.49					
Refinery Gas	4856022	278115.1	6.8	0.5	679.8	92.3	6.8	57.27	0.0014	0.0001	0.1400	0.0190	0.0014
Liquid Wastes	1297324	100179.4	3.8	0.8	259.5	19.5	3.8	77.22	0.0029	0.0006	0.2000	0.0150	0.0029
Gas Wastes	364080	92376.2	0.5	0.0	36.4	6.9	0.5	253.73	0.0014	0.0001	0.1000	0.0190	0.0014
GAS FUELS	1638517	85522.5	0.4	0.2	224.1	31.1	0.8	52.20	0.0002	0.0001	0.1368	0.0190	0.0005
Natural Gas	1638517	85522.5	0.4	0.2	224.1	31.1	0.8	52.20	0.0002	0.0001	0.1368	0.0190	0.0005
High Methan	225274	12579.2						55.84					
Nitrified	113684	6221.4						54.73					
Coal mine	1299559	66722.0						51.34					
SOLID FUELS	274806772	27349628.6	376.3	359.6	59742.5	16199.1	755.2	99.52	0.0014	0.0013	0.2174	0.0589	0.0027
Hard coal	254343727	23861358.6	370.7	356.1	57734.1	15696.2	741.3	93.82	0.0015	0.0014	0.2270	0.0617	0.0029
Brown coal	1129278	125410.4	2.7	1.6	169.4	135.5	5.4	111.05	0.0024	0.0014	0.1500	0.1200	0.0048
Coke gas	7226633	295313.8	1.7	0.7	870.5	137.3	3.6	40.86	0.0002	0.0001	0.1205	0.0190	0.0005
Blast-furnace Gas	12107134	3067545.8	1.2	1.2	968.6	230.0	4.8	253.37	0.0001	0.0001	0.0800	0.0190	0.0004
OTHER FUELS	13002035	1232150.8	130.0	26.0	260.0	650.1	390.1	94.77	0.0100	0.0020	0.0200	0.0500	0.0300
Black liquor	13002035	1232150.8	130.0	26.0	260.0	650.1	390.1	94.77	0.0100	0.0020	0.0200	0.0500	0.0300
BIOMASS	84769	9138.1	1.3	0.2	17.0	127.2	2.1	107.80	0.0150	0.0020	0.2000	1.5000	0.0250
Solid Wastes	84769	9138.1	1.3	0.2	17.0	127.2	2.1	107.80	0.0150	0.0020	0.2000	1.5000	0.0250
TOTAL	**335349463**	**32186737**	**548**	**411**	**70717**	**17716**	**1242**	**95.98**	**0.0016**	**0.0012**	**0.2109**	**0.0528**	**0.0037**

Table 26. (1.A.1.b.ii) Industrial CHP Ordered by Branches

Industrial Branches	Consumpt.	Emission (Mg)						Aggregate Emission Factor (kg/GJ)					
	GJ	CO2	CH4	N2O	NOx	CO	NMVOC	CO2	CH4	N2O	NOx	CO	NMVOC
COAL MINING	27837582	2482086.50	33.6	35.3	6133.5	1011.9	66.5	89.16	0.0012	0.0013	0.2203	0.0364	0.0024
OTHER MINING	9962324	933701.61	15.8	13.9	2206.6	721.1	31.7	93.72	0.0016	0.0014	0.2215	0.0724	0.0032
FOOD IINDUSTRY	26561311	2473169.22	61.8	36.3	4029.6	3068.1	124.4	93.11	0.0023	0.0014	0.1517	0.1155	0.0047
TEXTILE INDUSTRY	15051717	1416097.10	36.3	21.1	2258.6	1829.9	72.6	94.08	0.0024	0.0014	0.1501	0.1216	0.0048
WOOD INDUSTRY	5068357	475859.13	12.5	7.1	761.6	644.6	24.9	93.89	0.0025	0.0014	0.1503	0.1272	0.0049
PAPER INDUSTRY	36015364	3389740.68	165.2	58.2	5499.8	2220.2	460.2	94.12	0.0046	0.0016	0.1527	0.0616	0.0128
COKING and REFINING INDUSTRY	39343048	3127234.18	35.7	27.3	9199.0	1085.0	90.6	79.49	0.0009	0.0007	0.2338	0.0276	0.0023
CHEMICAL INDUSTRY	105761178	9724624.96	109.2	138.9	26775.8	3670.6	219.3	91.95	0.0010	0.0013	0.2532	0.0347	0.0021
MINERALS INDUSTRY	263355	24706.75	0.6	0.4	39.5	31.6	1.3	93.82	0.0024	0.0014	0.1500	0.1200	0.0048
METALLURGY INDUSTRY	52333227	6531571.39	35.5	48.5	11234.4	1343.6	68.8	124.81	0.0007	0.0009	0.2147	0.0257	0.0013
METAL PRODUCTS INDUSTRY	9039578	846257.78	21.6	12.6	1359.6	1058.7	43.2	93.62	0.0024	0.0014	0.1504	0.1171	0.0048
TRANSPORT EQUIPMENT INDUSTRY	5708503	535545.49	13.7	8.0	856.3	685.0	27.4	93.82	0.0024	0.0014	0.1500	0.1200	0.0048
OTHER BRANCHES of INDUSTRY	1032758	97506.28	3.0	1.5	157.0	180.6	5.8	94.41	0.0029	0.0014	0.1520	0.1749	0.0056
ELECTRICITY ONLY GENERATION	1371162	128636.11	3.3	1.9	205.7	164.5	6.6	93.82	0.0024	0.0014	0.1500	0.1200	0.0048
TOTAL	**335349463**	**32186737.20**	**548**	**411**	**70717**	**17716**	**1243**	**95.98**	**0.0016**	**0.0012**	**0.2109**	**0.0528**	**0.0037**

C.1.1.1.2. District Heating (1.A.1.c)

In Poland, distinctions are drawn between public, industrial and municipal heat plants.

Public heat plants (1.A.1.c.i)

The following types of fuels are used in the 41 public heat plants:

- hard coal only in 12 ,
- hard coal and oil (either fuel oil or diesel) in 23,
- hard coal and gas in 1 and fuel oil or diesel only in 5.

The inventorying of emissions of greenhouse gases in this subcategory of heat plants was done using the "bottom-up" method. The following were determined:

- the consumption of each type of fuel in the heat plants under consideration,
- the emission factors for the different greenhouse gases in relation to the technology of combustion,
- the emissions of the different greenhouse gases.

The estimation of emissions was complete.

The team made use of the accessible sources of data described in the presentation on public heat-and-power plants (1.A.1.b.i).

The accuracy of results on emissions which were obtained may be considered high, because the "bottom-up" method was used and because primary data were used from the statistical sheets for the power supply industry filled in by each particular heat plant.

The data and results presented in [3] refer to public heat plants and are considered complete. The sources of information used were analyses of fuel consumption and emission factors, and the methodology applied is identical to those discussed in the subcategory concerning public heat-and-power plants (1.A.1.b.i).

The research team did not do work of its own to verify emission factors, except for carrying out an analysis of the consistency of the energy balances for this subcategory of heat plants. This analysis included study of the calorific values of fuels which made it possible to apply formulae to define emissions of elemental C (worked out in [5]).

The reliability of the results obtained is high.

A summary presentation of estimated emissions by type of fuel and values of emission factors applied is made in table 27 (table 14 [3]).

The Team Report [3] contained the following fragmentary tables:

- consumption of different types of fuel in each public heat plant (table 3 [3])
- consumption of different types of fuel by technology of combustion (table 10 [3])

The research problems and guidelines for the improvement of statistics from the power supply industry with a view to inventorying greenhouse gases are the same as those discussed in subcategory 1.A.1.b.i.

Table 27. (1.A.1.c.i) Public District Heating

FUEL TYPE	Consumption	Emission (Mg)						Aggregate Emission Factors (kg/GJ)					
	GJ	CO 2	CH 4	N2O	NO x	CO	NMVO	CO 2	CH4	N2O	NO x	CO	NMVOC
LIQUID FUELS	7392268	571531.6	6.0	4.4	1447.8	110.9	15.8	77.31	0.0008	0.0006	0.1958	0.0150	0.0021
Oils	7392268	571531.6	6.0	4.4	1447.8	110.9	15.8	77.31	0.0008	0.0006	0.1958	0.0150	0.0021
Fuel Oils	7325779	566712.0						77.36					
Diesel Oils	66489	4819.6						72.49					
GAS FUELS	510	28.5	0.0	0.0	0.1	0.0	0.0	55.84	0.0001	0.0001	0.1250	0.0190	0.0004
Natural Gas	510	28.5	0.0	0.0	0.1	0.0	0.0	55.84	0.0001	0.0001	0.1250	0.0190	0.0004
SOLID FUELS	69604647	6529987.7	65.5	97.4	19079.2	2265.0	131.1	93.82	0.0009	0.0014	0.2741	0.0325	0.0019
Hard coal	69604647	6529987.7	65.5	97.4	19079.2	2265.0	131.1	93.82	0.0009	0.0014	0.2741	0.0325	0.0019
TOTAL	**76997425**	**7101548**	**72**	**102**	**20527**	**2376**	**147**	**92.23**	**0.0009**	**0.0013**	**0.2666**	**0.0309**	**0.0019**

Industrial heat plants (1.A.1.c.ii)

Industrial heat plants are in operation in over 8000 enterprises in various branches of industry. Each sends to the Main Statistical Office the G-03 sheet for statistics in the power supply industry (in just the same way as industrial heat-and-power plants do).

In the face of the large numbers of industrial heat plants it was not possible to make direct use of "bottom-up" methods. The Research Team therefore utilized an indirect "bottom-up" method in which industrial heat plants were first brought together according to the branch of industry to which they belonged. The set of heat plants in each branch was defined by way of the consumption of different fuels in GJ.

On the basis of the technology of combustion used in the industrial heat plants, expert evaluations were made to obtain emission factors. Data were organized methodologically in relation to the consumption of different types of fuel and the estimated emission factors related to them, and emissions were then calculated.

It was assessed that the estimation was full, albeit with the reservation that the certainty of estimations with exact delimitation of consumption by type of fuel subcategories was largely dependent on the emission factors selected. These were estimated to be highly reliable in the case of CO_2 only, with that for NO_x being considered of average reliability.

The estimated emissions of greenhouse gases by type of fuel are presented in table 28 (table 15 [3]) along with emission factors. Table 29 (table 18 [3]) gives the estimated emissions organized by branch, with a given consumption for each in energetic units, as well as values for aggregate emission factors.

Documentation in the Team Report [3] also contains a table on:

- consumption by type of fuel and by branch of industry (table 4 [3])

Notes on the methodology used in the collection of data, and on research problems, are discussed after the presentation of the results of emissions for municipal heat plants.

Table 28. (1.A.1.c.ii) Industrial District Heating

FUEL TYPE	Consumption	Emission (Mg)						Aggregate Emission Factors (kg / GJ)					
	GJ	CO 2	CH 4	N 2 O	NO x	CO	NMVOC	CO 2	CH 4	N 2 O	NO x	CO	NMVOC
LIQUID FUELS	7551488	580620.5	21.9	4.5	1363.5	113.3	21.9	76.89	0.0029	0.0006	0.1806	0.0150	0.0029
Oils	7342149	564455.3	21.3	4.4	1321.6	110.1	21.3	76.88	0.0029	0.0006	0.1800	0.0150	0.0029
Fuel Oils	6618851	512025.0						77.36					
Diesel Oils	723298	52430.3						72.49					
Liquid Wastes	209339	16165.2	0.6	0.1	41.9	3.1	0.6	77.22	0.0029	0.0006	0.2000	0.0150	0.0029
GAS FUELS	9556953	528380.4	13.4	1.0	955.7	181.6	13.4	55.29	0.0014	0.0001	0.1000	0.0190	0.0014
Natural Gas	9556953	528380.4	13.4	1.0	955.7	181.6	13.4	55.29	0.0014	0.0001	0.1000	0.0190	0.0014
High Methane	8187433	457181.3						55.84					
Nitrified	261635	14318.0						54.73					
Coal Mine	1107885	56881.0						51.34					
SOLID FUELS	270225777	24948110.3	645.2	374.0	40291.9	32088.9	1285.7	92.32	0.0024	0.0014	0.1491	0.1187	0.0048
Coal and Coke	266877683	24471342.6	640.5	373.6	40031.7	32025.3	1281.0	91.69	0.0024	0.0014	0.1500	0.1200	0.0048
Hard	256323964	23310998.4						90.94					
Brown	3499013	376682.7						107.65					
Coke	7054706	783661.4						111.08					
Coke Gas	1736643	70967.3	2.4	0.2	156.3	33.0	2.4	40.86	0.0014	0.0001	0.0900	0.0190	0.0014
Blast Furnace Gas	1270707	321955.0	1.8	0.1	69.9	24.1	1.8	253.37	0.0014	0.0001	0.0550	0.0190	0.0014
Town Gas	12273	504.1	0.0	0.0	1.2	0.2	0.0	41.07	0.0014	0.0001	0.1000	0.0190	0.0014
Generator Gas	328471	83341.3	0.5	0.0	32.8	6.2	0.5	253.73	0.0014	0.0001	0.1000	0.0190	0.0014
BIOMASS	8610374	899784.1	129.2	17.2	1722.1	12915.6	215.3	104.50	0.0150	0.0020	0.2000	1.5000	0.0250
Wood	1193451	124715.6	17.9	2.4	238.7	1790.2	29.8	104.50	0.0150	0.0020	0.2000	1.5000	0.0250
Solid Wastes	7416923	775068.5	111.3	14.8	1483.4	11125.4	185.4	104.50	0.0150	0.0020	0.2000	1.5000	0.0250
BIOGAS	155210	14177.0	0.2	0.0	15.5	2.9	0.2	91.34	0.0014	0.0001	0.1000	0.0190	0.0014
TOTAL	296099802	26971072	810	397	44349	45302	1536	91.09	0.0027	0.0013	0.1498	0.1530	0.0052

Table 29. (1.A.1.c.ii) Industrial District Heating Ordered by Branches

Industrial Branches	Consumption GJ	Emission (Mg) CO 2	CH 4	N 2 O	NO x	CO	NMVOC	Aggregate Emission Factors (kg/GJ) CO 2	CH 4	N 2 O	NO x	CO	NMVOC
AGRICULTURE	23450481	2161993.4	243.6	32.1	3600.5	4024.7	472.4	92.19	0.0104	0.0014	0.1535	0.1716	0.0201
COAL MINING	27561427	2472940.9	264.5	36.2	4034.1	3121.7	521.5	89.72	0.0096	0.0013	0.1464	0.1133	0.0189
OIL and NATURAL GAS MINING	367607	22751.6	1.8	0.1	39.8	13.2	2.4	61.89	0.0050	0.0003	0.1082	0.0360	0.0066
INDUSTRY													
OTHER MINING	11689194	918766.2	91.3	10.9	1548.4	976.6	165.6	78.60	0.0078	0.0009	0.1325	0.0835	0.0142
FOOD and TOBACCO	63054019	5670687.8	604.7	84.3	9458.3	7193.8	1195.6	89.93	0.0096	0.0013	0.1500	0.1141	0.0190
TEXTILE and LEATHER	18387406	1686128.1	182.5	25.4	2760.9	2238.7	363.3	91.70	0.0099	0.0014	0.1502	0.1218	0.0198
WOOD	10971719	1056444.3	194.5	17.9	1857.7	7166.1	346.6	96.29	0.0177	0.0016	0.1693	0.6531	0.0316
PAPER and PRINTING	7010032	663434.5	102.3	10.7	1134.3	3084.4	188.1	94.64	0.0146	0.0015	0.1618	0.4400	0.0268
COKING and REFINING	1894938	131375.6	11.1	1.3	260.7	102.8	17.9	69.33	0.0059	0.0007	0.1376	0.0543	0.0094
CHEMICALS	14276801	1285511.2	137.6	19.1	2139.4	1655.0	272.2	90.04	0.0096	0.0013	0.1499	0.1159	0.0191
MINERALS	20980542	1921589.3	202.0	28.3	3163.5	2424.3	399.9	91.59	0.0096	0.0013	0.1508	0.1156	0.0191
METALLURGY	14652200	1492710.0	129.3	17.2	2049.0	1480.8	248.1	101.88	0.0088	0.0012	0.1398	0.1011	0.0169
METAL PRODUCTS	33016629	3004391.9	325.9	45.4	4942.6	3922.2	648.9	91.00	0.0099	0.0014	0.1497	0.1188	0.0197
TRANSPORT EQUIPMENT	17623856	1603892.6	175.3	24.5	2647.7	2111.0	350.0	91.01	0.0099	0.0014	0.1502	0.1198	0.0199
ELECTRICITY GENERATION	7449364	656847.1	70.8	9.6	1085.6	837.4	139.0	88.17	0.0095	0.0013	0.1457	0.1124	0.0187
LAND TRANSPORT	2984055	281038.9	29.4	4.1	449.4	354.6	58.5	94.18	0.0098	0.0014	0.1506	0.1188	0.0196
WATER TRANSPORT	78745	7641.9	0.8	0.1	11.9	9.2	1.5	97.05	0.0098	0.0014	0.1508	0.1171	0.0195
AIR TRANSPORT	420	38.2	0.0	0.0	0.1	0.1	0.0	90.94	0.0100	0.0014	0.1500	0.1200	0.0200
CONSTRUCTION	8473810	789073.3	84.4	11.7	1270.6	1040.6	168.1	93.12	0.0100	0.0014	0.1499	0.1228	0.0198
OTHERS	12176557	1141566.7	150.2	17.5	1894.2	3558.1	283.3	93.75	0.0123	0.0014	0.1556	0.2922	0.0233
TOTAL	**296099802**	**26968824**	**3002**	**397**	**44349**	**45315**	**5843**	**91.08**	**0.0101**	**0.0013**	**0.1498**	**0.1530**	**0.0197**

Municipal heat plants (1.A.1.c.iii)

To date, municipal heat plants have constituted independent power supply enterprises which have supplied statistical information on G-03 forms. However, the reconstruction of the national economy by way of privatization has seen many of these enterprises divided into smaller, including private, units. This situation has given rise to a need for the development of a new system by which to collect data. However, data from 1992 were still in a reliable state, and it has thus been possible to use them in the calculation of emissions by an indirect "bottom-up" method involving the grouping of fuel consumption by type of fuel, and evaluation on the basis of familiarity with the technologies of combustion in the heat plants of this subcategory.

It should be emphasized that the subcategory "municipal heat plants" does not include local heat plants owned by housing co-operatives and under the administration of individual housing estates. This is because these heat plants do not represent legally-distinct enterprises and are not therefore obliged by law to supply the state statistical system with data. The emissions of greenhouse gases from these objects are taken into consideration under the category -Residential (1.A.5).

The data related to emission of greenhouse gases by type of fuel, expressed in energetic units and given along with emission factors are presented in table 30 (table 16 [3]).

The documentation of the Team Report [3], in the part devoted to this subcategory, additionally contains a table:

- total consumption of different types of fuel (table 5 [3])

Table 30. (1.A.1.c.iii) Municipal District Heating

FUEL TYPE	Consumption	Emission (Mg)						Aggregate Emission Factors (kg / GJ)					
	GJ	CO 2	CH 4	N 2 O	NO x	CO	NMVOC	CO 2	CH 4	N 2 O	NO x	CO	NMVOC
LIQUID FUELS	81323	6220.8	0.2	0.0	14.6	1.2	0.2	76.50	0.0029	0.0006	0.1800	0.0150	0.0029
Oils	81323	6220.8	0.2	0.0	14.6	1.2	0.2	76.50	0.0029	0.0006	0.1800	0.0150	0.0029
Fuel Oils	66909	5176.0						77.36					
Diesel Oils	14414	1044.8						72.49					
GAS FUELS	260371	14530.1	0.4	0.0	26.0	4.9	0.4	55.81	0.0014	0.0001	0.1000	0.0190	0.0014
Natural Gas	260371	14530.1	0.4	0.0	26.0	4.9	0.4	55.81	0.0014	0.0001	0.1000	0.0190	0.0014
High Methane	252444	14096.3						55.84					
Nitrified	7927	433.8						54.73					
SOLID FUELS	128555821	11856918.8	308.5	180.0	19282.2	15424.8	617.0	92.23	0.0024	0.0014	0.1500	0.1200	0.0048
Coal and Coke	128536824	11856142.3	308.5	180.0	19280.5	15424.4	617.0	92.24	0.0024	0.0014	0.1500	0.1200	0.0048
Hard	120194532	10930911.4						90.94					
Brown	425743	45832.9						107.65					
Coke	7916549	879398.0						111.08					
Coke Gas	18011	736.0	0.0	0.0	1.6	0.3	0.0	40.86	0.0014	0.0001	0.0900	0.0190	0.0014
Town Gas	986	40.5	0.0	0.0	0.1	0.0	0.0	41.07	0.0014	0.0001	0.1000	0.0190	0.0014
BIOMASS	43495	4545.2	0.7	0.1	8.7	65.2	1.1	104.50	0.0150	0.0020	0.2000	1.5000	0.0250
Wood	43495	4545.2	0.7	0.1	8.7	65.2	1.1	104.50	0.0150	0.0020	0.2000	1.5000	0.0250
TOTAL	**128941010**	**11882215**	**310**	**180**	**19332**	**15496**	**619**	**92.15**	**0.0024**	**0.0014**	**0.1499**	**0.1202**	**0.0048**

Summary presentation of the results for estimated emissions from the subcategory concerning heat plants.

The Research Team produced an overall presentation of the estimated emissions from public, industrial and municipal heat plants, which is reproduced in table 31 (table 13 [3]) entitled "Summary emissions from heat plants".

Table 31. (1.A.1.c) Summary District Heating

FUEL TYPE	Consumption	Emission (Mg)						Aggregate Emission Factors (kg / GJ)					
	GJ	CO 2	CH 4	N 2 O	NO x	CO	NMVOC	CO 2	CH 4	N 2 O	NO x	CO	NMVOC
LIQUID FUELS	15025079	1158373.0	28.2	9.0	2825.9	225.4	38.0	77.10	0.0019	0.0006	0.1881	0.0150	0.0025
Oils	14815740	1142207.8	27.5	8.9	2784.0	222.2	37.4	77.09	0.0019	0.0006	0.1879	0.0150	0.0025
Fuel Oils	14011539	1083913.0						77.36					
Diesel Oils	804201	58294.8						72.49					
Liquid Wastes	209339	16165.2	0.6	0.1	41.9	3.1	0.6	77.22	0.0029	0.0006	0.2000	0.0150	0.0029
GAS FUELS	9817834	542939.0	13.7	1.0	981.8	186.5	13.7	55.30	0.0014	0.0001	0.1000	0.0190	0.0014
Natural Gas	9817834	542939.0	13.7	1.0	981.8	186.5	13.7	55.30	0.0014	0.0001	0.1000	0.0190	0.0014
High Methan	8440387	471306.1	0.0	0.0	0.1	0.0	0.0	55.84					
Nitrified	269562	14751.8						54.73					
Coal Mine	1107885	56881.0						51.34					
SOLID FUELS	468386244.5	43335016.8	1019.25	651.36	78653.3	49778.7	2033.78	92.52	0.0022	0.0014	0.1679	0.1063	0.0043
Coal and Coke	465019154	42857472.6	1014.5	651.0	78391.3	49714.8	2029.1	92.16	0.0022	0.0014	0.1686	0.1069	0.0044
Hard coal	446123143	40771897.5	65.5	97.4	19079.2	2265.0	131.1	91.39					
Brown Coal	3924756	422515.7						107.65					
Coke	14971255	1663059.4						111.08					
Coke Gas	1754654	71703.3	2.5	0.2	157.9	33.3	2.5	40.86	0.0014	0.0001	0.0900	0.0190	0.0014
Blast Furnace Gas	1270707	321955.0	1.8	0.1	69.9	24.1	1.8	253.37	0.0014	0.0001	0.0550	0.0190	0.0014
Town Gas	13259	544.6	0.0	0.0	1.3	0.3	0.0	41.07	0.0014	0.0001	0.1000	0.0190	0.0014
Generator Gas	328471	83341.3	0.5	0.0	32.8	6.2	0.5	253.73	0.0014	0.0001	0.1000	0.0190	0.0014
BIOMASS	8653869	904329.3	129.8	17.3	1730.8	12980.8	216.3	104.50	0.0150	0.0020	0.2000	1.5000	0.0250
Wood	1236946	129260.9	18.6	2.5	247.4	1855.4	30.9	104.50	0.0150	0.0020	0.2000	1.5000	0.0250
Solid Wastes	7416923	775068.5	111.3	14.8	1483.4	11125.4	185.4	104.50	0.0150	0.0020	0.2000	1.5000	0.0250
BIOGAS	155210	14177.0	0.2	0.0	15.5	2.9	0.2	91.34	0.0014	0.0001	0.1000	0.0190	0.0014
TOTAL	**502038237**	**45954835**	**1191**	**679**	**84207**	**63174**	**2302**	**91.54**	**0.0024**	**0.0014**	**0.1677**	**0.1258**	**0.0046**

Summary and conclusions in relation to the estimation of emissions from heat-and-power plants and heat plants (1.A.1.b and 1.A.1.c).

Combined emissions of greenhouse gases from these two subcategories are presented in Table 32, using data from Tables 24, 25 and 31.

Table 32

Gas	Emission [Gg]
CO_2	218589.814
CH_4	2.613
N_2O	3.041
NO_x	597.782
CO	102.344
NMVOC	5.293

Comparison of tables 32 and 3 shows that the emission of CO_2 from heat-and-power and heat plants is 78% of the emission from category -Energy Industry-, and 61% of the emission from the category -Fuel combustion (1.A).

This finding necessitates analysis of the reliability of results obtained in both of the subcategories under consideration, with note taken of:

- the reliability of the determined consumption of fuel,
- the appropriateness of the emission factors utilized.

The formula for the calculation of emissions is a simple one:

$$\text{Emission} = \Sigma \quad (EF_{abc} \times A_{abc})$$

where:

EF - emission factor
A - consumption of fuel
a - type of fuel
b - sector or branch
c - technology of combustion.

Examination of the above factors suggests that the following relationships can be considered the most important in the studied subcategories:

- the relationship between the emission factor for a given greenhouse gas and the type of fuel and its technology of combustion,
- the relationship in the determination of fuel consumption for a given technology of combustion.

The team carried out their own estimates of reliability where the two above relationships were concerned. The entry point of the estimation was the list of selected values defined by the requirements of the statistical sheets for the power supply sector. These values are as follows:

- the consumption of fuel by type and technology,
- the characterization of the fuel, including its chemical composition and calorific value,
- the chemical characterization of waste gases and the combustible fraction in solid wastes,
- the emissions of pollutants (particulates, SO_2, NO_x, CO and CO_2)[x].

[x] - the quantities of these pollutants are not always measured, but are rather estimated for the needs of the calculation of fees for the economic use of the environment.

It is the view of the research team that the completion of statistical sheets with these values (and with others not mentioned) over many years has given rise to enhanced reliability of the data constituting the base for the inventorying of greenhouse gases.

Circumstances favouring this may be the resolutions contained in the draft "Energy Law", which anticipate the concessioning of enterprises for the production of energy. The requirement for the periodic supply of the aforementioned values should be an ingredient of significance in the decision to award a concession. The introduction of measurement to objects producing energy is an expensive procedure, and is likely to take a long time in Polish conditions. It is for this reason postulated that studies in the interim period should be carried out on representative samples of combustion technologies drawn up on the basis of lists of boilers used in the country's power supply industry. On the basis of the results of representative research it would be necessary to work on an atlas of values for emission factors for all greenhouse gases, in relation to the defined types of fuel used and their technology of combustion.

The research team has estimated the certainty of its estimations of emissions on the basis of analyses carried out. These data are given in Table 33.

Tabela 33

Gas	Fuel consumption	Emission factors	Emission
CO_2	H	H	H
CH_4	H	L	L
N_2O	H	L	L
NO_X	H	M	M
CO	H	L/M	L/M
NMVOC	H	L	L

H = high
M = moderate
L = low

No conclusions have been submitted in relation to the IPCC request [2] for suggested methodological modifications to be made in the estimation of emissions.

C.1.1.2. Petroleum refining (1.A.1.d)

Poland has 7 operating oil refineries. 6 of these do not have their own industrial heat-and-power plants which would have emissions in subcategory (1.A.1.b.ii.). The sources of emission estimated in the present subcategory relate to fuel consumption in combustion processes other than those involved in the generation of electrical energy and heat.

The basic source of data on the consumption of the different types of fuel was the official publication of the Main Statistical Office [6]. Emission factors for CO_2 other than refinery gas were determined with formulae obtained by the regression analysis with calorific values done in [5]. Values of the emission factors for the other greenhouse gases were defined on the basis of expert analysis.

Using the results of emissions calculated for industrial heat-and-power plants and industrial heat plants (1.A.1.b.ii and 1.A.c.ii), as well as results of the estimations presented in table 34 (table 2 [7]), it was possible to give total emissions from this subcategory. The estimation of emissions from refining was done on the basis of a "bottom-up" method.

The quality of the results obtained was evaluated as high in the case of emissions of CO_2, and low in the case of the other greenhouse gases.

The team obtained an analysis of refinery gas and its calorific values from Polish refineries and were able to use this as a basis for determining the content of elemental carbon, which was 23.26 kg C/GJ, with a mean calorific value of 47.13 MJ/kg.

The team postulated that the Main Statistical Office could complete its statistical sheet for the power supply industry with information on fuel consumption in the aggregated technological installations of refineries. After periodic research taking in emissions of CO_2, CH_4, N_2O, NO_x, CO and NMVOCs, this would allow future inventories to make direct estimations of emissions by the "bottom-up" method.

Such collected information on emissions would also make it possible for fees for the use of the environment to be applied in relation to the measured criteria.

Notes concerning the IPCC methodology were not forthcoming.

Table 34. (1.A.1.d) Petroleum Refining

FUEL TYPE	Consump.	Emission Estimates (Gg)						Emission Factors (kg / GJ)					
	PJ	CO 2	CH 4	N 2 O	NO x	CO	NMVOC	CO 2	CH 4	N 2 O	NO x	CO	NMVOC
A.1.d													
Hard Coal	0.013	1.141	0.000030	0.000018	0.002604	0.001359	0.000061	89.84	0.0024	0.0014	0.205	0.1070	0.0048
Natural Gas	1.127	62.007	0.001578	0.000113	0.065383	0.019164	0.002142	55.01	0.0014	0.0001	0.058	0.0170	0.0019
Refinery Gas	8.809	507.052	0.044046	0.000881	1.233274	0.218466	0.396410	57.56	0.0050	0.0001	0.140	0.0248	0.0450
Fuel Oil	11.505	899.859	0.033365	0.006903	1.852337	0.172578	0.033365	78.21	0.0029	0.0006	0.161	0.0150	0.0029
TOTAL	**21.454**	**1470.059**	**0.079019**	**0.007915**	**3.153598**	**0.411567**	**0.431977**	**68.52**	**0.0037**	**0.0004**	**0.147**	**0.0192**	**0.0201**

C.1.1.3. The production of processed solid fuels (1.A.1.e.)

Emissions from this subcategory are connected solely with the production of coke, because the production of coal briquettes is at a level of less than 0.1% in comparison to that of coke. Data on the use of fuels in coke production were taken from [6], while emission factors for the different greenhouse gases were as in [5]. Some emission factors were verified with measurement data or statistical data in coking plants. The values for emissions were presented in a segment (1.A.1.e) of Table 35 (table 2 [8]).

Emissions of greenhouse gases from coking plants should be measured for any future inventory.

Table 35. (1.A.1.e) Solid Fuel Production

FUEL TYPE	Consump.	Emission Estimates (Gg)						Emission Factors (kg/GJ)					
	PJ	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
A.1.e													
Coke	0.021	2.341	0.000000	0.000030	0.001060	0.000170	0.000051	110.43	—	0.0014	0.050	0.0080	0.0024
Coke gas	38.838	1563.433	4.854788	0.003884	0.699089	3.650800	4.078022	40.25	0.1250	0.0001	0.018	0.0940	0.1050
Blast Furnace Gas	1.202	305.017	0.150213	0.000120	0.021631	0.112960	0.126179	253.82	0.1250	0.0001	0.018	0.0940	0.1050
TOTAL	**40.061**	**1870.791**	**5.005000**	**0.004034**	**0.721780**	**3.763930**	**4.204251**	**46.70**	**0.1249**	**0.0001**	**0.018**	**0.0940**	**0.1049**

C.1.1.4. Other Energy Industries (1.A.1.f)

Counted in this subcategory were the energetic needs of the industries involved in the extraction of coal, oil and gas and in other processing branches of the power supply industry, including municipal and industrial plants producing combustible gases. For the purposes of calculation, the coal industry was divided off from the rest. The calculation of emissions of greenhouse gases was done on the basis of the "top-down" method, using determined consumptions of fuel by type.

The emission factors for the different greenhouse gases were defined on the basis of expert opinions with partial comparison with data from the results of measurements at enterprises.

The results of calculations are presented in Table 36 (table 2 [8]) for subcategory (1.A.1.f) as a whole and with a division into 36a - the coal industry, and 36b - the others. The results obtained were considered by the research team to be moderately reliable where the estimations of gases other than CO_2 were concerned. This was a result of the uncertainty of values for emission factors for these gases.

Table 36 Other Energy Industries (1.A.1.f.)

Fuel Type	Consumpt. PJ	Emission Estimate						Emission Factors					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVO
Hard Coal	3.524	334.821	0.008458	0.00493	0.726558	0.376732	0.016916	95.01	0.0024	0.0014	0.206	0.1069	0.0048
Brown Coal	0.007	0.676	0.000017	0.00001	0.001449	0.000749	0.000034	96.58	0.0024	0.0014	0.207	0.1070	0.0048
Natural Gas	5.681	311.339	0.007953	0.00056	0.377601	0.096572	0.008120	54.80	0.0014	0.0001	0.066	0.0170	0.0014
Coke	0.138	15.261	0.000330	0.00019	0.012953	0.012815	0.000000	110.58	0.0024	0.0014	0.094	0.0930	-
Fuel Oil	1.201	93.919	0.003483	0.00072	0.193329	0.018012	0.003483	78.20	0.0029	0.0006	0.161	0.0150	0.0029
Nitrified Nat. Gas	3.639	200.036	0.005095	0.00036	0.243813	0.061863	0.005095	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Refining Gas	5.293	304659	0.007410	0.00052	0.741006	0.089979	0.010057	57.56	0.0014	0.0001	0.140	0.0170	0.0019
Coke Gas	17.760	728.790	0.024864	0.00177	1.189920	0.301920	0.024864	41.04	0.0014	0.0001	0.067	0.0170	0.0014
Town Gasi	0.030	1.246	0.000043	0.00000	0.002023	0.000513	0.000043	41.26	0.0014	0.0001	0.067	0.0170	0.0014
TOTAL	**37.273**	**1990.748**	**0.057653**	**0.00909**	**3.488652**	**0.959156**	**0.068610**	**53.41**	**0.0015**	**0.00**	**9.094**	**0.0257**	**0.0018**

Table 36.a Coal Mining (1.A.1.f.i)

Fuel Type	Consumpt. PJ	Emission Estimate Gg						Emission Factors kg/GJ					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Hard Coal	3.498	332.458	0.008395	0.004897	0.724086	0.374286	0.016790	95.04	0.0024	0.0014	0.207	0.1070	0.0048
Brown Coal	0.007	0.676	0.000017	0.000010	0.001449	0.000749	0.000034	96.58	0.0024	0.0014	0.207	0.1070	0.0048
Natural Gas	0.334	17.234	0.000468	0.000033	0.019372	0.005678	0.000635	51.60	0.0014	0.0001	0.058	0.0170	0.0019
Coke	0.131	14.511	0.000314	0.000183	0.012314	0.012183	0.000000	110.77	0.0024	0.0014	0.094	0.0930	-
Fuel Oil	0.004	0.313	0.000012	0.000002	0.000644	0.000060	0.000012	78.18	0.0029	0.0006	0.161	0.0150	0.0029
Total	**3.974**	**365.192**	**0.009206**	**0.005126**	**0.757865**	**0.392956**	**0.017470**	**91.90**	**0.0023**	**0.0013**	**0.191**	**0.0989**	**0.0044**

[able 36. b Residual Fuel Industry (1.A.1.f.ii)

Fuel Type	Consumpt. PJ	Emission Estimate Gg						Emission Factors kg/GJ					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Hard Coal	0.026	2.363	0.000063	0.000037	0.002472	0.002446	0.000126	89.86	0.0024	0.0014	0.094	0.0930	0.0048
Natural Gas	5.347	294.105	0.007485	0.000535	0.358229	0.090894	0.007485	55.01	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat. Gas	3.639	200.036	0.005095	0.000364	0.243813	0.061863	0.005095	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Refining Gas	5.293	304.659	0.007410	0.000529	0.741006	0.089979	0.010057	57.56	0.0014	0.0001	0.140	0.0170	0.0019
Coke	0.007	0.750	0.000016	0.000010	0.000639	0.000632	0.000000	110.30	0.0024	0.0014	0.094	0.0930	-
Fuel Oil	1.197	93.606	0.003471	0.000718	0.192685	0.017952	0.003471	78.21	0.0029	0.0006	0.161	0.0150	0.0029
Coke Gas	17.760	728.790	0.024864	0.001776	1.189920	0.301920	0.024864	41.04	0.0014	0.0001	0.067	0.0170	0.0014
Town Gas	0.030	1.246	0.000043	0.000003	0.002023	0.000513	0.000043	41.26	0.0014	0.0001	0.067	0.0170	0.0014
Total	**33.299**	**1625.556**	**0.048447**	**0.003971**	**2.730787**	**0.566200**	**0.051140**	**48.81**	**0.0015**	**0.0001**	**0.082**	**0.0170**	**0.0015**

C.2. Industry (1.A.2.)

Estimations of emissions of greenhouse gases in industry (with the exclusion of the use of fuels in energy transformations, and own use of this conversion) were made in accordance with the International Standard Industrial Classification.

Research and calculations were done for the following industrial subcategories:

- (1.A.2.a) - iron and steel - 371 (ISK)
- (1.A.2.b) - non-ferrous metals - 373
- (1.A.2.c) - chemicals - 35
- (1.A.2.d) - pulp, paper and print - 34
- (1.A.2.e) - food processing, beverages and tobacco - 31
- (1.A.2.f) - Other industries, divided into:
  - metal products - 38
  - machinery - 38
  - precision instruments - 38
  - means of transport - 38
  - electrical engineering - 38
  - building materials - 3692
  - glass - 362
  - whiteware ceramics - 32
  - wood - 32
  - textiles - 32
  - clothing - 32
  - leather - 32
  - animal fodder
  - others

The carrying-out of research tasks saw the consumption of fuel determined on the basis of data from [6], according to type and for the subcategories of industry distinguished. Account was taken (by way of subtraction) of the consumption of fuel leading to emissions from sections involved in -energy conversion (1.A.1).

A basic problem was the determination of emission factors for the different greenhouse gases and from the different types of fuel considered. Research tasks were divided into two parts:

- the determination of emission factors for CO_2
- the determination of those for the other greenhouse gases.

Worked out in the first stage of the study was a complete list (in line with the IPCC/OECD classification) of types of fuel used in Polish industry. The list included coal and its derivatives, liquid fuels and their derivatives, gaseous fuels, and solid, liquid and gaseous wastes. The characterization of each type of fuel took in calorific value and the related chemical composition. Determined at this stage was an emission factor for carbon and hence CO_{2max}.

Emission factors for fuels playing a significant role in the energy balance of the country were determined with formulae resulting from regression analysis with calorific values of fuels and their chemical compositions. The following formulae were obtained:

The emission factor for elemental carbon from hard coal:

$$C_{hc} \left[\frac{kg\ C}{GJ}\right] = 30.05 - 0.1884 \times LHV,$$

where:

C_{hc} - emission factor for hard coal,
LHV - Low Heat Value of hard coal [MJ/kg],

The emission factor for elemental carbon from brown coal:

$$C_{bc} \left[\frac{kg\ C}{GJ}\right] = 66.1 - 3.587 \times LHV,$$

where:

C_{bc} - emission factor for brown coal,
LHV - Low Heat Value of brown coal [MJ/kg],

The emission factor for elemental carbon from coke and semi-coke:

$$C_{c} \left[\frac{kg\ C}{GJ}\right] = 53.139 - 0.811 \times LHV,$$

where:

C_{c} - emission factor for coke,
LHV - Low Heat Value of coke [MJ/kg],

The emission factor for elemental carbon from motor spirits and diesel:

$$C_{go} \left[\frac{kg\ C}{GJ}\right] = 28.03333 - 0.192 \times LHV,$$

where:

C_{go} - emission factor for gasoline or diesel oil,,
LHV - Low Heat Value [MJ/kg],

The emission factor for elemental carbon from fuel oil:

$$C_{fo} \left[\frac{kg\ C}{GJ}\right] = 39.7549 - 0.45 \times LHV,$$

where:

C_{fo} - emission factor for fuel oil,
LHV - Low Heat Value of fuel oil [MJ/kg],

The emission factor for elemental carbon from high-methane natural gas:

$$C_{ngm} \left[\frac{kg\ C}{GJ}\right] = 24.9018 - 0.2843 \times LHV,$$

where:

C_{ngm} - emission factor for high methane natural gas,
LHV - Low Heat Value of high methane natural gas [MJ/kg],

Assumed for nitrified natural gas were the following values:

$$C_{ngn} = 15.0 \text{ [kg C/GJ]},$$

where :

C_{ngn} - emission factor for nitrified natural gas.

Within the framework of verification, the above values were determined from the analysis of 27 samples, and gave an error of less than +/- 0.5% for the 92% of samples fulfilling the following conditions:

$\sum$ (share by volume of CH_4 + N_2) $\geq$ 97.5%, as well as
$\sum$ (share by volume of higher hydrocarbons) $\leq$ 2.15%

The value for the error does not exceed $\pm$ 1.5% where:

2.15% $\sum$ (share by volume of higher hydrocarbons) $\leq$ 2.5%

which relates to 7% of population of samples.

In only one case did the error attain a value of around 4.9%, where:

$\sum$ (share by volume of CH_4 + N2) $\geq$ 87.02% while
$\sum$ (share by volume of higher hydrocarbons) $\leq$ 12.75%.

The emission factor for elemental carbon from coke-oven gas and town gas was calculated on the basis of the following formula:

$$C_{cg,tg} \left[\frac{kg\ C}{GJ}\right] = 10.678 + 0.029 \times LHV,$$

where:

$C_{cg,tg}$ - emission factor for coke and town gas,
LHV - Low Heat Value of coke and town gas [MJ/m^3],

The emission factor for elemental carbon from blast-furnace gas was calculated using the following formula:

$$C_{bfg} \left[\frac{kg\ C}{GJ}\right] = 115.5 - 13.43 \times LHV,$$

where:

C_{bfg} - emission factor for blast furnace gas,
LHV - Low Heat Value of blast furnace gas [MJ/m^3],

Gathered together in the second stage of the work were the emission factors for CO, CH_4, non-methane volatile organic compounds and NO_2, on the basis of the information obtained from industrial plants, institutions in various branches of industry and selected works in the literature. Given wherever possible was a range of values for these factors in relation to the technology of combustion.

With a view to use in the estimation of emissions from industrial processes, the team also took in emission factors for carbon from combustion processes linked with technological processes e.g. in blast furnaces; converters, electrical and open-hearth steelworks, in the processes by which other non-ferrous metals are smelted, and in the burning of clinker, lime and gypsum.

The process of determining emissions of greenhouse gases should take account of the fact that the elemental carbon from combustion processes does not only take the form of CO_2, but also the other gases CO, CH_4 and NMVOCs. The balance is therefore as follows:

$$C_i \left[\frac{kgC}{GJ}\right] = \frac{12}{44}(CO_2) + \frac{12}{28}(CO) + \frac{12}{16}(CH_4) + \frac{26.4}{31.4}(NMVOC)$$

The next stage of the estimation of emissions in industry (1.A.2) considered the relationship between the emission factor for CO_2 and the calorific value of the types of fuels used in economic sectors and branches of industry.

Defined in energy statistics [6] are consumptions of the different types of fuel for sectors and branches of industry. From these it can be concluded that the calorific values of types of fuel are different in different sectors and branches. Defined on the basis of the data from energy statistics [6] were the aggregate calorific value, the emission factor for elemental carbon and the maximum value of the emission factor for CO_2. These were arranged by sector and specified branch of industry and for the following types of fuel contained in documentation of Team Report [5]:

- hard coal (table 1 annex [5]),
- brown coal (table 2 annex [5]),
- coke (table 3 annex [5]),
- gasoline and diesel oil (table 4 annex [5]),
- fuel oil (table 5 annex [5]),
- high-methane natural gas (table 6 annex [5]),
- coke-oven gas (table 7 annex [5]),
- town gas (table 8 annex [5]),
- blast-furnace gas (table 9 annex [5])

Emission factors for elemental carbon were calculated as a function of calorific values for types of fuel aggregated for sectors and branches, and with the use of the aforementioned formulae obtained by the regression analysis method for different types of fuel.

It follows from the aforementioned results of the research done that the evaluation of emissions of greenhouse gases was done by an indirect "bottom-up" method. The selection of emission factors was made in an expert way in the different branches, on the basis of analysis of the technology of combustion of the types of fuel in the technologies of branches of industry.

The basic source of data on fuel consumption was the publication by the Main Statistical Office (GUS) [6]. Values for the consumption of fuel were taken from [6] and were reduced by the consumption resulting from the fact that most of the branches considered had their own industrial heat-and-power plants or heat plants. Emissions of greenhouse gases from these last sources had already been determined as emissions in subcategories (1.A.1.b.ii) and (1.A.1.c.ii).

To obtain data of the highest possible reliability on the consumption of types of fuel in the branches of industry under consideration, appropriate work was done on the energy balances in these branches, with the values of balance positions being set against data from other industrial information sources where necessary.

Overall results from the estimation of emissions of greenhouse gases from different branches of industry (1.A.2) have been presented in Table 3 as well as Table 4. The detailed results of calculations have been arranged by branch of industry and identified by the symbols of the ISIC classification and are presented in table 37 (table 3 [8]).

As stated above, it is mainly the determination of emission factors that is complicated by the problem of reliability in estimations of the greenhouse gases which results from combustion in technological installations in industry. It was for this reason that the conclusions of the research team estimating emissions in industry were related to systemic activities aimed at the continued updating of values for emission factors. It is anticipated that the procedure will move forward in the following way:

- work will be done to draw up a list of the technologies in each branch which have a significant role in emissions from combustion (examples might be heat furnaces, special technological boilers, dryers etc.),
- work will be done on guidelines for measurement to ensure the accurate establishment of measured amounts and calculation procedures in the determination of emission factors for greenhouse gases,
- obligations will be brought in to determine emissions, with the introduction of new technology within the framework of the modernization of branches of industry and on the basis of balances for energy, substances and elements during the initial testing of newly- received equipment,
- the nomination of a centre for research on gathered data on emission factors for installations in which the technological combustion of fuels occurs, as well as for production lines as a whole (emissions per unit of production, the consumption of different types of fuel per unit of production).

The above recommendations are aimed at the generation of reliable values for emission factors in industrial technologies. They should find reflection in a system for the collection of statistical data from industry for formulae already produced and continually improved, with consideration given to emissions of greenhouse gases and energy statistics discussed in subcategory (1.A.1).

Table 37 (1.A.2) Industry (ISIC)

Industry Branch Fuel Type	Consum PJ	Emission Estimation Gg						Emission Factors kg/GJ					
		CO_2	CH_4	N_20	NO_x	CO	NMVOC	CO_2	CH_4	N_20	NO_x	CO	NMVOC
I. Iron and Steel 371		(1.A.2.a)											
Hard Coal	1.288	116.588	0.003091	0.001803	0.121072	0.119784	0.005667	90.52	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	22.247	1269.953	0.000000	0.002225	1.223585	0.411569	0.133482	57.08	-	0.0001	0.055	0.0185	0.0060
Coke	83.201	9557.060	0.000000	0.116481	4.160050	0.665608	0.199682	114.87	-	0.0014	0.050	0.0080	0.0024
Fuel Oil	5.239	416.602	0.000000	0.003143	3.143400	1.833650	0.029338	79.52	-	0.0006	0.600	0.3500	0.0056
Coke Gas	44.068	1812.640	0.000000	0.004407	2.423740	0.815258	0.264408	41.13	-	0.0001	0.055	0.0185	0.0060
Genarator Gas	0.600	152.768	0.000840	0.000060	0.033000	0.006000	0.000840	254.61	0.0014	0.0001	0.055	0.0100	0.0014
Blast Furnace Gas	27.111	6902.159	0.000000	0.002711	1.491105	0.501553	0.162666	254.59	-	0.0001	0.055	0.0185	0.0060
Total	**183.754**	**20227.770**	**0.003931**	**0.130831**	**12.595952**	**4.353423**	**0.796084**	**110.08**	**0.000001008**	**0.0007**	**0.069**	**0.0237**	**0.0043**
II. Non-Ferrous Metals 372		(1.A.2.b)											
Hard Coal	0.817	77.519	0.001961	0.001144	0.076798	0.075981	0.003595	94.88	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	1.117	62.985	0.000000	0.000112	0.061435	0.020665	0.006702	56.39	-	0.0001	0.055	0.0185	0.0060
Nitrified Nat. Gas	4.406	242.142	0.000000	0.000441	0.242330	0.081511	0.026436	54.96	-	0.0001	0.055	0.0185	0.0060
Coke	5.716	646.006	0.000000	0.008002	0.285800	2.903728	0.013718	113.02	-	0.0014	0.050	0.5080	0.0024
Fuel Oil	1.101	77.852	0.000000	0.000661	0.137625	6.326346	0.002752	70.71	-	0.0006	0.125	5.7460	0.0025
Coke Gas	0.188	7.698	0.000000	0.000019	0.010340	0.003478	0.001128	40.95	-	0.0001	0.055	0.0185	0.0060
Total	**13.345**	**1114.202**	**0.001961**	**0.010378**	**0.814328**	**9.411708**	**0.054332**	**83.49**	**0.0001**	**0.0008**	**0.061**	**0.7053**	**0.0041**
III. Chemicals 35		(1.A.2.c)											
Hard Coal	1.442	138.459	0.003461	0.002019	0.135548	0.134106	0.006345	96.02	0.0024	0.0014	0.094	0.0930	0.0044
Brown Coal	0.041	3.319	0.000098	0.000057	0.003854	0.003813	0.000180	80.95	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	62.733	3364.299	10.037280	0.006273	77.475255	0.627330	21.705618	53.63	0.1600	0.0001	1.235	0.0100	0.3460
Nitrified Nat.Gas	0.326	17.435	0.052160	0.000033	0.402610	0.003260	0.112796	53.48	0.1600	0.0001	1.235	0.0100	0.3460
Coke	4.759	449.798	0.000000	0.006663	0.237950	0.038072	0.011422	94.52	-	0.0014	0.050	0.0080	0.0024
Fuel oil	1.487	116.632	0.004312	0.000892	0.239407	0.022305	0.003718	78.43	0.0029	0.0006	0.161	0.0150	0.0025
Coke Gas	0.449	17.757	0.071840	0.000045	0.554515	0.004490	0.155354	39.55	0.1600	0.0001	1.235	0.0100	0.3460
Town Gas	0.001	0.040	0.000160	0.000000060	0.001235	0.000010	0.000346	39.77	0.1600	0.0001	1.235	0.0100	0.3460
Blast Furnace	0.140	35.441	0.022400	0.000014	0.172900	0.001400	0.048440	253.15	0.1600	0.0001	1.235	0.0100	0.3460
Total	**71.378**	**4143.181**	**10.191712**	**0.015996**	**79.223274**	**0.834786**	**22.044218**	**58.05**	**0.1428**	**0.0002**	**1.110**	**0.0117**	**0.3088**
IV.Pulp, Paper and Print 34		(1.A.2.d)											
IV.1. Pulp and Paper		(1.A.2.d.i)											
Hard Coal	0.041	3.920	0.000057	0.000057	0.002050	0.000328	0.000180	95.61	0.0014	0.0014	0.050	0.0080	0.0044
LPG	0.031	2.039	0.000003	0.000000	0.004495	0.002945	0.000090	65.78	0.0001	-	0.145	0.0950	0.0029
Coke	0.025	2.951	0.000035	0.000035	0.001250	0.000200	0.000060	118.05	0.0014	0.0014	0.050	0.0080	0.0024
Fuel Oil	1.312	103.038	0.000787	0.000787	0.190240	0.124640	0.003280	78.54	0.0006	0.0006	0.145	0.0950	0.0025
Subtotal	**1.409**	**111.948**	**0.000883**	**0.000880**	**0.198035**	**0.128113**	**0.003610**	**79.45**	**0.0006**	**0.0006**	**0.141**	**0.0909**	**0.0026**

IV.2. Print	(1.A.2.d.ii)												
Hard Coal	0.007	0.659	0.000000	0.000010	0.000350	0.000056	0.000031	94.14	-	0.0014	0.050	0.0080	0.0044
Natural Gas	0.015	0.842	0.000021	0.000002	0.001005	0.000255	0.000021	56.14	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat.Gas	0.006	0.330	0.000008	0.000001	0.000402	0.000102	0.000008	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	0.009	1.039	0.000000	0.000013	0.000450	0.000072	0.000022	115.49	-	0.0014	0.050	0.0080	0.0024
Town Gas	0.001	0.041	0.000001	0.0000000	0.000067	0.000017	0.000001	41.26	0.0014	0.0001	0.067	0.0170	0.0014
Subtotal	**0.038**	**2.912**	**0.000031**	**0.000025**	**0.002274**	**0.000502**	**0.000083**	**76.62**	**0.0008**	**0.0006**	**0.060**	**0.0132**	**0.0022**
Total (IV.1.+IV.2)	**1.447**	**114.860**	**0.000913**	**0.000904**	**0.200309**	**0.128615**	**0.003694**	**79.38**	**0.0006**	**0.0006**	**0.138**	**0.0889**	**0.0026**
V. Food Processing, Beverages and	(1.A.2.e)												
Hard Coal	2.680	252.614	0.006432	0.003752	0.251920	0.249240	0.011792	94.26	0.0024	0.0014	0.094	0.0930	0.0044
Brown Coal	0.001	0.102	0.000002	0.000001	0.000094	0.000093	0.000004	102.40	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	0.769	42.582	0.001077	0.000077	0.051523	0.013073	0.001077	55.37	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat.Gas	0.228	12.533	0.000319	0.000023	0.015276	0.003876	0.000319	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	1.901	216.010	0.000000	0.002661	0.072238	0.048285	0.004562	113.63	-	0.0014	0.038	0.0254	0.0024
LPG	0.024	1.579	0.000000	0.000002	0.003480	0.002280	0.000070	65.78	-	0.0001	0.145	0.0950	0.0029
Fuel Oil	6.419	507.002	0.018615	0.003851	1.033459	0.096285	0.016047	78.98	0.0029	0.0006	0.161	0.0150	0.0025
Coke Gas	0.126	5.175	0.000176	0.000013	0.008442	0.002142	0.000176	41.07	0.0014	0.0001	0.067	0.0170	0.0014
Town Gas	0.001	0.041	0.000001	0.0000000	0.000067	0.000017	0.000001	41.26	0.0014	0.0001	0.067	0.0170	0.0014
Total	**12.149**	**1037.638**	**0.026623**	**0.010381**	**1.436499**	**0.415291**	**0.034050**	**85.41**	**0.0022**	**0.0009**	**0.118**	**0.0342**	**0.0028**
VI. Others Industris	(1.A.2.f)												
VI.1. Metal Products Industry 38	(1.A.2.f.i)												
Hard Coal	0.211	20.128	0.000506	0.000295	0.019834	0.019623	0.000928	95.40	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	1.378	76.305	0.001929	0.000138	0.092326	0.023426	0.001929	55.37	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat.Gas	0.219	12.038	0.000307	0.000022	0.014673	0.003723	0.000307	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	2.446	275.916	0.000000	0.003424	0.293520	0.036690	0.005626	112.80	-	0.0014	0.120	0.0150	0.0023
LPG	0.021	1.381	0.000000	0.000002	0.003045	0.001995	0.000061	65.78	-	0.0001	0.145	0.0950	0.0029
Fuel Oil	0.043	3.382	0.000125	0.000026	0.006923	0.000645	0.000125	78.65	0.0029	0.0006	0.161	0.0150	0.0029
Coke Gas	0.449	18.408	0.000629	0.000045	0.030083	0.007633	0.000629	41.00	0.0014	0.0001	0.067	0.0170	0.0014
Genarator Gas	0.154	39.209	0.000216	0.000015	0.010318	0.002618	0.000216	254.60	0.0014	0.0001	0.067	0.0170	0.0014
Subtotal	**4.921**	**446.768**	**0.003711**	**0.003968**	**0.470722**	**0.096353**	**0.009820**	**90.79**	**0.0008**	**0.0008**	**0.096**	**0.0196**	**0.0020**
VI.2. Machinery Industry 38	(1.A.2.f.ii)												
Hard Coal	0.162	15.513	0.000389	0.000227	0.015228	0.015066	0.000713	95.76	0.0024	0.0014	0.094	0.0930	0.0044
Brown Coal	0.001	0.110	0.000002	0.000001	0.000094	0.000093	0.000004	109.84	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	2.819	157.235	0.003947	0.000282	0.188873	0.047923	0.003947	55.78	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat.Gas	0.363	19.954	0.000508	0.000036	0.024321	0.006171	0.000508	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	1.178	134.178	0.000000	0.001649	0.141360	0.017670	0.002709	113.90	-	0.0014	0.120	0.0150	0.0023
LPG	0.010	0.658	0.000000	0.000001	0.001450	0.000950	0.000029	65.78	-	0.0001	0.145	0.0950	0.0029
Fuel Oil	0.064	5.034	0.000186	0.000038	0.010304	0.000960	0.000160	78.65	0.0029	0.0006	0.161	0.0150	0.0025
Coke Gas	0.203	8.315	0.000284	0.000020	0.013601	0.003451	0.000284	40.96	0.0014	0.0001	0.067	0.0170	0.0014
Town Gas	0.001	0.041	0.000001	0.0000000	0.000067	0.000017	0.000001	41.26	0.0014	0.0001	0.067	0.0170	0.0014
Subtotal	**4.801**	**341.038**	**0.005317**	**0.002255**	**0.395298**	**0.092301**	**0.008356**	**71.03**	**0.0011**	**0.0005**	**0.082**	**0.0192**	**0.0017**

VI.3. Presission Instruments		(1.A.2.f.iii)											
Hard Coal	0.006	0.572	0.000014	0.000008	0.000564	0.000558	0.000026	95.40	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	0.012	0.668	0.000017	0.000001	0.000804	0.000204	0.000017	55.70	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat.Gas	0.015	0.825	0.000021	0.000002	0.001005	0.000255	0.000021	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	0.014	1.573	0.000000	0.000020	0.001680	0.000210	0.000032	112.33	-	0.0014	0.120	0.0150	0.0023
Coke Gas	0.009	0.369	0.000013	0.000001	0.000603	0.000153	0.000013	40.96	0.0014	0.0001	0.067	0.0170	0.0014
Subtotal	**0.056**	**4.007**	**0.000065**	**0.000032**	**0.004656**	**0.001380**	**0.000109**	**71.55**	**0.0012**	**0.0006**	**0.083**	**0.0246**	**0.0019**
VI.4. Transport Equipments		(1.A.2.f.iv)											
Hard Coal	0.349	33.370	0.000838	0.000489	0.032806	0.032457	0.001536	95.62	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	1.560	86.726	0.002184	0.000156	0.104520	0.026520	0.002184	55.59	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat.Gas	0.159	8.740	0.000223	0.000016	0.010653	0.002703	0.000223	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	0.434	48.718	0.000000	0.000608	0.052080	0.006510	0.000998	112.25	-	0.0014	0.120	0.0150	0.0023
LPG	0.023	1.513	0.000000	0.000002	0.003335	0.002185	0.000067	65.78	-	0.0001	0.145	0.0950	0.0029
Fuel Oil	0.152	11.861	0.000441	0.000091	0.024472	0.002280	0.000380	78.03	0.0029	0.0006	0.161	0.0150	0.0025
Coke Gas	0.017	0.696	0.000024	0.000002	0.001139	0.000289	0.000024	40.96	0.0014	0.0001	0.067	0.0170	0.0014
Town Gas	0.001	0.041	0.000001	0.0000000	0.000067	0.000017	0.000001	41.26	0.0014	0.0001	0.067	0.0170	0.0014
Subtotal	**2.695**	**191.665**	**0.003710**	**0.001363**	**0.229072**	**0.072961**	**0.005412**	**71.12**	**0.0014**	**0.0005**	**0.085**	**0.0271**	**0.0020**
VI.5. Electrical Engineering		(1.A.2.f.v)											
Hard Coal	0.040	3.803	0.000096	0.000056	0.003760	0.003720	0.000176	95.07	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	0.208	11.068	0.000291	0.000021	0.013936	0.003536	0.000291	53.21	0.0014	0.0001	0.067	0.0170	0.0014Nitrif
Nitrified Nat.Gas	0.286	15.721	0.000400	0.000029	0.019162	0.004862	0.000400	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	0.060	6.777	0.000000	0.000084	0.007200	0.000900	0.000138	112.95	-	0.0014	0.120	0.0150	0.0023
LPG	0.006	0.395	0.000000	0.000001	0.000870	0.000570	0.000017	65.78	-	0.0001	0.145	0.0950	0.0029
Fuel Oil	0.007	0.551	0.000020	0.000004	0.001127	0.000105	0.000018	78.65	0.0029	0.0006	0.161	0.0150	0.0025
Coke Gas	0.026	1.065	0.000036	0.000003	0.001742	0.000442	0.000036	40.96	0.0014	0.0001	0.067	0.0170	0.0014
Town Gas	0.003	0.124	0.000004	0.0000000	0.000201	0.000051	0.000004	41.26	0.0014	0.0001	0.067	0.0170	0.0014
Subtotal	**0.636**	**39.503**	**0.000848**	**0.000197**	**0.047998**	**0.014186**	**0.001081**	**62.11**	**0.0013**	**0.0003**	**0.075**	**0.0223**	**0.0017**
VI.6. Building Materials Industry		(1.A.2.f.vi)											
Hard Coal	62.906	5894.758	0.106940	0.088068	30.582381	20.643233	0.276786	93.71	0.0017	0.0014	0.486	0.3282	0.0044
Brown Coal	0.027	2.646	0.000065	0.000038	0.002538	0.002511	0.000119	98.00	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	1.965	108.182	0.002358	0.000197	0.928777	0.570164	0.002751	55.05	0.0012	0.0001	0.473	0.2902	0.0014
Nitrified Nat.Gas	0.480	26.180	0.000576	0.000048	0.226877	0.139277	0.000672	54.54	0.0012	0.0001	0.473	0.2902	0.0014
Coke	10.346	1198.335	0.017588	0.014484	5.029811	3.395143	0.023796	115.83	0.0017	0.0014	0.486	0.3282	0.0023
Fuel Oil	3.411	265.703	0.006651	0.002047	1.774402	0.986325	0.008527	77.90	0.0020	0.0006	0.520	0.2892	0.0025
Coke Gas	0.181	7.356	0.000217	0.000018	0.085551	0.052519	0.000253	40.64	0.0012	0.0001	0.473	0.2902	0.0014
Blast Furnace	0.153	39.797	0.000184	0.000015	0.072317	0.044394	0.000214	260.11	0.0012	0.0001	0.473	0.2902	0.0014
Subtotal	**79.469**	**7542.957**	**0.134579**	**0.104915**	**38.702655**	**25.833567**	**0.313119**	**94.92**	**0.0017**	**0.0013**	**0.487**	**0.3251**	**0.0039**
VI.7. Glass Industry 362		(1.A.2.f.vii)											
Hard Coal	0.155	14.330	0.000264	0.000217	0.007750	0.001240	0.000682	92.45	0.0017	0.0014	0.050	0.0080	0.0044
Natural Gas	13.099	720.788	0.015719	0.001310	0.484663	0.065495	0.018339	55.03	0.0012	0.0001	0.037	0.0050	0.0014
Nitrified Nat.Gas	4.096	225.237	0.004915	0.000410	0.151552	0.020480	0.005734	54.99	0.0012	0.0001	0.037	0.0050	0.0014

Coke	0.025	2.814	0.000000	0.000035	0.001250	0.000200	0.000060	112.56	-	0.0014	0.050	0.0080	0.0024
LPG	0.017	1.118	0.000000	0.000002	0.002465	0.001615	0.000049	65.78	-	0.0001	0.145	0.0950	0.0029
Coke Gas	0.645	26.362	0.000903	0.000064	0.023865	0.003225	0.000903	40.87	0.0014	0.0001	0.037	0.0050	0.0014
Genarator Gas	2.353	613.100	0.003294	0.000235	0.087061	0.011765	0.003294	260.56	0.0014	0.0001	0.037	0.0050	0.0014
Subtotal	**20.390**	**1603.749**	**0.025095**	**0.002273**	**0.758606**	**0.104020**	**0.029061**	**78.65**	**0.0012**	**0.0001**	**0.037**	**0.0051**	**0.0014**
VI.8. Whiteware Industry	(1.A.2.f.viii)												
Hard Coal	0.625	58.630	0.001063	0.000875	0.031250	0.005000	0.002750	93.81	0.0017	0.0014	0.050	0.0080	0.0044
Brown Coal	0.003	0.338	0.000007	0.000004	0.000150	0.000024	0.000013	112.80	0.0024	0.0014	0.050	0.0080	0.0044
Natural Gas	1.988	109.246	0.002386	0.000199	0.073556	0.009940	0.002783	54.95	0.0012	0.0001	0.037	0.0050	0.0014
Nitrified Nat.Gas	0.588	32.334	0.000706	0.000059	0.021756	0.002940	0.000823	54.99	0.0012	0.0001	0.037	0.0050	0.0014
Coke	0.001	0.118	0.000002	0.000001	0.000050	0.000008	0.000002	117.54	0.0017	0.0014	0.050	0.0080	0.0024
LPG	0.001	0.066	0.000000	0.00000006	0.000145	0.000095	0.000003	65.78	-	0.0001	0.145	0.0950	0.0029
Fuel Oil	0.007	0.548	0.000020	0.000004	0.001127	0.000105	0.000018	78.21	0.0029	0.0006	0.161	0.0150	0.0025
Coke Gas	0.529	21.679	0.000635	0.000053	0.019573	0.002645	0.000741	40.98	0.0012	0.0001	0.037	0.0050	0.0014
Genarator Gas	0.307	79.992	0.000368	0.000031	0.011359	0.001535	0.000430	260.56	0.0012	0.0001	0.037	0.0050	0.0014
Subtotal	**4.049**	**302.951**	**0.005186**	**0.001226**	**0.158966**	**0.022292**	**0.007563**	**74.82**	**0.0013**	-	**0.039**	**0.0055**	**0.0019**
VI.9. Wood Industry 33	(1.A.2.f.ix)												
Hard Coal	0.089	8.499	0.000151	0.000125	0.004450	0.000712	0.000392	95.49	0.0017	0.0014	0.050	0.0080	0.0044
Brown Coal	0.008	0.792	0.000019	0.000011	0.000400	0.000064	0.000035	99.05	0.0024	0.0014	0.050	0.0080	0.0044
Natural Gas	0.234	12.997	0.000281	0.000023	0.033930	0.022230	0.000328	55.54	0.0012	0.0001	0.145	0.0950	0.0014
Coke	0.022	2.504	0.000037	0.000031	0.001100	0.000176	0.000053	113.80	0.0017	0.0014	0.050	0.0080	0.0024
Fuel Oil	1.245	98.290	0.003611	0.000747	0.200445	0.018675	0.003113	78.95	0.0029	0.0006	0.161	0.0150	0.0025
Total	**1.598**	**123.083**	**0.004099**	**0.000937**	**0.240325**	**0.041857**	**0.003920**	**77.02**	**0.0026**	**0.0006**	**0.150**	**0.0262**	**0.0025**
VI.10. Textile Industry 32	(1.A.2.f.x)												
Hard Coal	0.023	2.200	0.000055	0.000032	0.002162	0.002139	0.000101	95.65	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	0.038	2.142	0.000053	0.000004	0.002546	0.000646	0.000053	56.36	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat.Gas	0.035	1.924	0.000049	0.000004	0.002345	0.000595	0.000049	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	0.021	2.468	0.000000	0.000029	0.001050	0.000168	0.000050	117.54	-	0.0014	0.050	0.0080	0.0024
LPG	0.002	0.132	0.000000	0.000000032	0.000290	0.000190	0.000006	65.78	-	0.0001	0.145	0.0950	0.0029
Coke Gas	0.003	0.123	0.000004	0.0000000	0.000201	0.000051	0.000004	41.04	0.0014	0.0001	0.067	0.0170	0.0014
Town Gas	0.001	0.041	0.000001	0.0000000	0.000067	0.000017	0.000001	41.26	0.0014	0.0001	0.067	0.0170	0.0014
Subtotal	**0.123**	**9.030**	**0.000163**	**0.000069**	**0.008661**	**0.003806**	**0.000265**	**73.42**	**0.0013**	**0.0006**	**0.070**	**0.0309**	**0.0022**
VI.11. Clothing Industry 32	(1.A.2.f.xi)												
Hard Coal	0.040	3.756	0.000096	0.000056	0.003760	0.003720	0.000176	93.89	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	0.009	0.507	0.000013	0.000001	0.000603	0.000153	0.000013	56.36	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat. Gas	0.003	0.165	0.000004	0.0000000	0.000201	0.000051	0.000004	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	0.016	1.881	0.000000	0.000022	0.000800	0.000128	0.000038	117.54	-	0.0014	0.050	0.0080	0.0024
Coke Gas	0.001	0.041	0.000001	0.0000000	0.000067	0.000017	0.000001	41.04	0.0014	0.0001	0.067	0.0170	0.0014
Town Gas	0.001	0.041	0.000001	0.0000000	0.000067	0.000017	0.000001	41.26	0.0014	0.0001	0.067	0.0170	0.0014
Subtotal	**0.070**	**6.391**	**0.000116**	**0.000080**	**0.005498**	**0.004086**	**0.000234**	**91.30**	**0.0017**	**0.0011**	**0.079**	**0.0584**	**0.0033**

VI.12. Lether Industry	(1.A.2.f.xii)												
Hard Coal	0.019	1.813	0.000046	0.000027	0.001786	0.001767	0.000084	95.40	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	0.008	0.449	0.000011	0.000001	0.000536	0.000136	0.000011	56.14	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat. Gas	0.001	0.055	0.000001	0.0000000	0.000067	0.000017	0.000001	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	0.005	0.573	0.000000	0.000007	0.000250	0.000040	0.000012	114.54	-	0.0014	0.050	0.0080	0.0024
Total	**0.033**	**2.889**	**0.000058**	**0.000035**	**0.002639**	**0.001960**	**0.000108**	**87.56**	**0.0018**	**0.0010**	**0.080**	**0.0594**	**0.0033**
VI.13. Feed and	(1.A.2.f.xiii)												
Hard Coal	0.029	2.731	0.000070	0.000041	0.002726	0.002697	0.000128	94.19	0.0024	0.0014	0.094	0.0930	0.0044
Coke	0.012	1.364	0.000000	0.000017	0.000600	0.000096	0.000029	113.66	-	0.0014	0.050	0.0080	0.0024
Subtotal	**0.041**	**4.095**	**0.000070**	**0.000057**	**0.003326**	**0.002793**	**0.000156**	**99.88**	**0.0017**	**0.0014**	**0.081**	**0.0681**	**0.0038**
VI.14. Residual	(1.A.2.f.xiv)												
Hard Coal	0.004	0.380	0.000010	0.000006	0.000376	0.000372	0.000018	94.92	0.0024	0.0014	0.094	0.0930	0.0044
Brown Coal	0.001	0.110	0.000002	0.000001	0.000094	0.000093	0.000004	109.84	0.0024	0.0014	0.094	0.0930	0.0044
Natural Gas	0.017	0.954	0.000024	0.000002	0.001139	0.000289	0.000024	56.14	0.0014	0.0001	0.067	0.0170	0.0014
Nitrified Nat. Gas	0.001	0.055	0.000001	0.0000000	0.000067	0.000017	0.000001	54.97	0.0014	0.0001	0.067	0.0170	0.0014
Coke	0.015	1.732	0.000000	0.000021	0.000750	0.000120	0.000036	115.49	-	0.0014	0.050	0.0080	0.0024
Fuel Oil	0.002	0.157	0.000006	0.000001	0.000322	0.000030	0.000005	78.65	0.0029	0.0006	0.161	0.0150	0.0025
Subtotal	**0.040**	**3.389**	**0.000043**	**0.000031**	**0.002748**	**0.000921**	**0.000088**	**84.71**	**0.0011**	**0.0008**	**0.069**	**0.0230**	**0.0022**
Total (VI.1 do VI.14)	**118.922**	**10621.514**	**0.183061**	**0.117439**	**41.031170**	**26.292483**	**0.379293**	**89.31**	**0.0015**	**0.0010**	**0.345**	**0.2211**	**0.0032**
Sum Total	**400.995**	**37259.165**	**10.408201**	**0.285928**	**135.301532**	**41.436307**	**23.311670**	**92.92**	**0.0260**	**0.0007**	**0.337**	**0.1033**	**0.0581**

C.3. Transport - (1.A.3)

The research done to estimate emissions of GHGs in transport made reference to the use of means of air, road and railway transport, as well as inland and sea-going vessels. Emissions from the evaporation of fuels and from their storage and distribution were taken account of in the subcategory involving fugitive emissions from the system involving oil (1.B.1.a). The research team also determined emissions from the use of tractors and agricultural machinery, as well as forest machinery, which were included in the category of emission sources -agriculture and forestry (1.A.6).

Emissions were estimated on the basis of "bottom-up" methods realizing the following tasks:

- **an inventory reflecting the IPCC classification [2], for the means of transport used in Poland:**
    - <u>air transport:</u>
        - (a.i.) - civil aviation,
        - (a.ii) - other (private aviation, flying clubs, agricultural aviation),
    - <u>road transport:</u>
        - (b.i) - private cars:
            - (i.α) - four-stroke engines without catalytic converters,
            - (i.β) - two-stroke engines without catalytic converters,
            - (i.γ) - engines with catalytic converters,
        - (b.ii) - motor vehicles with masses of up to 3500 kg:
            - (ii.α) - four-stroke engine without catalytic converters,
            - (ii.β) - two-stroke engine without catalytic converters,
            - (ii.γ) - engines with catalytic converters,
        - (b.iii) - motor vehicles with masses of more than 3500 kg:
            - (iii.α) - heavy goods vehicles,
            - (iii.β) - buses,
        - (b.iv) - motorbikes
        - (b.v) - mopeds and autocycles
        - (b.vi) - tractors
    - <u>rail transport</u>
    - <u>navigation on inland waterways</u>
    - <u>marine navigation:</u>
        - (e.i) - sea-going vessels
        - (e.ii) - fishing vessels
    - <u>other types of transport:</u>
        - (f.i) - mobile technological machines,
        - (f.ii) - other machines
    - <u>agriculture and forestry (1.A.6)</u>
        - (a) tractors
        - (b) agricultural and forestry machinery.

- **work on a set of fuel types** arranged with reference to the means of transport detailed above.

- **presentation of a methodology for the determination of emissions factors** of greenhouse gases (CO_2, CH_4, N_2O, NO_x, CO and NMVOCs) together with calculation procedures.

- **analysis of the activity** in the different types of transport (e.g. taking into account road transport journeys of the in-town or out-of-town types).

- **determinations of fuel consumption** for different means of transportation, together with the methodological description and several versions of mathematical formulae for determining them in relation to the available input data, but in each case with the following general form:

$$Z = \varrho \times L \times (a \times Q_m + b \times Q_b) \times P$$

where:

Z - consumption of fuel by a given means of transport (kg/year),
ϱ - density of fuel (kg/dm3)
L - number of vehicles,
a - proportion of urban traffic,
b - proportion of out-of-town traffic,
Q_m - mean consumption of fuel by urban traffic on the road (dm3/100 km),
Q_b - mean consumption of fuel by out-of-town traffic on the road (dm3/100km),
P - mean distance covered by vehicles in the course of a year (km),
W - $L \times P$ = total number of vehicle-kilometers per year.

- **agreement between the use of types of fuel and the official statistical data**

- **the carrying-out of estimates of emissions** of greenhouse gases in the transport category (1.A.3) and subcategory (1.A.6).

Analysis of the determination of emission factors in transport - the role of research carried out specially for the needs of the study.

As described above, one of the important research tasks of the team was to determine emission factors for greenhouse gases.

The research team distinguished two main groups of data source in terms of their availability:

- research that they themselves had done concerning emissions of CO_2, CO, NMVOCs and NO_x in subcategories of road transport (1.A.3.b) as well as agriculture/forestry (1.A.6),
- data from the literature, in particular for emissions of CO_2, NMVOCs and NO_x from the remaining subcategories of transport, as well as emissions of CH_4 and N_2O for all subcategories.

The Team Report [9], in relation to research carried out for the needs of the study, contains detailed methodological assumptions and the scope of the test research done with reference to the UN-ECE rules of research procedure appropriate to the subject. Also given were calculation formulae for the correction of the results of test research, which took into consideration the operating conditions of engines, atmospheric conditions and the technical state of vehicles. Finally, the chapter gave a formula for determining the weighted mean values of emission factors for given types of vehicle, with account taken of urban and out-of-town traffic as well as the fuel consumption appropriate to them. The chapter discusses individually, and presents, procedures for the determination of, CO, NMVOCs and NO_x for the subcategory (1.A.3.b). These are based on research done for the needs of the study. Also given is the manner in which to determine emission factors for these gases from the available sources in the literature, as well as the expert correction to Polish conditions of the factors for the remaining subcategories of transport (1.A.3.a,c,d,e,f) and agriculture/forestry (1.A.6).

Analysis also centered on the data in litt. concerning emission factors for CH_4 and N_2O. Account was taken of the aforementioned declaration for all types of subcategory considered in transport, and expert knowledge was used to determine the values for the factors to be used in the calculation of emissions.

Tables 38 and 39 (table 7 & 8 [9]) give the results of the determinations of emission factors on the basis of work done specially for the present study and analysis of sources in the literature.

Tablica 38. Emission Factors CO, NMVOC, NO_x for Air Transport (1.A.3.a)

Source according with [9]	Emission Factor (g/kg)		
	CO	NMVOC	NO_x
Jet/Turbine Airplanes			
(19)	5,4	---	13,1
(20)	5,2	0,78	12,5
(43)	14,6	2,6	17,9
(42)	3,0	0,5	10,0
(44)	2,0	1,0	12,0
Accepted	5,2	0,78	12,5
Piston Airplanes			
(19)	1053	---	3,65
(20)	1034	24	3,52
Accepted	1034	24,0	3,52

Table 39. Emission Factors CH_4 and N_2O for Transport Subcategories (1.A.3)

Source according with [9]	Emission Factor (g/kg)	
	CH_4	N_2O
I.A.3.b.i.α.BS; I.A.3.b.ii.α.BS		
(19)	1,65	---
(20)	1,18 - 1,38	0,040
(22)	1,70	0,043
(23)	1,70	---
(25)	2,50	---
(27)	---	0,10
Accepted	1,7	0,10
I.A.3.b.i.α.ON; I.A.3.b.ii.α.ON		
(19)	0,08	---
(20)	0,06 - 0,10	0,08
(22)	---	0,13
(23)	0,10	0,8 (?)
(27)	---	0,07 - 0,59
Accepted	0,1	0,13
I.A.3.b.iii.BS		
(19)	2,74	---
(20)	0,65 - 1,02	0,02
(23)	2,7	0,14
(25)	2,5	---
Accepted	2,5	0,10
I.A.3.b.iii.ON		
(19)	0,34	---
(20)	0,23 - 0,26	0,08
(23)	0,30	0,2
(25)	---	0,2
Accepted	0,30	0,2

I.A.3.e.(alltypes)		
(19)	0,89	---
(20)	---	0,08
(23)	0,9	0,2
(24)	0,36	---
(25)	0,2	---
Accepted	0,36	0,2
I.A.3.i.PL; I.A.3.ii.PL		
(19)	0,09	---
(20)	0,087	---
(23)	0,1	0,2
(24)	0,5(?)	---
(25)	0,1	---
Accepted	0,1	0,2

The results of inventorying emissions of greenhouse gases in transport

At the beginning it should be indicated that emissions of CO_2 were calculated as real emissions E^R_{CO2} (with account having been taken of the incomplete combustion in engines) as well as the potential emissions E^P_{CO2} appropriate to complete combustion (with CH_4, CO and NMVOCs not occurring in exhaust gases).

The results of the research estimating emissions were presented in the form of following tables:

table 40 Total balance of the engine fuels supply and consumption in 1992 [Gg] (Table 1 [9]),

table 41 Properties of fuel types (Table 5 [9]),

table 42 Town traffic share (a) and outsidetown traffic share (b) in total traffic by categories of motor vehicle (Table 6 [9]),

table 43 Fuel consumption, emissions factors [g/kg] and emission estimated ordered by vehicle types in 1992 (table 9 [9]),

table 44 Fuel consumption, emissions factors [kg/GJ] and emission estimated ordered by vehicle types in 1992 (Table 10 [9]),

table 45 Fuel consumption and emission estimates ordered by type of fuel (table 13 [9]),

table 46 Emissions estimates ordered by IPCC sources categories (table 12 [9]),

Additionally the documentation of the Team Report [9] contains the following tables:

- the detailed systematics of means of transport, along with definitions of the type of fuel and its symbol (Annex 1 [9]),
- in accordance with the IPCC/OECD methodology, structural links between means of transport and the structure used in the documentation of report [9] (Annex 2 [9]),
- detailed balance for motor spirits in 1992 [Gg] (table 2 [9]),
- detailed balance for diesel oil in 1992 [Gg] (table 3 [9]),
- numerical situation of road vehicles as of 31.12.1992, as well as number of vehicle-kilometers and mean consumption of fuels (table 4 [9]),
- percentage shares of fuel consumption by means of transport, and percentage shares of emissions of the different greenhouse gases (Table 11 [9]),
- Percentage shares of fuel consumption and emissions by type of fuel (Table 14 [9]),

Table 40. Total balance of engine fuels supply and consumption in 1992 (1.A.3 . 1.A.6)

Fuel Type	Total consumption (Gg)				Quantity of consumption adopted in Study	Share of Total consumption [%]
	Total	in which:				
		Indisgenous Supply	"Bunker"	Own Use		
Motor Gasoline (BS)	3965,4	3954,4	---	11,0	3954	99,7
Aviation Gasoline (BL)	2,0	1,9	---	0,1	2	~100
LPG (LG)	---	---	---	---	5	---
Diesel Oil (ON) in which: type I type II	5066,6 4734,6 332,0	4840,5 4695,6 144,9	216,9 34,1 182,8	9,2 4,9 4,3	4922 4730 192	97,1 99,9 57,8
Fuel Oil (OP)	2761,0	1480,8	899,9	380,3	903	32,7
Jet fuel (PL)	314,8	227,1	87,6	0,1	315	~100
Hard coal (WK)	---	---	---	---	15	---

Table 41. **Properties of Fuel Types**

Fuel Type	Carbon mass fraction [%]		Low Heat Value [GJ/Gg]	
	accepted	ac. [35]	accepted	ac. [35]
BS	86,0	84,7	43500	44800
BL	86,0	---	43500	---
PL	86,0	86,9	43100	44590
ON	86,0	87,5	42700	43330
OP	85,0	84,8	41000	40190
WK	65,5	---	24000	---
LG	81,4	81,4	47310	47310

Table 42. Town Traffic Share (a) and Outsidetown Traffic Share (b) in Total Traffic

No.	Vehicle Category	Shares	
		a	b
1.	Passanger Cars	0.38	0.62
2.	Light Duty Trucks	0.36	0.64
3.	Heavy Duty Trucks	0.18	0.82
4.	Busses	0.39	0.61
5.	Motocycles	0.23	0.77

Table 43. Fuel Consumption [Gg], Emission Factors [g/kg] and Emission Estimation [Gg] ordered by Vehicle Types in 1992 (1..A.3 & 1.A.6)

No	Vehicle - Fuel Types	Consumption [Gg]	Emission Factors [g/kg]							Emission Estimates [Gg]						
			CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x	CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x
1	I.A.3.a.i.PL	168	3153	3142	0,087	0,20	5,2	0,78	12,5	529,7	527,9	0,015	0,0336	0,87	0,13	2,10
2	I.A.3.a.ii.BL	2	3153	1450	0,87	0,011	1034	24,0	3,52	6,3	2,9	0,002	0,0000	2,07	0,05	0,01
3	I.A.3.a.ii.PL	147	3153	3142	0,087	0,20	5,2	0,78	12,5	463,5	461,9	0,013	0,0294	0,76	0,11	1,84
4	I.A.3.b.i.α.BS	2518	3153	2606	1,70	0,10	250	46,5	32,2	7939,3	6561,9	4,281	0,2518	629,5	117,09	81,0
5	I.A.3.b.I.α.LG	5	2985	2616	1,70	0,10	170	30,3	32,0	14,9	13,1	0,009	0,0005	0,85	0,15	0,16
6	I.A.3.b.i.ON	265	3153	3093	0,10	0,13	19,1	6,3	12,6	835,5	819,6	0,027	0,0345	5,06	1,67	3,34
7	I.A.3.b.i.β.BS	150	3153	1661	2,55	0,02	327	219	6,6	473,0	249,2	0,383	0,0030	49,05	32,85	0,99
8	I.A.3.b.i.γ.BS	15	3153	3040	0,32	0,30	49,9	10,5	7,94	47,3	45,6	0,005	0,0045	0,75	0,16	0,12
9	I.A.3.b.ii.α.BS	906	3153	2513	1,70	0,10	307	47,5	34,8	2856,6	2276,8	1,540	0,0906	278,4	43,04	31,5
10	I.A.3.b.ii.ON	196	3153	3091	0,10	0,13	19,1	6,9	12,6	618,0	605,8	0,020	0,0255	3,74	1,35	2,47
11	I.A.3.b.ii.β.BS	11	3153	2001	2,55	0,022	338	192	7,2	34,7	22,0	0,028	0,0002	3,72	2,11	0,08
12	I.A.3.b.ii.γ.BS	0	---	---	---	---	---	---	---	0	0	0	0	0	0	0
13	I.A.3.b.iii.α.BS	108	3153	2463	2,55	0,10	337	47,6	35,9	340,5	266,0	0,275	0,0108	36,40	5,14	3,88
14	I.A.3.b.iii.α.ON	1891	3153	3049	0,30	0,20	32,5	12,5	67,0	5962,3	5765,7	0,567	0,3782	61,46	23,64	126,
15	I.A.3.b.iii.β.ON	640	3153	3000	0,35	0,20	55,7	15,8	57,1	2017,9	1920,0	0,244	0,1280	35,65	10,11	36,5
16	I.A.3.b.iv.BS	70	3153	1351	2,55	0,02	546	293	6,5	220,7	94,6	0,179	0,0014	38,22	20,51	0,46

Table 43 cont.

No.	Vehicle-Fuel Type	Consumption [Gg]	Emission Factors [g/kg]							Emission Estimates [Gg]						
			CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x	CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x
17	I.A.3.b.v.BS	29	3153	988	2,55	0,011	580	390	3,6	91,4	28,7	0,074	0,0003	16,82	11,31	0,10
18	I.A.3.b.vi.ON	270	3153	3042	0,19	0,16	46,3	8,0	53,5	851,3	821,3	0,051	0,0432	12,50	2,16	14,45
19	I.A.3.c.ON	221	3153	3058	0,30	0,16	29,5	12,7	54,0	696,8	675,8	0,066	0,0354	6,52	2,81	11,93
20	I.A.3.c.WK	15	2402	2394	0,058	b.d.	2,23	1,16	7,9	36,0	35,9	0,001	---	0,03	0,02	0,12
21	I.A.3.d.ON	37	3153	3058	0,30	0,16	29,5	12,7	54,0	116,7	113,1	0,011	0,0059	1,09	0,47	2,00
22	I.A.3.e.i.ON	139	3153	3113	0,36	0,20	8,0	6,0	58,4	438,3	432,7	0,050	0,0278	1,11	0,83	8,12
23	I.A.3.e.i.OP	782	3117	3077	0,36	0,20	8,0	6,0	58,4	2437,5	2406,2	0,282	0,1564	6,26	4,69	45,67
24	I.A.3.e.ii.ON	88	3153	3113	0,36	0,20	8,0	6,0	58,4	277,5	273,9	0,032	0,0176	0,70	0,53	5,14
25	I.A.3.e.ii.OP	121	3117	3079	0,36	0,20	8,0	6,0	58,4	377,2	372,6	0,044	0,0242	0,97	0,73	7,07
26	I.A.3.f.i.ON	250	3153	3038	0,29	0,22	40,0	12,1	74,0	788,3	759,5	0,073	0,0550	10,00	3,03	18,50
27	I.A.3.f.ii.BS	147	3153	1322	2,3	0,031	510	320	10	463,5	194,3	0,338	0,0046	74,97	47,04	1,47
28	I.A.3.f.ii.ON	170	3153	3047	0,30	0,19	34,0	12,4	65,0	536,0	518,0	0,051	0,0323	5,78	2,11	11,05
29	I.A.6.a.ON	630	3153	3042	0,19	0,16	46,3	8,0	53,5	1986,4	1916,5	0,120	0,1008	29,17	5,04	33,71
30	I.A.6.b.ON	125	3153	3020	0,31	0,19	50,0	12,8	63,0	394,1	377,5	0,039	0,0238	6,25	1,60	7,88
Overall Total		10116	3149	2823	0,869	0,15	130,3	33,7	45,3	31851,1	28558,9	8,795	1,5192	1318,42	340,47	458,47

b.d. - brak danych

Table 44. Fuel Consumption [GJ], Emission Factors [kg/GJ] and Emission Estimates [Gg] ordered by Vehicle Types in 1992 (1.A.3 ; 1.A.6)

No	Vehicle - Fuel Type	Consumption [GJ 10^3]	Emission Factors [kg/GJ]							Emission Estimates [Gg]						
			CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x	CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x
1	I.A.3.a.i.PL	7241	73,16	72,90	0,00202	0,00464	0,12064	0,01810	0,29002	529,7	527,9	0,015	0,0336	0,87	0,13	2,10
2	I.A.3.a.ii.BL	87	72,48	33,33	0,02000	0,00025	23,77012	0,55172	0,08090	6,3	2,9	0,002	0,0000	2,07	0,05	0,01
3	I.A.3.a.ii.PL	6336	73,16	72,90	0,00202	0,00464	0,12064	0,01810	0,29002	463,5	461,9	0,013	0,0294	0,76	0,11	1,84
4	I.A.3.b.i.α.BS	109533	72,48	59,91	0,03908	0,00230	5,74713	1,06900	0,74022	7939,3	6561,9	4,281	0,2518	629,50	117,09	81,08
5	I.A.3.b.i.α.LG	236	63,09	55,29	0,03593	0,00211	3,59332	0,64045	0,67638	14,9	13,1	0,009	0,0005	0,85	0,15	0,16
6	I.A.3.b.i.ON	11316	73,84	72,44	0,00234	0,00304	0,44730	0,14754	0,29508	835,5	819,6	0,027	0,0345	5,06	1,67	3,34
7	I.A.3.b.i.β.BS	6525	72,48	38,18	0,05862	0,00046	7,51724	5,03448	0,15172	473,0	249,2	0,383	0,0030	49,05	32,85	0,99
8	I.A.3.b.i.γ.BS	653	72,48	69,89	0,00736	0,00690	1,14713	0,24137	0,18252	47,3	45,6	0,005	0,0045	0,75	0,16	0,12
9	I.A.3.b.ii.α.BS	39411	72,48	57,77	0,03908	0,00230	7,05747	1,09195	0,80000	2856,6	2276,8	1,540	0,0906	278,14	43,04	31,53
10	I.A.3.b.ii.ON	8369	73,84	72,39	0,00234	0,00304	0,44730	0,16159	0,29508	618,0	605,8	0,020	0,0255	3,74	1,35	2,47
11	I.A.3.b.ii.β.BS	479	72,48	46,00	0,05862	0,00051	7,77011	4,41380	0,16551	34,7	22,0	0,028	0,0002	3,72	2,11	0,08
12	I.A.3.b.ii.γ.BS	0	---	---	---	---	---	---	---	0	0	0	0	0	0	0
13	I.A.3.b.iii.α.BS	4698	72,48	56,62	0,05862	0,00230	7,74713	1,09425	0,82528	340,5	266,0	0,275	0,0108	36,40	5,14	3,88
14	I.A.3.b.iii.α.ON	80746	73,84	71,41	0,00703	0,00468	0,76112	0,29274	1,56909	5962,3	5765,7	0,567	0,3782	61,46	23,64	126,70
15	I.A.3.b.iii.β.ON	27328	73,84	70,26	0,00890	0,00468	1,30445	0,37002	1,33724	2017,9	1920,0	0,224	0,1280	35,65	10,11	36,54
16	I.A.3.b.iv.BS	3045	72,48	31,06	0,05862	0,00046	12,55172	6,73563	0,14942	220,7	94,6	0,179	0,0014	38,22	20,51	0,46

Tabela 44 cont.

No	Vehicle - Fuel Type	Consumption [GJ10³]	Emission Factors [kg/GJ]							Emission Estimates [Gg]						
			CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x	CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x
17	I.A.3.b.v.BS	1262	72,48	22,71	0,05862	0,00025	13,33333	8,96552	0,08276	91,4	28,7	0,074	0,0003	16,82	11,31	0,10
18	I.A.3.b.vi.ON	11529	73,84	71,24	0,00445	0,00375	1,08431	0,18735	1,25293	851,3	821,3	0,051	0,0432	12,50	2,16	14,45
19	I.A.3.c.ON	9437	73,84	71,62	0,00703	0,00375	0,69086	0,29742	1,26464	696,8	675,8	0,066	0,0354	6,52	2,81	11,93
20	I.A.3.c.WK	360	100,08	99,75	0,00242	b.d.	0,09292	0,04833	0,32916	36,0	35,9	0,001	---	0,03	0,02	0,12
21	I.A.3.d.ON	1580	73,84	71,24	0,00703	0,00375	0,69086	0,29742	1,26464	116,7	113,1	0,011	0,0059	1,09	0,47	2,00
22	I.A.3.e.i.ON	5935	73,84	72,90	0,00843	0,00468	0,18735	0,14051	1,36768	438,3	432,7	0,050	0,0278	1,11	0,83	8,12
23	I.A.3.e.i.O	32062	76,02	75,05	0,00878	0,00488	0,19512	0,14634	1,42439	2437,5	2406,2	0,282	0,1564	6,26	4,69	45,67
24	I.A.3.e.ii.ON	3758	73,84	72,90	0,00843	0,00468	0,18735	0,14051	1,36768	277,5	273,9	0,032	0,0176	0,70	0,53	5,14
25	I.A.3.e.ii.OP	4961	76,02	75,85	0,00878	0,00488	0,19512	0,14634	1,42439	377,2	372,6	0,044	0,0242	0,97	0,73	7,07
26	I.A.3.f.i.ON	10675	73,84	71,15	0,00679	0,00515	0,93676	0,28337	1,73302	788,3	759,5	0,073	0,0550	10,00	3,03	18,50
27	I.A.3.f.ii.BS	6395	72,48	30,39	0,05287	0,00071	11,72414	7,35632	0,22988	463,5	194,3	0,338	0,0046	74,97	47,04	1,47
28	I.A.3.f.ii.ON	7259	73,84	71,36	0,00703	0,00445	0,79625	0,29039	1,52225	536,0	518,0	0,051	0,0323	5,78	2,11	11,05
29	I.A.6.a.ON	26901	73,84	71,24	0,00445	0,00375	1,08431	0,18735	1,25293	1986,4	1916,5	0,120	0,1008	29,17	5,04	33,71
30	I.A.6.b.ON	5337	73,84	70,73	0,00726	0,00445	1,17096	0,29976	1,47541	394,1	377,5	0,039	0,0238	6,25	1,60	7,88
Total		433452	73,48	65,88	0,0203	0,00350	3,042	0,786	1,058	31851,1	28558,9	8,795	1,5192	1318,42	340,47	458,47

b.d. -Lack of data

Table 45. Fuel Consumption [Gg] and Emission Estimates ordered by Fuel Type in 1992 (1.A.3, 1.A.6)

Type of Fuel	Fuel symbol	Consumption		Emission Estimates [Gg]						
		Gg	GJ 10^3	CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x
Motor Gasoline	BS	3954	171999	12467,0	9739,0	7,102	0,3672	1127,56	279,24	119,70
Aviation Gasoline	BL	2	87	6,3	2,9	0,002	0,0000	2,07	0,05	0,01
LPG	LG	5	237	14,9	13,1	0,009	0,0005	0,85	0,15	0,16
Jet Fuels	PL	315	13577	993,2	989,7	0,027	0,0630	1,64	0,25	3,94
Diesel Oil	ON	4922	210169	15519,1	14999,6	1,330	0,9079	179,04	55,34	281,81
Fuel Oil	OP	903	37023	2814,7	2778,8	0,325	0,1806	7,22	5,42	52,74
Hard Coal	WK	15	360	36,0	35,9	0,001	b.d	0,03	0,02	0,12
Total:		10116	433452	31851,1	28558,9	8,795	1,5192	1318,42	340,47	458,47

b.d. - lack of data

Tabela 46. Emission Estimates ordered by IPCC Sources Categories (1.A.3 & 1.A.6)

	Emission [Gg]						
	CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x
I.A.3.TRANSPORT	29470,6	26265,0	8,637	1,3947	1283,00	333,83	416,89
I.A.3.a. Air Transportation	999,5	992,6	0,029	0,0630	3,71	0,29	3,94
I.A.3.b. Road Transportation	22303,5	19490,2	7,661	0,9725	1171,86	271,29	301,89
i. Passanger cars	9310,0	7689,4	4,703	0,2943	685,21	151,92	85,69
Passanger cars with 3-wayy catalysts	47,3	45,6	0,005	0,0045	0,75	0,16	0,12
Passanger cars without 3-way catalysts	9262,7	7643,8	4,698	0,2898	684,46	151,76	85,57
ii. Light Duty Trucks	3509,3	2904,6	1,588	0,1163	285.60	46,50	34,08
Light Duty Trucks with 3-way catalysts	0	0	0	0	0	0	0
Light Duty Trucks without 3-way catalysts	3509,3	2904,6	1,588	0,1163	285,60	46,50	34,08
iii. Heavy Duty Trucks and Busses	8320,8	7951,7	1,067	0,5170	133,50	38,89	167,12
iv. Motocycles	220,7	94,6	0,179	0.0014	38,22	20.51	0,46
v. Mopedes	91,4	28,7	0,074	0,0003	16,82	11,31	0,10
vi. Agricultural tractors	851,3	821,3	0,051	0,0432	12,50	2,16	14,45

Tabela 46 cont.

	Emission [Gg]						
	CO_2^P	CO_2^R	CH_4	N_2O	CO	NMVOC	NO_x
I.A.3.c. Railways	732,8	711,7	0,067	0,0354	6,55	2,82	12,05
I.A.3.d. Internal Navigation	116,7	113,1	0,011	0,0059	1,09	0,47	2,00
I.A.3.e. International Marine	3530,4	3485,4	0,407	0,2260	9,04	6,78	65,99
I.A.3.f. Other Transportation	1787,8	1471,8	0,462	0,0919	90,75	52,17	31,02
I.A.6. AGRICULTURAL/FORESTRY	2380,5	2294,0	0,158	0,1246	35,42	6,64	41,58
I.A.6.a. Agricultural Tractors & Machines	2380,5	2294,0	0,158	0,1246	35,42	6,64	41,58
TOTAL:	31851,1	28558,9	8,795	1,5192	1318,42	340,47	458,47

Assessment of the accuracy of estimations of emissions, and guidelines for the updating of databases. Assessments of certainty.

The certainty of estimations of overall emissions for the category -transport (1.A.3)- is variable for different greenhouse gases. In fact, three groups should be distinguished:

- CO^{P}_{2} ,
- CO^{R}_{2}, CO, NMVOCs and NO_x,
- CH_4 and N_2O.

The consumptions of fuels included within this category of emission were determined with relatively high accuracy, in spite of it having been assumed that supplies to the market are equal to consumption. This was because of the small volumes stored by distributors and users. The emission factor CO^{P}_{2}, being related to the carbon content, is completely representative of a primary fuel. The error in the estimation of potential emission was assessed to be one of ± 3%.

By analysis of following components:

- the number of vehicle-kilometers and the unit consumption of fuel,
- the proportions of urban and out-of-town traffic (Table 40),
- the values of emission factors from the literature grouped in Tables 38 and 39, and the values of emission factors determined on the basis of work done specially for the needs of the study.

the probable divisions in the estimation of emissions were determined and are presented in the table 47 (table 15 [9]).

The research team considered that the real emissions of CO^{R}_{2}, CO, NMVOCs and NO_x were within the intervals presented in Table 47 with a probability estimated at 95%. Report [9] contained justifications for this last assessment of certainty. It should be noted that assessments of the reliability of emissions of CH_4 and N_2O were not carried out.

Tabela 47. Intervals of Emission Estimates (1.A.3)

Fuel Type		CO_2^R		CO		NMVOC		NO_x	
		min.	maks.	min.	maks.	min.	maks.	min.	maks.
Motor Gasoline		8860	10900	845	1350	195	350	95	140
Aviation Gasoline		954	1020	0,6	4	0,15	0,80	3,2	5,6
Diesel Oil		14290	15800	125	232	39	72	225	338
Fuel Oil		2640	2920	1,7	13	2,4	12	22	79
For all transport categories	Evaluated	26744	30640	972,3	1599	236,55	434,8	345,2	562,6
	Rounded off	26700	30600	970	1600	240	430	350	560

min. - minimum value
maks. -maximum value

Principles for the updating of databases in future inventories

The team discussed in detail the basic factors conditioning the accuracy of future inventories. In general, it can be stated that the list of necessary data should be expanded to take account of:

- the number of cars and the structural changes resulting from the increase in the proportion of vehicles that are low-emission models fitted with catalytic reactors,
- the distance covered annually by motor vehicles, arranged by type of vehicle,
- changes in the properties of fuels and changes in the structure of the types of fuel used (gaseous fuels, unleaded fuel and motor spirits with elevated contents of oxidized compounds).

It is postulated that a specialized unit should be set up to run or steer research and the collection of the data which - when accepted by the Ministry of Environmental Protection, Natural Resources and Forestry - would be of an official nature. The official publication of these data, e.g. in the "Environmental Protection" report from the Main Statistical Office (GUS), would prevent discrepancies from arising in various authors' estimations of emissions in transport (category 1.A.3).

Summary

As mentioned above, the results of the estimations of emissions were presented in Table 46 within the structural categories and subcategories from IPCC/OECD. There are two parts: (1.A.3) - Transport as emissions from the operation of means of transport and (1.A.6) - as emissions from the use of agricultural and forestry machinery. It should be mentioned that - at the suggestion of the team - the estimations of CO_2 in summary tables 3, and 4 refer to CO^P_2 values for emissions. Tables 3 and 4 have values for emissions (1.A.3) from Table 46 marked with the symbol (1.A.3.1) - Transport (Mobile Sources), because an additional subcategory 1.A.3.2 - Transport (Stationary Sources) was introduced into transport. Subcategory 1.A.3.2 - Stationary Sources arose as the balance difference when the use of fuel in transport was reduced by the consumption of motor spirits - considered in (1.A.3.1.), and the use of other fuels taken into consideration in industrial heat-and-power plants (1.A.1.c.ii).

The results of estimations of emissions for the new subcategory -Stationary Sources of emission in transport (1.A.3.2)- are presented in Table 48.

Table 48. (1.A.3.2) Transport - Stationary Sources.

Fuel Type	Consumpt. GJ	Emission Estimates Gg					Emission Factors kg/GJ				
		CO_2	CO	CH_4	NMVOC	NO_x	CO_2	CO	CH_4	NMVOC	NO_x
Hard Coal	9280000	865,917	0,863	0,022	-	0,872	93,31	0,093	0,0024	-	0,094
Brown Coal	22000	2,419	0,002	-	-	0,002	109,95	0,093	0,0024	-	0,094
Coke	3323000	380,517	0,309	0,008	-	0,312	114,51	0,093	0,0024	-	0,094
High Methane Natural Gas.	174000	9,575	0,003	-	-	0,012	55,03	0,017	0,0014	0,0019	0,067
Total	12799000	1258,428	1,177	0,030	-	1,198	x	x	x	x	x

C.4. Municipal management (public/institutional - 1.A.4)

In their present reporting format, Polish energy statistics do not separate out the consumption of fuels in public premises and those of public institutions (specified in IPCC/OECD methodology), but merely refer to a single division "municipal management". It is for this reason that the present inventory gives greenhouse gases under this category of emission source. Ensured in this way is the fullest possible assessment of emissions from all sources. The present category did not include municipal heat plants, whose emissions were determined within (1.A.1.c.iii).

Emissions were estimated by the "top-down" method, taking information on fuel consumption in municipal management from [6]. Emission factors for different types of fuel were defined on the basis of the expertise of those making the assessment. The results of estimations are presented in the form of Table 49 (table 5 [8]).

For the following reasons, the reliability of estimations of emissions was considered to have been low:
* because the evaluation was done using a "top-down" method,
* because the emission factors were estimated roughly with no consideration given to the technology of combustion.

Future inventories should be preceded by an accurate reconnaissance of emission sources in municipal management. In addition, to ensure concordance with emission categories from IPCC, it is essential that changes be made to the system by which information is collected in relation to the energetic activity in trade and public institutions.

Table 49. Commercial / Institutional represented Municipal Sector (1.A.4)

Fuel Type	Consump. PJ	Emission Estimate Gg						Emission Factor kg/GJ					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
A.4. Commercial / Institutional													
Hard Coal	0.103	9.809	0.000247	0.000144	0.012360	0.001545	0.000237	95.23	0.0024	0.0014	0.120	0.015	0.0023
Natural Gas	0.016	0.908	0.000022	0.000002	0.000800	0.000128	0.000038	56.78	0.0014	0.0001	0.050	0.008	0.0024
Nitified Natural Gas	0.010	0.550	0.000014	0.000001	0.000500	0.000080	0.000024	54.98	0.0014	0.0001	0.050	0.008	0.0024
Coke	0.045	5.284	0.000108	0.000063	0.002250	0.000360	0.000108	117.43	0.0024	0.0014	0.050	0.008	0.0024
Fuel Oil	0.014	1.107	0.000041	0.000008	0.001680	0.000210	0.000032	79.10	0.0029	0.0006	0.120	0.015	0.0023
Coke Gas	0.005	0.205	0.000007	0.000001	0.000250	0.000040	0.000012	41.05	0.0014	0.0001	0.050	0.008	0.0024
Town Gas	0.005	0.206	0.000007	0.000001	0.000250	0.000040	0.000012	41.27	0.0014	0.0001	0.050	0.008	0.0024
Total	0.198	18.070	0.000446	0.000219	0.018090	0.002403	0.000464	91.26	0.0023	0.0011	0.091	0.012	0.0023

C.5 Residential sector - (1.A.5)

In Poland, this sector is not distinguished as a separate branch from the point of view of energy statistics. Data on the consumption of different types of fuel were taken from primary sources of information which distinguish only a category entitled "other recipients" - Table 2 (62) [6]. Analysis of the balances for fuel consumption in this category was followed by comparison between these data and other sources of information and corrections for consumption by type of fuel.

Emission factors for CO_2 from different types of fuel were calculated using formulae in chapter 5.1.2, as a function of aggregate calorific values. Emission factors for the remaining greenhouse gases were defined on the basis of expert opinions.

The results of the estimations of emissions have been presented in Table 50 (table 6 [8]). Emissions of CO_2 from the residential sector amount to about 18% of the total emissions in the category -Combustion of Fuels (1.A). Taking note of this share in the total emission as well as the fact that housing is also provisioned with heat from subcategories -heat-and-power plants (1.A.1.b) and -heat plants (1.A.1.c), the research team postulated the development of research for the needs of future inventories. This research would have as its aim the determination of a set of emission sources arranged by technology of combustion, as well as the working-out of a division covering residential requirements for heat (heating and the use of hot water) from centralized and individual sources. Work in this field is now underway within the framework of work on a strategy to reduce emissions in the future, and will form the basis upon which prognoses can be made as to emissions from the housing sector.

On the other hand, it is also essential that new systemic solutions are found for the collection - within the framework of the official energy statistics - of data on the residential consumption of different types of fuel.

Table 50. Residential (1.A.5)

Fuel Type	Consum PJ	Emission Estimate						Emission Factor					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMV
A.5. Residential													
Hard Coal	492.492	46877.445	1.181981	0.689489	18.222204	22.162140	1.132732	95.18	0.0024	0.0014	0.037	0.045	0.0023
Natural Gas	136.539	7752.410	0.191155	0.013654	6.826950	1.092312	0.327694	56.78	0.0014	0.0001	0.050	0.008	0.0024
Natural Gas Nitified	21.215	1166.425	0.029701	0.002122	1.060750	0.169720	0.050916	54.98	0.0014	0.0001	0.050	0.008	0.0024
Wood	31.545	3091.061	0.018927	0.063090	3.533040	0.567810	0.788625	97.99	0.0006	0.0020	0.112	0.018	0.0250
Coke	72.423	8503.671	0.173815	0.101392	8.690760	1.086345	0.166573	117.42	0.0024	0.0014	0.120	0.015	0.0023
LPG	1.838	104.358	0.002573	0.000184	0.091900	0.014704	0.004411	56.78	0.0014	0.0001	0.050	0.008	0.0024
Coke Gas	11.565	474.704	0.016191	0.001157	0.578250	0.092520	0.027756	41.05	0.0014	0.0001	0.050	0.008	0.0024
Town Gas	1.308	53.977	0.001831	0.000131	0.065400	0.010464	0.003139	41.27	0.0014	0.0001	0.050	0.008	0.0024
Total	768.925	68024.051	1.616174	0.871218	39.069254	25.196015	2.501846	88.47	0.0021	0.0011	0.051	0.033	0.0033

C.6. Agriculture and Forestry -(1.A.6)

This category includes emissions from the combustion of fuels for technological purposes (in heat furnaces, heat boilers, driers and other things). This is because the consumption of fuel in heating and the generation of hot water for everyday uses was included in the category - residential (1.A.5).

Also included in the above category are emissions from the consumption of fuels for the propulsion of agricultural and forestry machinery determined in [9] and separated out in Table 46.

The estimation of emissions in the agricultural category under consideration does not in fact give the full actual energetic activity in agriculture. Since the political changes of 1989, private agriculture has come to account for 80% of arable and livestock production. Nevertheless it has not been separated out in the system by which energy statistics are collected. As a result, there was an identified need for research to be carried out to determine the probable consumption of different types of fuels in agriculture, in order that this could then be used to determine emissions. The selection of emission factors for different greenhouse gases was made in accordance with expert evaluations.

The results of the estimation of emissions are given in the form of Table 51 (table 7 [8]).

Notes relating to the urgent need to change the system of energy statistics have already been discussed for the other categories of emission source (1.A.4) & (1.A.5.), but also hold good for agriculture as a separate entity. Augmentation guidelines concerning statistics for agriculture as an economic sector are given in the presentation on emissions from agriculture (4).

Table 51. Agriculture and Forestry (1.A.6)

Fuel Type	Consump. PJ	Emission Estimate Gg						Emission Factor kg/GJ					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
A.6. Agriculture / Forestry													
Hard Coal	27.300	2587.803	0.065520	0.038220	3.276000	0.409500	0.062790	94.79	0.0024	0.0014	0.120	0.015	0.0023
Natural Gas	0.165	9.096	0.000231	0.000017	0.008250	0.001320	0.000396	55.13	0.0014	0.0001	0.050	0.008	0.0024
Natural Gas Nitified	0.040	2.199	0.000056	0.000004	0.002000	0.000320	0.000096	54.98	0.0014	0.0001	0.050	0.008	0.0024
Wood	0.345	33.806	0.000207	0.000690	0.038640	0.006210	0.008625	97.99	0.0006	0.0020	0.112	0.018	0.0250
Coke	1.320	154.506	0.003168	0.001848	0.158400	0.019800	0.003036	117.05	0.0024	0.0014	0.120	0.015	0.0023
LPG	0.005	0.284	0.000007	0.000001	0.000250	0.000040	0.000012	56.78	0.0014	0.0001	0.050	0.008	0.0024
Gasoline	0.095	6.628	0.000276	0.000057	0.025460	0.111625	0.025840	69.76	0.0029	0.0006	0.268	1.175	0.2720
Diesel Oil	1.306	91.496	0.003787	0.000784	0.350008	1.534550	0.355232	70.06	0.0029	0.0006	0.268	1.175	0.2720
Total	**30.576**	**2885.818**	**0.073252**	**0.041620**	**3.859008**	**2.083365**	**0.456027**	**94.38**	**0.0024**	**0.0014**	**0.126**	**0.068**	**0.0149**

C.7. Fugitive emissions from fuels - (1.B)

Such emissions from the production, transmission, storage and distribution of fuels were arranged in the following way:

1. Fugitive emissions from the system involving oil- (1.B.1.a.),

2. Fugitive emissions from the system involving natural gas -(1.B.1.b.),

3. Fugitive emissions from the system involving coal -(1.B.2).

C.7.1. Fugitive emissions from the system involving oil (1.B.1.a)

Only 1% of the Polish oil system is sustained by domestic deposits. Up to 50% of the country's oil is imported in oil tankers and the other 50% via pipeline from Russia. The system serves an additional role as a transit system supplying Germany from either Russia or the sea.

Poland has 7 operational oil refineries which processed a total of 12.6 million Mg of oil in 1992. The largest refinery (in Plock) processed about 74% of this total, while the refinery in Gdansk processed 20% and the other 5 just over 6%. Oil products are distributed by way of wholesale methods (with more than 190 storage bases) and subsequently retail at more than 3550 stations dealing mainly with motor spirits. Also in existence are a certain small number of internal fuel stations in industry and the armed forces, which are not taken into account in the inventory because of a lack of data available.

From the outset, the research team drew up a schematic representation of the whole system involving oil and oil-related products (fig. 2). This served as a basis for the analysis of emission sources and took account of the mutual links between the obtaining of oil (by extraction or import), its processing, and its wholesale and retail distribution. To arrange subcategories of emission in the form of aggregate emission sources, consideration was given to the places of occurrence of sources (emitters) resulting from technological connections or location and functional connections.

To estimate fugitive emissions in the whole system involving oil and oil-related products and from the point of view of the method of calculating emissions, a division was made into the following units constituting subcategories:

- The extraction of oil,

- The transport and storage of oil,
  - the offloading of vessels in port,
  - pipeline transport,
  - transport in railway tankers,

- The processing of oil,

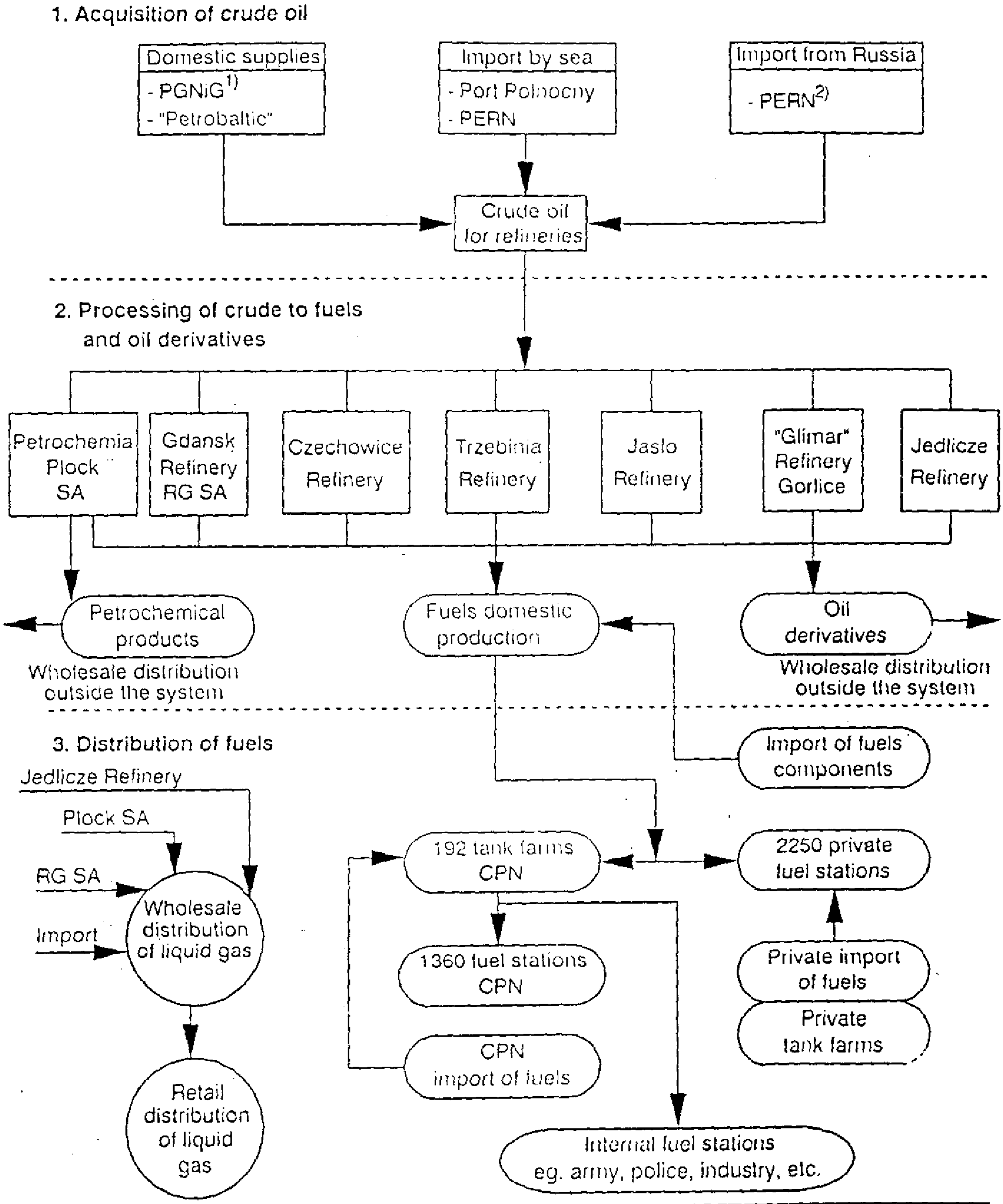
- The distribution of oil:
  - wholesale,
  - retail.

The estimation of emissions took in the gases NMVOCs, CH_4 and CO_2 (derived from oil deposits).

Figure.2

Flowchart of the crude oil system in Poland

(flows of crude oil, liquid fuels, and oil derivatives)



1) PGNiG - Polskie Gornictwo Naftowe i Gazownictwo
2) PERN - Przedsiebiorstwo Eksploatacji Rurociagow Naftowych

C.7.1.1 Emissions from the extraction of oil (1.b.1.a.i).

Included in this subcategory are:

- oil wells, as well as treatment installations and tanks for the storage of oil,
- the "Petrobaltic" oil-extraction platform.

Information on the extraction of oil was taken from the statistics of enterprises. It also included a gas-oil ratio for exploited oil-bearing deposits. The last quantity was not made use of because its value was found to be variable.

Estimations of emissions from this subcategory were based on annual reports from the different wells. Balanced and arranged in accordance with the IPCC methodology were the following data:

- the amount of oil extracted,
- the amount of associated gas in the extraction, and its mean chemical composition,
- the proportion of gas emitted to the atmosphere as compared with the total amount of associated gas in the extraction,
- the proportion of gas burnt off by flaring, in relation to the total amount of associated gas in the extraction.

The total amount of oil extracted nationally in 1992 was 0.199 million Mg - a quantity which corresponded to an energy value of 8.4 PJ (at a calorific value of 42 GJ/Mg). It has already been mentioned that this represented slightly over 1% of the oil processed in Poland.

The summary results of emission estimation are presented in Table 52.

Additionaly the documentation in the Team Report [10] included 7 tables presenting results of research and calculations:

- algorithms for the determination of aggregate emission factors for CH_4, NMVOCs and CO_2 (table 6.1 [10]) ,
- the chemical composition of associated gas in extractions (table 6.2 [10]),
- indicative balance data for wells, concerning associated gas in extraction, with a division into that discharged to the atmosphere and that burnt off by flaring [m3/Mg of oil] (table 6.3 [10]),
- determined emission factors for CH_4, NMVOCs and CO_2 in kg/Mg and kg/PJ (table 6.4 [10]),
- emissions of CH_4 from the subcategory "extraction" (table 6.5 [10]),
- emissions of NMVOCs from the subcategory "extraction"(table 6.6 [10]),
- emissions of CO_2 from the combustion of gas by flaring at wells (table 6.7 [10]).

Table 52. Estimations of emissions of greenhouse gases from the extraction of oil (1.B.1.a.i)

Type of gas	Emission factor kg/GJ	Emission Gg
CH_4	0.0628	0.5
NMVOC	0.0475	0.4
CO_2	6.3150	52.8

The results in Table 52 are located in Table 5 in point (1.B.1.a.i).

C.7.1.2. Emissions from the transport and storage of oil (1.b.1.a.ii)

Estimations in this subcategory relate only to NMVOCs. As mentioned above, almost 99% of Poland's oil is supplied by offloading in seaports and by pipeline. It is for this reason that analysis of emissions in this subcategory was concerned with the following sources of emission:

- the offloading of oil from tankers in port,
- the transport of oil by pipeline and in railway tankers.

Each of these sources of emission is equipped with its own storage bases as well as with offloading and filling installations.

The first stage of the determination of emissions involved the determination of activity in the transport of oil. Official statistical sources provided a value for the amount of oil imported for processing in Poland. The figure for 1992 was 12,769 Gg. A second area of activity in transport whose calculation was essential was the amount of oil in transit through Poland to Germany. In the face of a lack of official data on this, it was necessary for an evaluation to be made on the basis of expert opinions. The accepted quantity for pipeline transit supplied from Russia and from the ports was 20,000 Gg, and this figure was used in calculations. A third data item concerning activity in transport was the amount of oil pumped out of tankers in port. This was estimated by way of an expert opinion at 800 Gg. It was further assumed that 20% of this quantity was offloaded from vessels not equipped with separate ballast installations. This type of offloading is a primary source of the emission of NMVOCs.

Estimated finally were the emissions of NMVOCs from the transport system and from storage, in distinguished sets of emission sources:

a. from the storage bases of transport (filling and offloading operations) with reference to the total amount of oil processed in Poland and the amount of oil in transit through it - a total value of 32,769 Gg,

b. from spills, breakdowns and imperfect seals, in relation to the total amount transported across Polish territory,

c. from the offloading of oil from tankers without separate ballast installations, in relation to the 20% of oil offloaded in port.

The following emission factors were accepted when the sets of emission sources separated out above were taken into account:

ad.a. 0.009% by weight of the oil pumped through the national transport system - a figure determined on the basis of results from 1991 - publication [5] in the Team Report [10]

ad.b. 0.001% by weight for the total amount of oil pumped by the national system - the value of this factor being accepted on the basis of expert analysis carried out for the needs of the study,

ad.c. 0.003% by weight of oil, representing the 20% of the total amount of oil offloaded from tankers in port.

The data resulting from the calculation have been appended in the form of Table 53(table 6.8 [10]). Aggregate data from Table 53 are also to be found in Table 5 in the position (1.B.1.a.ii).

Table 53 (1.B.1.a.ii) NMVOC Emission from Crude Oil Transportation.

Operation in Subsystem	Total Activity	Activity Factor	Accounted Activity Gg	Energy Activity PJ	Emission Factor %	Emission Gg	Emission Factor Mg/PJ
Storage tanks form	32769	1.0	32769	1376.3	0.009	2.949	2.143
Spilling, failure and piping leakage	32769	1.0	32769	1376.3	0.001	0.328	0.238
Reloading in harbor	8000	0.2	1600	67.2	0.003	0.480	7.143

TOTAL 3.757

C.7.1.3. Emissions from refineries (1.b.1.a.iii)

The estimations of emissions of greenhouse gases took in NMVOCs only.

The Team Report [10] contained a simplified schematic representation of the technology of all 7 Polish refineries. This served in the analysis of emission sources, which were ordered as follows in the first stage of the research:

- storage and operating tanks,
- loading facilities,
- processing installations,
- installations of the technical infrastructure of the refinery.

It was considered appropriate to determine emission factors for particular refineries treated as one aggregate emission source. The factor behind such a methodological approach was the register of emissions - including those of NMVOCs - which each refinery possesses and which were made available for the period 1991-1993. Part of the data contained in the registers at refineries was evaluated using the API and CONCAWE methodologies.

The values of aggregate emission factors for NMVOCs are presented in table 54 (table 6.19 [10]). From analysis of this table it follows that there was a clear tendency for values of emission factors in the different refineries to fall in the years 1991-1993. The reduction in emissions is an effect of the improvement in refining processes, the use of gaseous discharges, the modernization of tanks (with floating roofs), the sealing of loaders etc. The observation that emission factors have changed makes it necessary for future inventories to re-determine their values each time.

Table 54. (1.B.1.a.iii) NMVOC Emission Factor for Refineries in kg/PJ

Refinery	1991	1992	1993
A	23 100	16 100	16 900
B	10 400	8 300	6 400
C	19 500	19 000	19 300
D	41 000	41 700	27 100
E	124	67 800	65 100
F	30 900	11 300	11 500
G	204	180	117

The research team proposed that the method of calculation of emission factors be made uniform and be based on:

- registers of the operation of installations (the filling and pumping-out of tanks and loading facilities to cisterns) - for emissions from loading facilities,
- assessments of non-organized emissions from technological installations - by using data generated for the purposes of an inventory as well as those from the US EPA and CONCAWE,
- registers and estimations for breakdown situations, pipeline spills and periodic leaks.

Tables 55 and 56 (table 6.10 [10]) the results of estimations of NMVOCs, determined according to the values accepted for emission factors in 1992, and expressed in kg/PJ.

Table 55 (1.B.1.a.iii) NMVOC Emission from Refineries

Refinery	Production PJ	Emission Factor kg/PJ	Emission Gg
A	389.6	16 100	6.3
B	103.6	8 300	0.9
C	14.4	19 000	0.3
D	5.7	41 700	0.2
E	5.0	67 800	0.3
F	4.6	11 300	0.1
G	5.1	180 400	0.9
Total	528.1	17 000	9.0

Table 56. (1.B.1.a.iii) NMVOC Emission from Refineries

No.	Refinery	Production Mg/year	Emission kg/year	Emission Factor kg/Mg crude oil	Emission Factor kg/PJ
1	2	3	4	5	6
1.	A	9275737	6285695	0.678	16135
2.	B	2466087	856522	0.347	8270
3.	C	344000	274622	0.798	19008
4.	D	135434	236990	1.750	41664
5.	E	119400	340000	2.848	67801
6.	F	109500	52101	0.476	11329
7.	G	122496	928000	7.576	180379
8.	**Total**	**12572654**	**8973930**		
9.	**Average from all refinery industry**			**0.714**	**16995**

The above results are also placed in Table 5 under the position (1.B.1.a.iii).

C.7.1.4 The wholesale distribution of fuels (1.b.1.a.iv)

Estimations of emissions of NMVOCs relate to petrol (gasoline) and to diesel oil. Enterprises involved in the wholesale distribution of fuels do not register the discharges of gas resulting from all wholesale operations with the exception of the transfer of petrol to railway tankers and car tanks, and also the filling of tanks with fixed roofs and the emptying of tanks with floating roofs. The latter requirements are formal conditions for the establishment of fees for the economic use of the environment.

Methodologies of calculation and emission factors were available (e.g. those of API), but were not in fact used as an approach to determining emission factors for NMVOCs for each wholesaler, because the number was considered to be too large and the detailed data too difficult to obtain. Used in place of this approach based on the organizational division was a model of the wholesale market constructed within the framework of research and taking account of: the manner in which products were dispatched and the share of the different bases in the wholesale trade. The following subcategories of wholesale base were ultimately typified for the market model:

- large bases at the ends of pipelines, equipped with hermetically-sealed loading facilities and vapour recovery units, and serving in re-dispatch by railway or road;

- large bases at the ends of pipelines with tanks with floating roofs, but not having hermetically-sealed loading facilities and vapour recovery units and serving in re-dispatch by railway or road;

- large bases at the ends of pipelines: tanks with fixed roofs and not equipped with hermetically-sealed loading facilities serving in re-dispatch by railway or road;

- large bases supplied by rail and serving in re-dispatch by road only;

- large bases at ports accepting imported fuels from tankers and barges, and serving in re -dispatch via rail or road;

- small bases supplying a small number of petrol (gasoline) stations and equipped with tanks with fixed roofs.

The market model was only used in the estimation of emissions of NMVOCs from the wholesale trade in petrol (gasoline).

The detailed model was abandoned in the case of the distribution of diesel, because emission factors were considerably lower. The scale of activity in relation to direct use given by the Main Statistical Office were determined in this same proportion as for petrol (28% more). Emission factors for diesel were established at a level ten times lower than for petrol (gasoline). The scale of activity amounted to 266 PJ and the emission of NMVOCs to 0.9 Gg - a figure taken account of in the summary presentations for the category 1.B.1.a.

Each type of wholesale base was characterized as a subcategory by an emission factor for NMVOCs calculated using API and CONCAWE methodologies. The Team Report [10] contains the appropriate algorithms which were applied.

The results of calculation of emission of NMVOCs from the wholesale distribution of petrols according to the market model are presented in table 57 (table 6.13 [10]).

Table 57. (1.B.1.a.iv) NMVOC Emission from Gasoline Trade Distribution

Terminal/ Trade Base	Gasoline Trade Turnover PJ	Emission Factor kg/PJ	Emission Gg
Sea Terminals	21.3	32 200	0.7
Piping PT	54.8	30 400	1.7
Piping PT	18.3	21 500	0.4
Others-Large	97.5	29 500	2.9
Small bases	32.5	48 600	1.6
Total	226.3	32 100	7.3

In addition, the documentation in the Team Report [10] included the following tables:

- emission factors for NMVOCs from the wholesale trade in petrols (gasoline), organized by operations (table 6.11. [10]),
- emission factors for NMVOCs from the wholesale trade in petrols (gasoline) organized by size and type of loading installation (table 6.12.[10]),
- algorithms for the calculation of emissions of NMVOCs from the wholesale trade in petrols (gasoline) (table 6.14.a [10]),
- algorithms for the calculation of emissions of NMVOCs from the wholesale trade in diesel (table 6.14.b[10]).

C.7.1.5 Emissions of NMVOCs from the retail distribution of fuels (1.b.1.a.iv)

The following subcategories of emission were distinguished within the retail distribution of petrols (gasoline):

- emissions from tanks at petrol stations,
- emissions from tankers as they are filled,
- emissions from spills during the loading of the tanks of motor vehicles.

Emissions of NMVOCs were estimated in the following way:

- by the definition of the consumption of petrol taken from [6],

- with the total number of retail stations divided into three types:
  - those without hermetic seals;
  - those with hermetic sealing during the filling of storage tanks (at "stage 1"),
  - those also having hermetic sealing during the filling of tanks in motor vehicles (at "stage 2").

- with the calculation of emissions of NMVOCs on the assumption that each station distributes the national mean quantity of fuel calculated from total consumption and the number of stations, and with use being made of an emission factor appropriate to the type of station (i.e. the degree to which it is sealed).

It follows from the above that the calculation of emissions from individual stations was abandoned on account of the lack of the required statistics on the trade in fuels at particular stations. Emission factors related to the type of station were taken from CONCAWE reports.

Table 58 (table 6.15 in [10]) presents the emission factors for NMVOCs which were used in the calculations, and arranges them by types of station and their emission sources.

The summary presentation of emissions of NMVOCs is given (along with additional information):

* for petrols (gasoline) - in Table 59 (Table 6.16a [10])
* for diesel oil - in Table 60 (table 6.16 in [10]).

Estimations were augmented by assessments of emissions from the retail distribution of diesel, on the assumption that the emission factor for NMVOCs from this source would be 10 times lower than that for petrol (gasoline).

Table 58. (1.B.1.a.iv) NMVOC Emission Factors

Filling Station Type	% vol. (m3)	kg / Mg	kg / PJ
Without hermet.			
Reservoir	0.160	1.280	30476
Car filling	0.180	1.440	34286
Spilling	0.010	0.080	1905
Total	0.350	2.800	66667
I stage hermet.			
Reservoir	0.027	0.216	5143
Car filling	0.180	1.440	34286
Spilling	0.010	0.080	1905
Total	0.217	1.736	41335
II stage hermet.			
Reservoir	0.027	0.216	5143
Car filling	0.080	0.640	15238
Spilling	0.010	0.080	1905
Total	0.117	0.936	22286

Table 59. (1.B.1.a.iv) NMVOC Emission from gasoline distribution 1992 r.

End use of gasoline	-	4097
LHV of 1 Gg gasoline	-	0.043 PJ
No. of gasoline station	-	3550
No. of gasoline station without hermet.	-	3540
No. of gasoline station I stage of hermet.	-	0
No. of gasoline station II stage of hermet.	-	10

Gasoline station	End use PJ	Factor kg/PJ	Emission NMVOC Gg
without hermet.	175.7	66667	11.712
I st. hermet.	0.0	41333	0.000
II st. hermet.	0.5	22286	0.011
Total	176.2		11.723
Average		66542	

Table 60.(1.B.1.a.iv) Emission from diesel oil distribution in 1992

End use of diesel oil -4929 Gg
LHV of 1 Gg-0.042 PJ

End use	End use PJ	Factor kg/PJ	Emission NMVOC Gg
Average	**207.0**	**6654**	**1.378**

Summary presentation of the results of the estimation of emissions from the system involving oil (1.B.1.a).

Summary results of the estimations made for the oil system are presented for NMVOCs, CH_4 and CO_2 separately, respectively:

- for NMVOCs in Tables 61 (table 6.17 [10]),
- for CH_4 in table 62 (table 6.18a [10])
- for CO_2 in table 63 (table 6.18b [10]).

Total estimated 1992 emissions of greenhouse gases from the system involving oil were as follows:

- NMVOCs - 33.789 Gg
- CH_4 - 0.517 Gg
- CO_2 - 52.783 Gg

Table 61. (1.B.1.a) Total NMVOC Emission from Oil System in 1992

Statistic Data	Gg/year	PJ/year	Data source
Indigenous Production	199	8.359	GUS
Import	12769	536.298	GUS
Transit	20000	840.000	estimat.
Domestic Refinery Processing	12573	528.051	GUS
Range of Gasoline Trade Operations	5262	226.257	estimat.
Range of Diesel Oil Trade Operations	6330	265.874	estimat
Gasoline End Use	4097	176.171	GUS
Diesel Oil End Use	4929	207.018	GUS
Subcategory / Operation	**Quantity PJ**	**Emission Factor Gg/PJ**	**Emission Gg**
1. Indigenous Production	8.4	0.047517	0.397
2. Transportation	1376.3	0.002730	3.757
3. Refining	528.1.	0.016995	8.974
4. Trade Distribution a. gasoline b. diesel oil	 226.3 265.9	 0.029899 0.002990	 6.765 0.795
5. Retail distribution a. gasoline b. diesel oil	 176.2 207.0	 0.066542 0.006654	 11.723 1.378
Total	2788.0	-	33.788

GUS - Main Statistical Office

Table 62. CH_4 Emission form Crude Oil Production (1.B.1.a)

Production	199 Gg/year - Data from GUS		
	Activity w PJ	Emission Factor Gg/PJ	NMVOC Emission Gg
CH_4	8.4	0.0618225	0.517

Table 63. CO_2 Emission from Flaring of Natural Gas during Production (1.B.1.a)

Production	199 Gg/year -Data from GUS		
	Activity w PJ	Factor Emission Gg/PJ	Emission CO_2 Gg
CO_2	8.4	6.314655	52.783

Summary and conclusions

In the estimation of emissions of greenhouse gases from the oil system, the research team made use of 17 foreign publications, 3 Polish works and 11 reports from enterprises in the oil industry.

The team considered the results of the estimations of emissions to be accurate. In spite of the research activities undertaken in relation to the system, use was made of practically every available source of information, including production and ecological reports from enterprises in the oil industry.

Nevertheless, it emerged that the sources of information were insufficient for a fully reliable estimation of emissions, and in connection with this it is proposed that:

- research be developed for the uniform definition of the sources of hydrocarbon emissions, the ways of determining emission factors, the methods of calculation and the system for the collection of data,
- work be done on the legal principles allowing for periodic ecological reviews of the system involving oil.

Presented at, specialist seminars, organized by the team, for the environmental protection services in the oil industry, aroused the interest of the participants the results of research. The programme for the restructuring of the oil sector anticipates the increased processing of oil in Poland and the modernization of the existing refinery technology. It is assumed that the award of concessions for activities within the oil sector (processing, wholesaling and retail distribution) will be conditioned by the meeting of ecological requirements to be defined by legal regulation, and by an obligation to carry out appropriate measurement.

The team's assessment was that the following emissions were underestimated:

- those of CH_4 from refineries,
- those of NMVOCs from wholesale distribution.

The main reasons for this situation are:

- the difficulty of choosing emission factors for NMVOCs from different sources, including the transport of oil and distribution,
- the omission of emissions of CH_4 in refineries and in distribution, in the face of the consideration of these emissions in the "extraction" category only.

It was assessed that emissions of CH_4 might even have been underestimated by 100%, while those of NMVOCs by only a few per cent.

C.7.2. Fugitive emissions from the gas system (1.B.1.b)

The system of gas supply in Poland is made up of three separate subsystems:

- the subsystem involving high-methane natural gas,
- the subsystem involving nitrified natural gas,
- the subsystem involving coke-oven gas.

In 1992, the system for the supply of gas had about 14,000 km of transmission pipeline, 61,000 km of distribution pipeline, 27 systemic and deposit-located pumping stations, about 3200 primary or secondary reduction or reduction-and-measurement stations and 4 underground stores for gas with a total capacity of about 0.6 billion m3. In 1994, the transmission network had around 16,400 km of pipeline and the distribution network around 68,000 km.

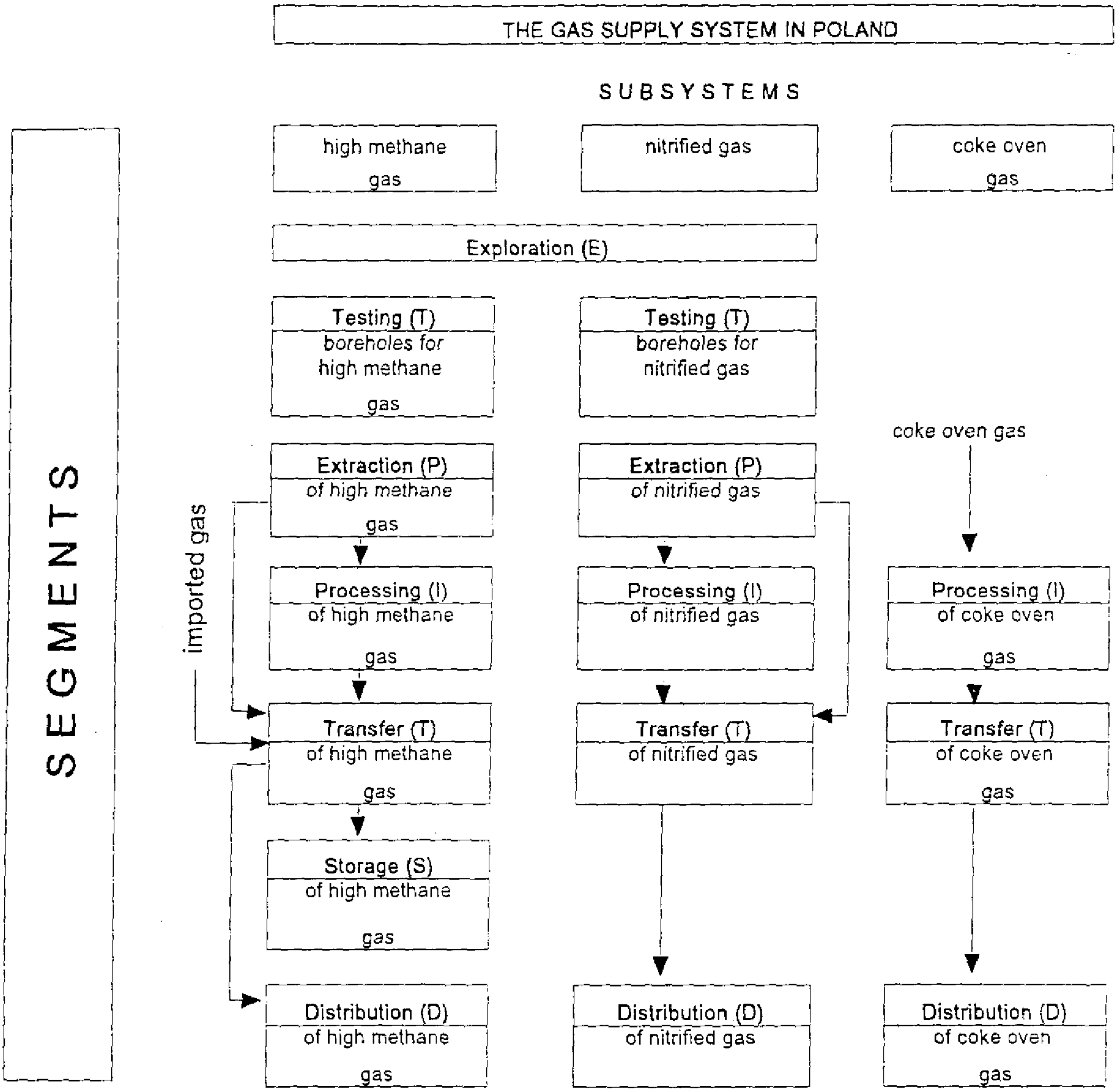
The gas system supplies about 6.1 million domestic customers, including 5.7 million in 498 towns and cities, and 0.4 million in 2000 villages. About 10% of recipients use gas for heating. Gas is also used by about 70% of industrial plants. A dominant role in the system is played by the subsystem involving high-methane natural gas, which extends through more or less the whole country. This subsystem is supplied from domestic deposits in the Carpathian foothills, from Plants for the Denitrifying of nitrified natural gas, from Russia via Belorussia and from Ukraine. The subsystem is also connected with the gas system of Germany via Zgorzelec and the Swinoujscie region.

Underground stores for gas operate only in the subsystem involving high-methane natural gas. The subsystem involving coke-oven gas includes Silesia only and it is anticipated that all domestic recipients will have switched from coke-oven gas to natural gas by the end of 1995.

The research team drew up a detailed schematic representation of the whole gas supply system and its division into subsystems and segments (fig.3.). This was used in the determination of the systematics of emission sources. Emissions were calculated in each segment (source subcategory) in the subsystem, with additions done in accordance with the accepted systematics of sources. No source of emission was omitted.

The methodology for estimating emissions of CH_4, NMVOCs and CO_2 from the gas system is in agreement with that of the IPCC.

Figure 3.



Blockwise schematic representation of the subdivision of the system of gas supply in Poland into the segments and subsystems taken into account in the inventorying of emissions.

The analysis of the Polish gas supply system and the ways in which data for reports were obtained and collected, made it impossible to take the full and detailed approach to estimations (level III in [2]) involving the precise specification of emission sources (boreholes, pipelines, installations, reduction-and-measurement stations etc.), the specifics of their operation (normal functioning, repair and renovation work and breakdowns) and the determination of emission factors for them.

However, in order to obtain estimates that were as detailed as possible, a mixed approach was taken which involved:

- accepting that emissions were equal to reported losses in those situations where there was no basis for detailed specification by type of source and exploitative operations carried out.

- the determination of emissions on the basis of emission factors selected or determined from the analysis of losses,

- the indication of emissions on the basis of emission factors taken from the subject literature following analyses of the similarity of structure of the subsystems.

Organized for specified segments (subcategories) of subsystems, emission sources in the segment and the exploitative operations ascribed to them were full algorithms in the methodology for the calculation of emissions are presented in [11] for the systematics of emission sources so defined.

Essential in the use of this methodology for the estimation of emissions were the following basic data:

- the amount of gas produced from domestic sources,
- the composition of the gas produced from domestic sources,
  the amount of gas derived from imports,
- the composition of gas in the gas supply system,
- the calorific value of the gas,
- the (weighted) mean molecular mass of non-methane volatile organic compounds,
- physical constants (the molar volume of the gas, the molecular masses of components of the gas and calorific values of these components).

Each of the above values were determined for high-methane natural gas, nitrified natural gas and coke-oven gas.

The sources of quantitative information were [6] and [4], as well as reports from sites where gas is extracted and other enterprises within the gas industry, which made it possible to make appropriate corrections. The summary presentation of the aforementioned basic data was organized by subsystem in table 64 (table III-2 [11]).

Table 64. **Basic Data for Calculation Emission of Gas, Methane, NMVOC and CO_2 from Polish Gas System (1.B.1.b)**

		Subsystem			Molar Mass	LHV
		High Methane Gas	Nitrified Gas	Coke Gas	kg/kmol	MJ/m3
Chemical Analysis % v/v	CH4	96.450	62.500	23.900	16.043	35.882
	C2H6	0.316	2.000	1.330	30.069	64.353
	C3H8	0.160	0.370	1.270	44.096	93.207
	C4H10	0.130	0.000	0.000	58.123	123.46
	C5H12	0.056	0.000	0.000	72.150	156.62
	C6H14	0.017	0.000	0.000	86.177	189.60
	CO	0.000	0.000	9.400	28.010	12.634
	CO2	0.140	0.040	3.100	44.010	0.0000
	H2	0.000	0.180	53.500	2.016	10.779
	He	0.000	0.180	0.000	4.003	0.0000
	N2	2.731	34.910	7.500	28.013	0.000
Average Molar Mass	kg/kmol	43.62	32.26	36.92		
NMVOC Share	% v/v	0.679	2.370	2.600		
Gas Quantity in	mln	7600.0	2519	999.2		
Indigenous Production	mln m3/year	1509.0	2519	4697.2 *		
Average LHV	MJ/m3	35.24	24.06	17.57		
Energy Subsystem Load	PJ/year	267.83	60.60	17.56		

* - not used in calculation

C.7.2.1 Emissions in the course of exploratory work

The research team collected data related to:

- the number of drillholes and the number of drillhole meters in the years 1988-1993 (table IV-1 [11]) ,
- the breakdowns associated with blowouts (table IV-2 [11]),
- the releases of methane from areas in which exploratory drilling is or was carried out (table IV-3 [11]).

Emissions of NMVOCs and CH_4 were calculated on the basis of worked-out algorithms and data.

C.7.2.2 Emissions in the course of the testing of successful drillholes.

In this range, the research team:

- gives the number of test boreholes, the amounts of gas emitted and its chemical composition (table V-1 [11]),
- presents values for the emissions of NMVOCs, CH_4 and CO_2 from successful test boreholes drilled for high-methane and nitrified natural gas, along with emission factors relating to units of production of gas (table V-3 [11]).

C.7.2.3. Emissions from the extraction of gas and its preparation for transportation

In this range, the research team collected the following data and obtained the following results:

- an extract from the report determining losses and calculated emission factors per unit of gas production (table VI-1 [11]),
- the number of emission sources in this subcategory (areas of extraction, wellheads, separators, heat exchangers, glycol desiccators, glycol regenerators and well pipelines) for the subsystems involving high-methane natural gas and nitrified natural gas (table VI-2 [11]),
- emission factors according to the US EPA organized by emission source and elements of their operation (the lack of a full seal, outflows from monitoring and measurement apparatus and blowouts) (table VI-3 [11]),
- emissions of NMVOCs, CH_4 and CO_2 from the extraction of high-methane and nitrified natural gas, as well as values for the calculated emission factors expressed in terms of kg/PJ of extracted gas (table VI-4 [11]).

C.7.2.4 Emissions from installations for the processing of gas.

The research team, in this range, presents:

- a technological characterization, and details of the output, of installations processing gas, which are assigned to the subsystems of high-methane natural gas and nitrified natural gas (table VII-I [11],
- calculated emissions of NMVOCs, CH_4 and CO_2 with division into operating condition (normal functioning, repair and breakdown), for the subsystems involving high-methane natural gas, nitrified natural gas and coke-oven gas, as well as calculated values for emission factors expressed in kg/PJ of gas consumed (table VII-2 [11]).

C.7.2.5 Emissions from the transmission system.

Defined overall for each gas supply subsystem were the sets of following data:

- the length of transmission pipelines,
- the mean diameter of the pipelines,
- the nominal pressure for the transmission of gas,
- the age of the pipelines,

and

- an inventory of reduction-and-measurement stations,
- an inventory of pumping stations.

Reports from District Gas Supply Plants do give data on losses of gas, but these do not usually distinguish between losses in the course of transmission and those incurred as gas is distributed to customers. An exception here was the Pomeranian District Gas Supply Plant which had been furnished with the appropriate measuring installations. Data on losses of gas from this Plant were subjected to analysis, and emission factors for CH_4 were determined on the basis of an exact characterization of the technical equipment of the district subsystem. The technical equipment of the studied district was presented with reference to transmission pipelines (organized by length, diameter and length of time in operation), a further division was made for pipelines in operation for more than 20 years, and specifying the reduction-and-measurement stations (input pressures and the number of stations).

Emission factors were calculated on the basis of the above, summary set of data. These were expressed in terms of m^3/km/year for the industry, for the lack of perfect seals, for breakdowns, for conservation work and for remaining installations in the gas supply networks, as well as for reduction and measurement stations in m^3/station/year.

Algorithms for calculation were worked out and were presented in Table VIII-3. The following were distinguished:

Em1 - emissions from the lack of a perfect seal along pipelines,
Em2 - emissions from pneumatic installations,
Em3 - emissions from compressor stations,
Em4 - emissions from reduction and measurement stations,
Em5 - emissions from renovation work and conservation,
Em6 - emissions resulting from breakdowns along pipelines.

Emission factors obtained from research for the Pomeranian District Gas Supply Plant were considered as representative for the remaining plants.

The kg/PJ emission factors for NMVOCs, CH_4 and CO_2, which were used in the calculation of emissions from the transmission of gas, were presented in table 65 (tableVIII-14 [11]).

Used in the calculation of emissions of NMVOCs, CH_4 and CO_2 were the data on chemical composition and activity which are gathered together in Table 64.

Summary results from the calculation of emissions of NMVOCs, CH_4 and CO_2 from transmission in all three gas subsystems were presented in table 66 (table VIII-13 [11]).

The tables containing the partial results of the calculations of emissions of NMVOCs, CH_4 and CO_2 from the transmission of gas were presented in Team Report [11] in the form of the following tables:

- for high-methane natural gas (tableVIII-10 [11]),
- for nitrified natural gas (tableVIII-11 [11]),
- for coke-oven gas (tableVIII-12 [11]).

Table 65. (1.B.1.b) Emission Factors CH4, NMVOC and CO2 from Gas Transportation ordered by Gas Subsystems and States of Exploatation

Emission Factors		Average Value	Coke Gaz subsystem	Nitrified Gas Subsystem	High Methane Natural Gas Subsystem
f.(CH4)	kg CH4/PJ	**130638**	**57991**	**109470**	**140189**
Normal	Em1-4	111761	44382	93162	120386
Routine Repair	Em5	16720	11863	15096	17406
Failure	Em6	2157	1746	1212	2397
f.(NMVOC)	kg NMVOC/PJ	**4276**	**14519**	**8347**	**2683**
Normal	Em1-4	3592	11111	7104	2304
Routine Repair	Em5	610	2970	1151	333
Failure	Em6	74	437	92	46
f.(CO2)	kg CO2/PJ	**1513**	**20643**	**192**	**558**
Normal	Em1-4	1201	15792	164	479
Routine Repair	Em5	287	4221	27	69
Failure	Em6	39	621	2	10

Em1 - Emission from Piping
Em2 - Emission from Pneumatic Devices
Em3 - Emission from Compresor Stations
Em4 - Emission from Pressure-Reducing and Measuring Station
Em5 - Emission from Routine Repair
Em6 - Emission from Failure

Table 66 (1.B.1.b) CH4, NMVOC and CO2 Emission from Transportation of All Gas Subsystems

Emission CH4 [kg/year]	Em1	Em2	Em3	Em4	Em5	Em6	Emission CH4 [kg/year]
Dolnoslaski	477079	419507	140071	1665344	459720	48836	3210557
Górnoslaski	1393003	813633	116239	1113867	891625	124015	4452382
Karpacki	2857245	1537573	1563640	8791046	1684960	302386	16736850
Mazowiecki	1671792	1024848	469092	5313521	1123086	149994	9752333
Pomorski	558968	499042	0	1947653	546878	38778	3591319
Wielkopolski	1490140	984408	671741	3148797	1078770	82221	7456077
TOTAL	**8448227**	**5279011**	**2960783**	**21980228**	**5785039**	**746230**	**45199518**

Emission NMVOC [kg/year]	Em1	Em2	Em3	Em4	Em5	Em6	Emission NMVOC [kg/year]
Dolnoslaski	56772	45036	17427	138864	49353	6167	313619
Górnoslaski	69428	42190	29102	36073	46234	6216	229243
Karpacki	54692	29432	29931	168274	32253	5788	320370
Mazowiecki	32001	19617	8979	101709	21498	2871	186675
Pomorski	11360	10343	0	41160	11335	798	74996
Wielkopolski	63604	46051	24431	166283	50465	3727	354561
TOTAL	**287857**	**192669**	**109870**	**652363**	**211138**	**25567**	**1479464**

Emission CO2 [kg/year]	Em1	Em2	Em3	Em4	Em5	Em6	Emission CO2 [kg/year]
Dolnoslaski	42310	27271	13965	27082	29885	5054	145567
Górnoslaski	70620	43740	41360	26883	47933	6340	236876
Karpacki	11377	6122	6226	35005	6709	1204	66643
Mazowiecki	6657	4081	1868	21158	4472	597	38833
Pomorski	2200	1956	0	7604	2144	152	14056
Wielkopolski	4566	2859	2224	8406	3133	243	21431
SUMA	**137730**	**86029**	**65643**	**126138**	**94276**	**13590**	**523406**

Em1 - Emission from Piping
Em2 - Emission from Pneumatic Devices
Em3 - Emission from Compresor Stations
Em4 - Emission from Pressure-Reducing and Measuring Station
Em5 - Emission from Routine Repair
Em6 - Emission from Failure

C.7.2.6 Emissions associated with the operation of gas stores.

The Polish natural gas system (for high-methane gas) has 4 underground stores for gas with a total capacity of 0.6 billion m^3. The Research Team did not obtain the necessary data with which to estimate emissions of gas from the statistics concerning the exploitation of underground gas stores. It was therefore decided to apply emission factors taken from a report by the US EPA from 1993.

Calculations took into consideration emissions from:

- the lack of a permanent seal in the wellheads of exploited drillholes,
- pneumatic installations,
- compressor stations,
- repair and renovation work,
- breakdowns.

The lack of data made it impossible to take account of emissions from imperfect seals along pipelines and installations preparing gas for transport from a store.

Summary results of estimations of emissions are included in Table 67 (table IX-2 in [11]).

Table 67. (1.B.1.b) CH4, NMVOC and CO2 Emission from Underground Gas Storages

Number	4	
Average Molar Mass NMVOC	43.62	kg/mol
Yearly Gas Consumption	7600	mln m3/rok
LHV	35.24	MJ/m3
Energy Storage Load	21.14	PJ/rok

Chemical analysis	% v/v
CH4	96.45
C2H6	0.316
C3H8	0.16
C4H10	0.13
C5H12	0.056
C6H14	0.017
CO2	0.14
N2	1.731

Emission Source		Emission						
		Gas	CH4		NMVOC		CO2	
		m3/year	m3/year	kg/year	m3/year	kg/year	m3/year	kg/year
Leakage		8154	7865	5629	55	108	11	22
Pneumatic Devices		604.2	583	417	4	8	1	2
Compressor Station		906000	873837	625456	6152	11972	1268	2491
Routine Repair		106920	103124	73812	726	1413	150	294
Failure		42288	40787	29193	287	559	59	116
	TOTAL	1063966	1026196	734507	7224	14060	1489	2925

Gas Emission Factor		0.0013	m3/m3 stored gas
CH4 Emission Factor	f.(CH4, gas storage)	34745	kg/PJ stored gas
NMVOC Emission Factor	f.(NMVOC, gas storage)	665	kg/PJ stored gas

C.7.2.7 Emissions from the distribution of gas to customers.

In-depth analysis was carried out to determine losses of gas from the national distribution system, on the basis of statistics concerning:

- annual losses in all districts,
- losses in the monthly distributions of selected districts.

On the basis of this analysis it was noted that the divergences in the values of losses ascribed to defined emission sources were such as to make it impossible - under the present system of measuring and registering losses - to draw up an inventory using statistics from the distribution network.

In the light of this, it was decided that emissions from the distribution network should be estimated on the basis of emission factors available in the literature. To realize this task, a list of the necessary data was compiled, and comparative studies carried out in relation to:

- the material structure of pipelines in the distribution networks of Poland, and of other countries which do make the measurements allowing emission factors to be determined,
- data on discovered leaks in Poland and in other countries (the USA and Denmark),
- the estimation of the length of the distribution network, as divided by type of gas and construction material of pipeline, and on the basis of:
    - data on the total 1992 consumptions of high-methane natural gas, nitrified natural gas and coke-oven gas,
    - the total length of the distribution network,
    - data on the lengths and material structures of pipelines in each district.
- determinations of the number of gas connections in selected districts,
- assessments of the number of secondary reduction-and-measurement stations for the different types of gas, with note taken of:
    - the total number of primary and secondary stations (3200),
    - the number of inventoried primary stations (910),
    - the total consumption of gas: 7600 billion m^3 of high-methane natural gas, 2519 billion m^3 of nitrified natural gas and 0.999 billion m^3 of coke-oven gas.

The above comparative research was of a reconnaissance and academic nature, but did nevertheless provide a basis upon which to estimate emissions, because:

- it led to the establishing of emission sources in the distribution network,

- it made possible the establishment of a database characterizing the activity of the different segments of the network,
- it allowed for the determination of emission factors for some sources on the basis of Polish data, as well for the justified selection of sets of foreign emission factors for the national inventory,
- it made possible the formulation of a programme of further research work aimed at the introduction of estimations of emissions with a defined degree of accuracy which would be higher than that achieved at present.

The results of the estimations of emissions are brought together in tables:

- table 68 a - for high-methane natural gas (table X-12a [11]),
- table 68 b - for nitrified natural gas (table X-12b [11]),
- table 68 c - for coke-oven gas (table-12 c [11]).

The emissions of CH_4, NMVOCs and CO_2 are given in Table 69 (table X-13 [11]).

Table 68a (1.B.1.b) Emission from High Methane Natural Gas Distribution in [m3/year]

Characteristic of Distribution					
Material		Steel	Cast Iron	PE	Number of Station
Net	km.	30500	110	13100	
Join Point	pieces	542500		232500	
StationII	pieces				1567

Emission		Steel	Cast Iron	PE	Station
Net		98332000	922130	1139700	
Join Point		16817500	0	46500	
StationII					1653185
Maintenance		94550	341	40610	
Failure		838750	3025	360250	
120248541		**116082800**	**925469**	**1587060**	**1653185**

Table 68b (1.B.1.b) Emission from Nitrified Natural Gas Distribution in [m3/year]

Characteristic of Distribution					
Material		Steel	Cast Iron	PE	Number of Station
Net	km.	10100	400	4350	
Join Point	pieces	184560		79100	
StationII	pieces				519

Emission		Steel	Cast Iron	PE	Station
Net		32562400	3353200	378450	
Join Point		5721360	0	15820	
StationII					547545
Maintenance		31310	1240	13485	
Failure		277750	11000	119625	
43033185		**38592820**	**3365440**	**527380**	**547545**

Table 68c (1.B.1.b) Emission from Coke Gas Distribution in [m3/year]

Characteristic of Distribution					
Material		Steel	Cast Iron	PE	Number of Station
Net	km.	1910	390		
Join Point	pieces	40840			
StationII	pieces				204

Emission		Steel	Cast Iron	PE	Station
Net		6157840	3269370	0	
Join Point		1266040	0	0	
StationII				0	215220
Maintenance		5921	1209	0	
Failure		52525	10725	0	
10978850		**7482326**	**3281304**	**0**	**215220**

Table 69. (1.B.1.b) CH_4, NMVOC i CO_2 Emission from Distribution Net and their Emission Factors

	High Methane Gas		Nitrified Gas		Coke Gas		Average Emission Factor
	Emission	Factor	Emission	Factor	Emission	Factor	
	kg/year	kg/PJ	kg/year	kg/PJ	kg/year	kg/PJ	kg/PJ
CH4	83013412	309945	19250842	317657	1878110	106980	300997
NMVOC	1589007	5933	1467901	24222	470202	26783	10194
CO2	330552	1234	33798	558	668268	38066	2985

Summary results from estimations of the fugitive emissions from the gas system

These results relate to CH_4, NMVOCs and CO_2 and are divided up in two ways:

- by gas subsystem (for high-methane natural gas, nitrified natural gas and coke-oven gas) (in Tables XI-1, XI-2 and XI-3 in [11]).
- by the greenhouse gases themselves - with quantities emitted from the gas system as a whole, and from the separate subsystems:
  - CH_4, - table 70 (table XI-4 in [11]),
  - NMVOCs - table 71 (table XI-5 in [11]),
  - CO_2 - table 72 (table XI-6 in [11]).

The last form of summary presentation of results is Table 73 (table XI-7 [11]), which adopts the structure proposed by IPCC in [2].

Table 70. (1.B.1.b) CH4 Emission from Gas System (1992)

Emission from High Methane Natural Gas

Segment of Subsystem		Emission	Reference activity	Emission Factor	
		kg/year	PJ/year	Value kg/PJ	Base Reference
Gas Production		5371953	53.27	100848	Mined Gas
Gas Processing		1164	267.83	4	Consumed Gas
Gas Transportation		37547276	267.83	140189	Consumed Gas
Underground Storage		734508	267.83	2742	Consumed Gas
Gas Distribution		83013412	267.83	309945	Consumed Gas
	SUM	**121296360**	267.83	**452880**	Consumed Gas
	TOTAL	**126668313**			

Emission from Nitrified Natural Gas

Segment of Subsystem		Emission	Reference activity	Emission Factor	
		kg/year	PJ/year	Value kg/PJ	Base Reference
Gas Production		2078977	60.6	34307	Mined Gas
Gas Processing		6134362	60.6	101227	Consumed Gas
Gas Transportation		6634170	60.6	109475	Consumed Gas
Underground Storage		0			
Gas Distribution		19250842	60.6	317671	Consumed Gas
	SUM	**32019374**	60.6	**528373**	Consumed Gas
	TOTAL	**34098351**			

Emission from Coke Gas

Segment of Subsystem		Emission	Reference activity	Emission Factor	
		kg/year	PJ/year	Value kg/PJ	Base Reference
Gas Production					
Gas Processing		9587	17.56	546	Consumed Gas
Gas Transportation		1018073	17.56	57977	Consumed Gas
Underground Storage		0		0	Consumed Gas
Gas Distribution		1878110	17.56	106954	Consumed Gas
	SUM	**2905770**	17.56	**165477**	Consumed Gas
	TOTAL	**2905770**			

TOTAL CH4 Emission 163 627 434 kg

Table 71. (1.B.1.b) NMVOC Emission from Gas System (1992)

Emission from High Methane Natural Gas

Segment of Subsystem		Emission kg/year	Reference activity PJ/year	Emission Factor Value kg/PJ	Emission Factor Base Reference
Gas Production		102828	53.27	1930	Mined Gas
Gas Processing		76	267.83	0	Consumed Gas
Gas Transportation		718714	267.83	2683	Consumed Gas
Underground Storage		14060	267.83	52	Consumed Gas
Gas Distribution		1589007	267.83	5933	Consumed Gas
	SUM	**2321857**	267.83	**8668**	Consumed Gas
	TOTAL	**2424685**			

Emission from Nitrified Natural Gas

Segment of Subsystem		Emission kg/year	Reference activity PJ/year	Emission Factor Value kg/PJ	Emission Factor Base Reference
Gas Production		158524	60.6	2616	Mined Gas
Gas Processing		3230	60.6	53	Consumed Gas
Gas Transportation		505864	60.6	8348	Consumed Gas
Underground Storage		0			Consumed Gas
Gas Distribution		1467901	60.6	24223	Consumed Gas
	SUM	**1976995**	60.6	**32624**	Consumed Gas
	TOTAL	**2135519**			

Emission from Coke Gas

Segment of Subsystem		Emission kg/year	Reference activity PJ/year	Emission Factor Value kg/PJ	Emission Factor Base Reference
Gas Production					Mined Gas
Gas Processing		2400	17.56	137	Consumed Gas
Gas Transportation		254884	17.56	14515	Consumed Gas
Underground Storage		0			Consumed Gas
Gas Distribution		470202	17.56	26777	Consumed Gas
	SUM	727486	17.56	41429	Consumed Gas
	TOTAL	727486			

TOTAL NMVOC Emission 5 287 690 kg

Table 72. (1.B.1.b) CO2 Emission from Gas System (1992)

Emission from High Methane Natural Gas

Segment of Subsystem		Emission	Reference activity	Emission Factor	
		kg/year	PJ/year	Value kg/PJ	Base Reference
Gas Production		21391	53.27	402	Mined Gas
Gas Processing		3848229	267.83	14368	Consumed Gas
Gas Transportation		149510	267.83	558	Consumed Gas
Underground Storage		2925	267.83	11	Consumed Gas
Gas Distribution		330552	267.83	1234	Consumed Gas
	SUM	**4331216**	267.83	**16171**	Consumed Gas
	TOTAL	**4352607**			

Emission from Nitrified Natural Gas

Segment of Subsystem		Emission	Reference activity	Emission Factor	
		kg/year	PJ/year	Value kg/PJ	Base Reference
Gas Production		3650	60.6	60	Mined Gas
Gas Processing		3110074	60.6	51321	Consumed Gas
Gas Transportation		11647	60.6	192	Consumed Gas
Underground Storage		0			Consumed Gas
Gas Distribution		33798	60.6	558	Consumed Gas
	SUM	**3155519**	60.6	**52071**	Consumed Gas
	TOTAL	**3159169**			

Emission from Coke Gas

Segment of Subsystem		Emission	Reference activity	Emission Factor	
		kg/year	PJ/year	Value kg/PJ	Base Reference
Gas Production					Mined Gas
Gas Processing		3411	17.56	194	Consumed Gas
Gas Transportation		362250	17.56	20629	Consumed Gas
Underground Storage		0			Consumed Gas
Gas Distribution		668268	17.56	38056	Consumed Gas
	SUM	1033929	17.56	58879	Consumed Gas
	TOTAL	1033929			

TOTAL CO2 EMSSION 8 545 705 kg

Table 73. (1.B.1.b) CH_4, NMVOC and CO_2 Fugitive Emission from Gas System

		Activity Data	Emissions Estimates			Aggregate emissions Factors		
			CH_4	NMVOC	CO_2	CH_4	NMVOC	CO_2
		PJ	Gg	Gg	Gg	kg/GJ	kg/GJ	kg/GJ
1.B.1.b	Gas (Total)	345.99	163.6724	5.2877	8.5457	0.4731	0.0153	0.0247
i	Production	113.78	7.4509	0.2614	0.0250	0.0655	0.0023	0.0002
ii	Consumption	345.99	156.2215	5.0263	8.5207	0.4515	0.0145	0.0246

1.B.1.b.i - production included emission from testing of positive exploatory well and from mining (high methane and nitrified natural gas)
1.B.1.b.ii - Consumption included emission from gas processing, transportation, storage and distribution.

The assessment of the uncertainties inherent in the estimations

* Emissions during exploratory work

- emissions from imperfectly-sealed wellheads and pipes were underestimated, but such emissions are small and should not influence the overall value for emissions in this subcategory,

* Emissions associated with successful test boreholes

- the uncertainty inherent in estimations was estimated at 5% (equal to the limits of error in the measurements made),

* Emissions associated with the extraction of gas and its preparation for transport

- the uncertainty inherent in estimations was considered to be small and to be related mainly to technological blowouts, whose values are defined with limited error,

* Emissions from the transmission system

- it is difficult to estimate the uncertainty because, in spite of the fact that many data were taken from precise inventories (pipelines, reduction and measurement stations, compressor stations), those concerning the crucially-important pneumatic installations were done with the aid of foreign emission factors (from the US EPA); a further element of uncertainty concerns the emission factors selected for the imperfect sealing of pipelines, for which measurements made in Poland are unavailable,

* Emissions from underground stores

- it is impossible to determine the uncertainty of these estimations because there are no measurement data for the compressor stations at stores - which are the main sources of emission,

* Emissions from the distribution of gas

- an assessment of the estimations made is impossible, because there is no way to set the emission factors taken from the literature against measurement data; comparisons between the results of estimations in this subcategory with the levels of registered losses (which are not always based on measurement themselves) suggest that the values of estimations may be rather higher than the actual emissions. This is likely since the emission factors selected from the literature were the highest ones available.

Summary of the estimation of fugitive emissions from the gas system.

The methodological approach employed II or III, or else a mixed approach based on the two, in accordance with the IPCC methodology. Emissions from sectors other than extraction were determined in relation to a breakdown into those resulting from normal exploitation, from conservation and renovation work and from breakdowns. The process by which emissions were estimated was ultimately verified by way of:

- checks upon the input data, including that from statistics and measurement,
- checks upon all calculations,
- comparisons between the results obtained and those from other published estimates,
- comparisons between the emission factors for different sources that were used or obtained from calculations.

The first two activities are obvious and need no further comment. The comparison of estimations with others made independently in other studies is an activity which was not carried out on account of the lack of available results from studies of this kind.

The values of the summary emission factor for methane from the three gas subsystems (473.1 Mg/PJ) was towards the middle of the range given by the IPCC for the countries of Eastern Europe. As already mentioned in different chapters, it is impossible to define the degree of uncertainty because of the lack of reliable bases for measurement. The Team was therefore of the opinion that the way in which emission factors were chosen (by taking the highest available) was likely to give rise to a situation in which the real emission is lower than the one estimated in the Study.

The study work brought together and made use of:

- 14 Polish research reports,
- 14 sets of data describing the gas systems and subsystems,
- 56 scientific publications, of which 50 were foreign and 6 from Poland.

Additional to these are a series of interviews and consultations with Polish experts.

The complexity of the gas system makes it impossible to present the guidelines drawn up by the team for the updating of data for future inventories and to outline essential research to enhance the reliability of future estimations of emissions. It should however be emphasized that the team's systemic approach to the problem of estimating emissions using the drawn-up schematic representation of the gas system and full identification of emission sources in the gas subsystems and their segments led to the working-out of appropriate methodological bases for the estimation of fugitive emissions from this system in Poland.

The programmes of future inventorying, measurement and analytical work should take account of:

- the tightening-up and updating of data on elements of the system,
- the verification of reported data concerning emissions during the operation, conservation, and renovation of the system, and in the course of the breakdowns occurring in it,
- work and testing in relation to the initiation of a system suitable for the estimation of emissions, for the reporting of losses during the operation, conservation, renovation and breakdown of the system,
- the determination by way of measurement of emission factors for greenhouse gases from imperfect seals in elements of the system.

The following list of priorities in future work on the inventorying of emissions has been established on the basis of estimates of the proportional roles of the segments in the overall emission of greenhouse gases from the gas supply system, the planned structure for supplying the system and analysis of the level of accuracy of data on emissions:

- emissions from the network for the distribution of gas,
- emissions from the network for the transmission of gas,
- emissions from the areas from which gas is extracted,
- emissions from installations for the purification and treatment of gas,
- emissions from exploratory drillholes for gas.

C.7.3. Fugitive emissions from the system involving coal (1.B.2)

Active in Poland's system involving coal in 1992 were 71 pits mining hard coal in three coalfields: the Upper Silesian coalfield (66), the Lower Silesian coalfield (4) and the Lublin coalfield (1). In addition, brown coal is also extracted by open-cast methods. In the main this coal serves in the direct supply of fuel to public heat-and-power plants. Mines exploiting hard coal are included in the gassy category, but open-cast workings for brown coal have previously been considered non-gassy. However, measurements carried out within the framework of the study in a single brown coal working have been sufficient to indicate the presence of methane in the deposits.

The Polish system for the exploitation of hard coal involves the following technological processes which release methane:

- the accessing of coal seams and their preparation for exploitation,
- the winning of coal and its transfer to the surface,
- the processing, storage, transport and crushing of coal prior to its final use,
- the demethanation of (removal of gas from) deposits before, during and after coal has been exploited,
- the dumping of post-production wastes.

The analysis of the technological processes presented above provided a basis for division into four subcategories of emission:

1. ventilation installations, which transfer to the atmosphere the methane liberated in the course of the accessing of deposits, the preparation of deposits for exploitation, the winning of coal and the transfer of coal to the surface; included within the methane in this subcategory is free methane, methane desorbed from coal, free methane in pores in the surrounding waste rock and methane desorbed from coaly substances diffused through these rocks,
2. installations for the demethanation of deposits, from which some gas known as the blow-out is released to the atmosphere rather than being used to supply energy,
3. post-extraction processes at the surface which result in the liberation of residual gas from the extracted coal,
4. spoilheaps of post-production waste, because residual gas is released from coaly substances diffused through waste rock.

The greatest role in emissions of methane is played by ventilation installations in mines working hard coal, which release up to 75% of the total.

Similar sources of emission can be distinguished in relation to the open-cast working of brown coal. However, the lack of measurements at such workings make it impossible to apply an approach based on analysis of separate technological processes. The team did carry out measurements of the methane content, but these only allowed for the distinguishing of emissions from the ventilation of deposits as well as ventilation emissions from surrounding rock strata.

The methodology of estimation

The research team's methodological approach to the estimation of emissions from mines working hard coal was in accordance with the recommendations in the IPCC methodology. Approach "C" was selected from the three available, and this involved the estimation of emissions from the exploitation of hard coal, on the basis of data for the emission of methane measured in mines. This required very detailed analysis of mine data, because such data are usually collected with a view to considering the threat posed by methane blowouts, rather than in relation to environmental protection and the concomitant estimation of emissions of methane. The team therefore decided to determine formulae of its own with which emission factors could be linked with the mean methane content of exploited seams of coal.

To define **emissions from ventilation installations**, analysis was carried out on the measurement methods for input data in coalmines, with a view to eliminating errors. The methane content was next defined for each coalmine and a regression equation was determined to relate emission factors for ventilation with the mean methane content of exploited deposits. These equations were then used as a basis upon which to determine emission factors, and 1992 emissions from ventilation in different mines were then calculated.

Where estimations of **emissions of methane from post-extraction processes** were concerned, work was done by the team on its own methods for determining emission factors for each coalmine. These were then used in the calculation of emissions.

Analogous procedures were applied in the estimation of **emissions from spoil heaps**, with emission factors being defined in this case for each of the coalfields by the team's own method.

Emissions of methane from installations for the removal of gas from mines were estimated using measurement data contained in mine registers. The emissions corresponded to blowouts, which is to say the differences in the streams of methane obtained by the demethanation installations and the proportion of that stream used to produce energy.

The use of the aforementioned methodologies required broad research which is described in detail (with formulae, data, graphs etc) in the Team Report [12]. The research done for the system involving hard coal included:

- analysis of gas-geological and mining data,
- research to define methane contents and indices for the desorption of methane, from core samples from drilled boreholes,
- levels of activity of each mine,
- work on data concerning ventilation emissions of methane, its uptake by degasification installations and its partial use,

- the provision of additional information on the uptake by degasification installations of methane from parts of deposits in which this methane was not released in the course of exploitation,
- analysis of the results of research on the content of coaly substances in waste rocks (production wastes),
- determinations of the amounts of production wastes stored on spoil heaps,
- work on the depths from which particular mines work hard coal.

The methods and procedures used in the realization of research tasks were described in report [12].

In relation to the estimation of emissions from **open-cast workings for brown coal** that would be in accordance with the IPCC methodology, work was done to obtain the necessary data on:

- the methane contents of deposits of brown coal,
- the determination of emission factors for methane from the strata surrounding deposits,
- the levels of production of brown coal by the open-cast method.

It should be emphasized that research on methane contents and on the determination of emission factors in layers surrounding deposits, was done for only one coalmine, and for remaining mines data were taken on the basis of obtained results of above mentioned research.

The results of the estimations

Emission factors for methane from mines working hard coal, for the ventilation installations and post-extraction processes ordered by mine, as well as emission factors from spoil heaps arranged by coalfield are presented in table 74 (table 1 and extracts from tables 4,5,6 [12]).

Summary presentation of emissions of methane from the whole system involving coal, arranged in accordance with the structure of data in IPCC forms [2] are presented in table 75)table 8 [12]. In addition, summary results of estimations of emissions from the coal system were included earlier in Table 7, along with a division into underground and open-cast mining.

The documentation of the Team Report [12] additionally contains the following tables:

- characterization of samples of brown coal: sampling depths, humidity, ash content, content of C_nH_{2n+2} in m^3/Mg_{csw} (csw-pure coaly substances) (table 2 [12],
- comparative presentation of estimations of emissions of carbon from mines working brown coal (table 3 [12]),
- ventilation emissions from mines working hard coal, arranged by coal mine (table 4 [12]),
- emissions from post-production processes in mines working hard coal, arranged by mine (table 5 [12]),

- emissions from spoil heaps for post-production wastes from hard coal, organized by coalfield (table 6 [12]),
- summary emissions from subcategories of source in mines working brown coal (table 7 [12]),

Table 74. (1.B.2) CH4 Emission Factors from Hard Coal System

Coal field	Number	Index of emission from source [m³/Mg]			Coal field	Number	Index of emission from source [m³/Mg]			Coal field	Number	Index of emission from source [m³/Mg]		
		Ventila tion sys- tems	Post extraction process	Spoil heaps			Ventila tion sys- tems	Post ex- traction process	Spoil heaps			Ventila tion sys- tems	Post extrac- tion process	Spoil heaps
USC	1	4,995	1,686	0,064	USC	26	30,108	1,907	0,064	USC	51	0,855	0,295	0,064
	2	23,010	1,686			27	18,104	1,673			52	0,579	0,212	
	3	2,286	1,686			28	27,432	1,224			53	0,273	0,091	
	4	17,126	1,686			29	5,413	1,224			54	0,273	0,091	
	5	4,866	1,686			30	5,453	1,224			55	0,123	0,044	
	6	5,322	1,686			31	4,515	1,224			56	0,132	0,044	
	7	3,417	1,469			32	5,442	1,224			57	0,132	0,044	
	8	2,974	1,368			33	4,310	1,224			58	0,131	0,043	
	9	3,800	1,320			34	4,288	1,224			59	0,107	0,036	
	10	12,784	1,145			35	2,830	1,138			60	0,098	0,032	
	11	14,498	0,975			36	3,397	1,138			61	0,095	0,032	
	12	2,367	0,911			37	2,830	1,138			62	0,094	0,032	
	13	2,010	0,751			38	2,562	1,003			63	0,084	0,028	
	14	1,764	0,647			39	10,041	0,992			64	0,049	0,014	
	15	1,459	0,524			40	1,959	0,729			65	0,029	0,009	
	16	1,148	0,408			41	2,315	0,716			66	0,000	0,000	
	17	1,161	0,408			42	1,786	0,715		TOTAL USC		5,916	1,489	0,064
	18	1,121	0,393			43	2,073	0,632		LSC	67	28,088	1,224	0,212
	19	1,121	0,393			44	2,073	0,632			68	4,553	1,224	
	20	5,203	1,907			45	1,386	0,547			69	27,088	1,224	
	21	29,551	1,907			46	1,456	0,523			70	27,996	1,224	
	22	13,926	1,907			47	1,381	0,493		TOTAL LSC		22,931	1,224	0,212
	23	9,315	1,907			48	1,195	0,421		LC	71	1,698	0,506	0,032
	24	13,917	1,907			49	1,020	0,355		TOTAL Poland		6,005	1,481	0,065
	25	23,580	1,907			50	0,912	0,316						

UPC -UPPER SILESIAN COALFIELD;LSC -LOWER SILESIAN COALFIELD;LC -LUBLIN COALFIELD

Table 75. (1.B.2.a and b). Compilation of emissions connected with the exploitation of coal in Poland for the year 1992

Module		ENERGY				
Sub-module		Emissions of methane from the produc-tion of coal				
Calculation sheet		1-4				
Page		A				
Mining activity		Extraction million t	Mean index of emission m^3 CH_4/t	Methane emission million m^3	Conversion factor	Methane emission Gg
		A	B	C	D	E
Underground mining	Ventilation emission	116,178	6,005	697,649	1/1,49	468,221
	Emission from degasification systems	-	-	57,681	1/1,49	38,712
	Emission from post-extraction processes	116,178	1,481	172,060	1/1,49	115,477
	Emissions from spoil heaps with post-production waste	116,178	0,065	7,552	1/1,49	5,068
Open- cast mining	Ventilation emissions from deposits	66,852	0,007	0,468	1/1,49	0,314
	Ventilation emissions from rocks surrounding deposits	66,852	0,012	0,802	1/1,49	0,538
	Emissions from post-extraction processes	66,852	0	0,000	1/1,49	0,000
TOTAL						**628,330**

Summary and conclusions

In research done for the needs of the study and in estimations of emissions of methane from the coal system, use was made of 36 foreign and Polish publications as well as available summary documentation of the exploitation and measurement of analyzed mines. Defined in the work was the relationship between emission factors for ventilation and the methane content of deposits of hard coal. This was of a parabolic nature and was different than for mines with higher or lower gas contents. Comparisons of the results of estimations using parabolic models with measurements of values of ventilation emissions allowed it to be determined that the error in the estimation lay within the limits of 4-15%.

The techniques for demethanation employed in Poland only allow in principle for the uptake by degassing installations of methane released by the working of coal. Thus, in the construction of parabolic regression models for ventilation emissions, consideration was given to the relationship between the total uptake of methane and methane contents, and amounts of methane used were then deducted from the estimated emissions. Emissions from degassing installations result from technical and economic factors. They cannot be estimated on the basis of familiarity with the natural conditions of the deposit alone. In Poland, their estimation with sufficient accuracy is possible if industrial measurements are used as a basis.

Emissions of methane from post-extraction processes and from spoil heaps are generally a function of the methane content of residual coal, or - in deposits (mines) with seams of low methane content - of the mean methane content of seams in exploited depth intervals. It is for this reason that values for residual methane content and mean methane contents of exploited seams were determined.

The sources of emission of methane identified in OECD studies for the coal system were augmented in the Polish research by an additional source, namely **the spoil heaps with post-production wastes.** Considering the long-term nature of the processes by which methane diffuses from coal, it is likely that extracted coal is used before all the methane contained in it has been released. Therefore, estimation of the actual emission from post-production processes is dependent on research considering the process of the diffusive desorption of methane from Polish coal, as well as determination of the mean time which passes between the extraction and final utilization of coal. In the face of this, it must be recognized that the proposed methodology for estimating emissions from post-extraction processes does not give the actual emission of methane but rather an estimate of the maximum possible value.

Noting the continuing changes in the depths exploited in particular coalmines, the steady progress in the recognition of gas conditions in deposits of coal, the clear tendency for amounts of production waste to be limited and the changes in the assumptions inherent in the use of resources, it is clear that the data used to calculate the presented emission factors will become outdated as time passes. It is therefore considered that the use of the calculated emission factors will provide relatively reliable estimates of emissions:

- for no more than 3-5 years in the case of ventilation emissions,
- for no more than 2-3 years in the case of emissions from spoil heaps.

As a result, it would seem valuable for calculations of emission factors to be redone every 3 years at least.

The presented emission factors and regression models make it possible to give accurate emissions of methane on the national scale. They should not however be used in relation to single mines (e.g. in the calculation of fees for the economic use of the environment).

More exact study in the presented sphere would make it possible to create a model that would also be suitable for the estimation of emissions from individual mines. In such research it would be necessary to use mine gas-geological and mining data in the estimation of emission factors for particular coalmines.

It should also be noted that the use of emission factors recommended in the world method for estimating emissions from open-cast mining give rise to a many-fold increase in the emissions estimated. The estimation of national emission factors for ventilation in the system involving brown coal is very general - made on the basis of extrapolation from very few results from one deposit. Of help however was the making of such measurements of methane content in deposits of brown coal which was done for the needs of the study. Essential in the future is the determination of:

- methane contents in brown coal, on the basis of the more wide-ranging direct measurement of them in samples of coal taken from the different exploited deposits of brown coal,
- methane contents of waters pumped out as deposits are exploited,
- contents of CO_2 in brown coal (its appearance in deposits is possible).

Noting the limited role of emissions from open-cast mining in total emissions from the coal system, it would seem more important to continue to attach greatest importance to work making more precise the determination of emission factors for the underground mining of coal.

The results of the estimations of emissions of methane should - like the emission factors determined for the considered subcategory on the basis of the team's own work - be considered well-documented where Polish hard coal is concerned. However, in relation to brown coal, the estimation of emissions has a reconnaissance character, and its results must be considered to be approximations only.

To compare the estimations obtained by the team's own methods and adjusted to Polish conditions, emissions of methane were also calculated on the basis of the global average factors given by IPCC in [2]. The results of estimations made in the two ways are presented in Table 76 (table 3, supplement in [12]).

It follows from the comparison made that the values for emissions obtained with the global average factor is 60% higher than that estimated by the team's own methods. However, the team continued to maintain that the results of its own work were characterized by a lower level of uncertainty.

Tabela 76. (1.B.2) COMPARISION OF CH4 EMISSION RESULTS FROM COAL MINING IN POLAND (1992) WITH ESTIMATION BASED ON AVERAGE WORLD EMISSION FACTORS PRESENTED BY OECD/IPCC [2]

Mining Activity		Production Gg		Emission Factor		CH4 Emission Gg	
		Net	Gross	Average World	Own Estimation	Average World	Own Estimation
Underground mining	Wentilation Emission	131.313	116.178	10.	6.005	881.295	468.221
	Emission from degasification systems	-	-	-	-	38.712	38.712
	Emission from post-extraction proesses	131.313	116.178	0.9	1.481	79.317	115.477
	Emission from spoil heaps with post-production waste	131.313	116.178	-	0.065	-	5.068
TOTAL UNDREGROUND MINING		131.313	116.178			999.324	627.478
Open-Cast Mining	Ventilation emission from deposits	131.313	-	0.3	0.007	14.460	0.314
	Ventilation emissions from rocks surrounding deposits	66.852	-	-	0.012	-	0.538
	Emissions from post-extraction processes	66.852	-	0.0	0.000	0.000	0.000
TOTAL OPEN CAST MINING		66.852	-			13.460	0.852
TOTAL MINING		66.852				1012.784	628.330

C.8. Industrial processes - (2)

Emissions from industrial processes were assessed by two research teams. In principle, both teams carried out estimations in accordance with the IPCC methodology [2]. The first team worked on subcategories of emission including:

- iron and steel making,
- the non-ferrous metals industry,
- the food industry,
- the timber industry,
- the papermaking industry.

The second team worked on subcategories of emission which included:

- the inorganic chemicals industry,
- the organic chemicals industry,
- the industry involved in the production of non-metallic mineral products.

The estimations of emissions involved all greenhouse gases (i.e. CO_2, CH_4, N_2O, NO_x, CO and NMVOCs), although not all of the technological processes considered were unambiguously associated with the emission of all the aforementioned gases.

The choice of the types of greenhouse gases resulted from analysis of the technological processes under consideration. Summary results are contained in table 8, and are organized in accordance with the inventory reporting forms supplied by IPCC [2].

To all intents and purposes, the determination of emissions involved the application of the simple relationship:

Emission = emission factor x activity of production

A basic problem lay in the appropriate selection of values of emission factors (if these were directly available data) as well as in the determination of factors on the basis of the data sets put at the disposal of those making the assessment by enterprises involved in the industrial processes under consideration. In some cases there was also a need to carry out further verification of emission factors already established - by making use of analysis of the process and by drawing up balances for the elements involved in it.

C.8.1 The iron and steel industry (2.A)

Emissions of greenhouse gases in the industrial processes of this industry arise not only via combustion in the course of the industrial processes described in (1.A.2), but also as by-products of technological processes which arise as a consequence of the presence of elemental carbon, H_2 and N_2 in furnace charge materials. Separated out in the analysis of the technological processes of this subcategory of emission source were those giving rise to additional emissions of greenhouse gases. These processes were in turn divided into contact and non-contact processes , with the former also being associated with the combustion of energetic fuels whose emissions had already been determined under (1.A.2). It was for this reason that the determination of emissions from contact processes required detailed analysis of each such processes in order to separate out additional emissions of particular greenhouse gases, and to determine for these emission factors relating to production activity.

The basic set of information utilized in the determination of emissions was made up of:

- data on production activity from the statistics kept by enterprises (which were set against data from statistical yearbooks [6] and [15]),
- registers of emissions, the results of measurements of emissions and sets of emission factors from industrial enterprises,
- 16 works from the domestic and foreign literature which made it possible to obtain emission factors for the industrial processes under analysis.

Presented below is a review of the industrial processes worked upon, which is accompanied by comments defining the manner and source of the determination of emission factors.

Contact processes

The following contact processes were distinguished:

- **sinter production** - emissions of CO were estimated using emission factors defined in data from enterprises and established by way of measurement, while emissions of CO_2 were determined on the basis of available analyses of waste gases from sintering plants,
- **the production of steel in open-hearth furnaces** - calculations of emissions of CO_2, CO, NMVOCs and NO_x made use of factors determined on the basis of the results of measurements for the process as a whole, with no separation of the different phases. The emission factor for NO_x referred to the open-hearth process with significant use in the steel refining phase,
- **the production of steel castings and iron castings** - emissions of CO_2, NO_x and CO were estimated for the production of steel castings, while those of CO_2, CH_4 and CO were calculated for the production of iron castings. Emission factors for CO_2 were estimated from the chemical composition of waste gases, while those for CH_4 and CO were taken from the literature and those for NO_x determined on the basis of reports from enterprises.

Non-contact processes

Estimates of emissions of greenhouse gases concerned the following non-contact processes in the iron and steel industry:

- **the charging of blast furnaces** - emissions of CO_2, CO and NMVOCs were determined. The emission factor for CO_2 was defined on the basis of the analysis of measurements, while those for CO and NMVOCs were gained respectively from data from enterprises and by way of calculation using data from enterprises, but taking account also of the charging of the tapping/cast of raw materials,
- **the production of converter steel** - estimates involved the gases CO_2, NO_x, CO and NMVOCs. Emission factors for CO_2 were determined on the basis of analysis of converter gas, while those for CO were decided on the basis of data from two enterprises producing converter steel. In turn, emission factors for NO_x were derived from the literature, and that for NMVOCs was in accordance with [14],
- **the production at electric steelworks** - emissions were calculated for CO_2, CH_4, N_2O, NO_x and CO. Emission factors were obtained in the following ways: for CO_2 from the composition of discharged gases, for CO and NO_x on the basis of data from enterprises, and for CH_4 and NMVOCs in accordance with data from the Institute of the Ecology of Industrialized Areas,
- **hot and cold rolling** - estimations were limited to NMVOCs and use was made of emission factors worked out by the Institute of the Ecology of Industrialized Areas,
- **the production of ferro-alloys** - emissions were determined for CO_2, NO_x and CO, for which emission factors were taken from enterprises, having been defined on the basis of measurement,
- **the production of coke** - estimation took in CH_4, CO and NMVOCs. Emission factors for CH_4 and NMVOCs, CO were taken from literature.

Summary results for the estimation of emissions from the iron and steel industry are presented in Table 77.

C.8.2 The non-ferrous metals industry (2.C)

Estimations of emissions took in the following subcategories of a non-contact nature:

- **the production of copper by electrolysis** - emissions of CO were determined on the basis of data obtained from enterprises involved,

- **the production of refined lead and zinc** - emissions of CO were determined on the basis of data obtained from enterprises involved,

- **the production of zinc by electrolysis** - emissions of NO_x, CO and NMVOCs were determined, with emission factors for the first and last being taken from the literature, and that for CO being calculated on the basis of data from relevant enterprises,
- **the production of aluminum** - emissions of CO_2, NO_x and CO were estimated using data available from enterprises involved and determined through measurement.

Summary results of the estimation of emissions from the non-ferrous metals industry are presented in Table 77.

C.8.3. Inorganic chemical processes (2.C)

Emission sources included within this subcategory were the production of: nitric acid, nitrates, ammonia, soda ash, carbon black, agricultural lime and urea. It should be noted that the separated subcategory for the production of nitrate fertilizers which was anticipated by the IPCC structure was not adopted in the above set because emissions of NO_x in this subcategory were taken note of within emissions from the production of nitric acid.

An outline of the methodology applied

The general principle in the estimation of emissions from industrial processes was the calculation of emissions as the product of production activity and an emission factor. So the methodological principles presented here refer also to other subcategories. The point of entry was the determination of the set of industrial processes accepted by IPCC, and the augmentation of these with additional sources of emission occurring in Poland, but not detailed in the IPCC set.

A set of sources for which estimation of emissions would be required was drawn up on the basis of analysis of the available (foreign and Polish) information on production activity and emission factors. The use of emission factors from the CORINAIR methodology as well made it necessary for these to be transformed in relation to the activity adopted by the IPCC methodology. The set of industrial processes accepted for estimation was reduced by 5 and 11 in comparison to that first considered, on account of the lack of reliable data concerning production activity and emission factors respectively. The processes concerned were mainly in the organic chemicals industry which will be considered as the next subcategory.

Estimations related to all types of greenhouse gas, with respective selections being made on the basis of analysis of the processes of the technologies under consideration and the indications in the IPCC methodology.

The determination of emission factors for industrial processes was done on the basis of a literature study which collected and made use of some 22 publications (of which 8 were Polish and 16 foreign). In addition, emission factors for the NMVOCs released by 23 industrial processes were defined using the results of measurements at technological installations. The values were lower than those given in the literature in 6 cases, and higher in the remaining 17. Emission factors higher than those in litt. were doubtless a reflection of the lack of equipment for treating gases at the installations where the measurements were made. In turn, emissions lower than those given in published sources are probably the result of the different chemical composition of the raw materials used in the production technologies under consideration.

The above methodological observations apply to all of the industrial processes considered, and are hence of relevance to the other subcategories presented below.

Summary Table 77 of the present report gives the results of the estimation of emissions from the subcategory concerned with inorganic chemical processes.

C.8.4. Organic chemical processes (2.D)

Reconnaissance work gave consideration to all 20 of the technological processes in this subcategory. However the lack of data in many cases led to the estimation of emissions for 7 processes only. The omission from estimation of many organic chemical processes was largely the result of a lack of data on production - in several cases, emission factors were available from foreign or Polish sources. A basic source of information on emission factors was the CORINAIR set, and this has found its reflection in Table 77. However, it should be noted that significant differences were noted between some of the CORINAIR values and their Polish counterparts based on measurement.

Estimations of emissions took in the organic chemical processes involved in the production of the following:

- ethylene (ethane) - with Polish emission factors for NMVOCs and CO_2 being applied,
- propylene (propene) - with emission factors for NMVOCs from the CORINAIR set,
- PVCs - with use made of Polish emission factors for NMVOCs (which were higher than those given by CORINAIR),
- light polyethylene (polythene) - with calculations making use of Polish emission factors for NMVOCs (which were higher than those given by CORINAIR),
- styrene and butadiene- with emission factors for NMVOCs from CORINAIR,
- ABS resins - with emissions of NMVOCs determined using the CORINAIR emission factor,
- rubber - with emissions of NMVOCs estimated in accordance with CORINAIR emission factors.

The results of estimations are brought together in Table 77, which also gives the set of organic chemical processes considered and the data collected within the framework of research work.

It should be noted that all of the worked-out Polish emission factors for NMVOCs have significantly greater values than those in CORINAIR. It may be supposed that the CORINAIR factors relate to more up-to-date technology and to installations in operation that are in a better technical state. Table 77 (table 3 & 4 [14]) presents (in position 2.D) the results of estimations of emissions of NMVOCs and CO_2 from the organic chemicals industry.

C.8.5. Processes in the industry producing non-metal mineral products (2.E)

This subcategory embraced the estimation of emissions of NMVOCs and CO_2. The latter made use of methodology and emission factors from CORINAIR, which were verified on the basis of data from Polish sources. The results of estimations for NMVOCs and CO_2 linked with the production of cement and lime are located in Table 77 at position 2.E.

C.8.6. Various industrial processes (2.F)

The following industrial processes were considered in relation to the emissions of NMVOCs and CO_2:

- in the food industry:
  - the production of sugar,
  - the output of bakeries,
  - the production of beer,
  - the production of spirit,
  - the production of yeast,

  (determined for this group of industrial processes were emissions of NMVOCs & CO),

- in the timber industry:
  - the production of chipboard,
- in the papermaking industry:
  - the production of paper pulp,
  - the production of cellulose pulp

  (emissions of NMVOCs alone were determined in the last two branches of industry listed).

Emission factors were adopted in accordance with expert assessments and on the basis of data from enterprises and available foreign data (mainly those from CORINAIR).

The large degree of uncertainty in the estimation of emissions from the industrial processes under consideration resulted mainly from the divergent values for emission factors given in the literature as well as from the not-always-certain results of domestic measurements. This may be exemplified by the estimated emissions of NMVOCs from the food industry which are about 30% smaller than those from estimates made using CORINAIR emission factors. In contrast, the estimated emission of CO_2 from the bakery, wine, beer and spirit industries is more than twice as great as that obtained using CORINAIR factors.

The results of estimation of emission for the subcategory are presented in table 77 in position 2.F.

For formal reasons the emissions of CO_2 from food industry were included in the Polish Study in accordance with IPCC recommendations (Vol.3 Reference Manual, Chapter 2.1 and Table 2-1).

The inclusion of these emissions is however controversial problem as it stems from the carbon in the biological feedstock (wheat, grapes etc). So, it is suggested to evaluate this particular problem within the framework of IPCC research activity to reach:

- an agreement on the inclusion or non-inclusion of CO_2 emissions from food industry processes in the list of evaluated industrial processes, taking under consideration the cohesion of the sources and sinks,
- a determination of the limits of balances for each of the respective industrial processes for unambiguous evaluation of its emission factor.

Table 77. (2) Industrial Processes

INDUSTRIAL PROCESS	Production Gg	EMISSION Mg							EMISSION FACTOR kg/Mg						
		CO	CO2	CH4	N2O	NOX	NMVOC	NMVOC	CO	CO2	CH4	N2O	NOX	NMVOC	NMVOC
A. Iron and Steel								COR							COR
Contact Process															
Sinter	8821.52	1207.01	69834.37	0.00	0.00	0.00	0.00		0.14	8.10					
Open Hearth Steel	1820.00	2311.40	94640.00	0.00	0.00	7098.00	36.40		1.27	52.00			3.90	0.0200	
Steel casting	69.00	172.50	4278.00	0.00	0.00	13.80	0.00		2.50	62.00			0.20		
Iron casting	550.00	1375.00	33550.00	110.00	0.00	0.00	0.00		2.50	61.00	0.20				
Sub Total		5065.91	202302.37	110.00	0.00	7111.80	36.40								
Non-contact Process															
Blast Furnace Charging	6498.00	1117.56	1429.56	0.00	0.00	0.00	2599.20		0.17	0.22				0.4000	
Tapping	6498.00	0.00	0.00	0.00	0.00	0.00	2599.20							0.4000	
Convertor Steel	6248.00	35807.26	70333.74	0.00	0.00	374.88	9.37		5.73	11.26			0.06	0.0015	
Electric Steel	1797.00	46.72	7727.10	222.83	0.00	1257.90	305.49		0.03	4.30	0.12		0.70	0.1700	
Hot Rolling	7550.00	0.00	0.00	0.00	0.00	0.00	151.00							0.0200	
Cold Rolling	884.00	0.00	0.00	0.00	0.00	0.00	132.60							0.1500	
Ferroalloys	36.09	78.69	19560.96	0.00	0.00	96.02	0.00		2.18	541.90			2.66		
Coke	11100.00	111.00	0.00	210.90	0.00	0.00	5550.00		0.01		0.20			0.5000	
Sub Total		**37161.23**	**99051.36**	**433.73**	**0.00**	**1728.80**	**11346.86**								
TOTAL		**42227.27**	**301353.73**	**543.73**	**0.00**	**8840.60**	**11383.26**								
B. NON FERROUS METALS															
Non-contact Process															
Electrolitic Copper	387.00	27109.35	0.00	0.00	0.00	0.00	0.00		70.05						
Zinc and Lead Refined	70.30	667.85	0.00	0.00	0.00	0.00	0.00		9.50						
Electrolitic Zinc	84.30	1702.86	0.00	0.00	0.00	87.67	42.15		20.20				1.04	0.5000	
Aluminium	43.60	3317.52	35069.22	0.00	0.00	37.06	0.16		76.09	804.34			0.85	0.0036	
TOTAL		**32797.58**	**35069.22**	**0.00**	**0.00**	**124.73**	**42.31**								
C. INORGANIC CHEMICALS															
Nitrid Acis	1388.30				4720.00	30540.00						3.40	22.00		
Nitrate	380.00		570.00							1.5 kg/t NH3					
Ammonia	1490.00		1490.00	7300.00	7450.00		7300.00	7300.00		1.00	4.90	5.00		4.9000	4.9
Calcined Soda	929.00		23225.00							25.00					40
Soot	25.88			260.00			1035.00	1035.00			10.00				
Soil Lime Use	3336.00		1467840.00							0.44 t/t					
Nitrogenous Fertilizers													x		
Urea	748.00				748.00							1.00			
TOTAL			**1493125.00**	**7560.00**	**12918.00**	**30540.00**	**8335.00**	**8335.00**							

		CO	CO2	CH4	N2O	NOX	NMVOC	NMVOC COR	CO	CO2	CH4	N2O	NOX	NMVOC	NMVOC COR
D. ORGANIC CHEMICALS															
Ethylene	283.13	85.0					3115.0	1415.0						11.0000	5.0000
Propylene	189.64						950.0	950.0						5.0000	5.0000
1,2 - Dichloroethane														5.0000	5.0000
Vinyl chloride	b.d													14.0000	2.5000
PVC	219.96						1760.0	660.0						8.0000	3.0000
Light Polyethylene	163.09						4240.0	1630.0						26.0000	10.0000
heavy Polyethylene														63.0000	10.0000
Styrene, butadiene	36.39						180.0	180.0						5.0000	5.0000
ABS Resin	0.36						2.0	2.0						5.0000	5.0000
1,2 - Epoxyethane														b.d	b.d
Formaldehyde														b.d	b.d
Ethylbenzene														1.8500	0.6000
Styrene-Butadiene Latex														b.d	b.d
Styrene-Butadiene Rubber														b.d	b.d
Phtalate Anhydride														b.d	b.d
Acrylonitrile										0.30				b.d	b.d
Przerob polimerow	b.d													b.d	b.d
Przerob elastopmerow	b.d													b.d	b.d
Przerob gumy *rubber processing*	171.00						2565.0	2565.0						15.0000	15.0000
Przerob plastiku *plastics processing*	b.d													b.d	b.d
TOTAL		**85.0**					**12812.0**	**7402.0**							
E. Non-METALIC MINERAL PRODUCTS															
Cement	11900.00		5950000.0				11900.0	11900.0		500.00				1.0000	1.0000
Lime	2526.00		2020800.0				4042.0	4042.0		800.00				1.6000	1.6000
TOTAL			**7970800.0**				**15942.0**	**15942.0**							
F. OTHERS INDUSTRIES															
Food Industry															
Sugar	1488.00	0.0	341750.4	0	0	0	0.0			232.80					
Backery Products	2634.00	0.0	0.0	0	0	0	8560.5							3.2500	
Wine*	2290.00	0.0	132820.0	0	0	0	93.7			58.00				0.0410	
Beer*	14100.00	0.0	141000.0	0	0	0	817.8			10.00				0.0580	
Spirit Beverages *	1040.00	0.0	104000.0	0	0	0	2496.0			100.00				2.4000	
Yeast	41.60	0.0	82700.8	0	0	0	0.0			1988.00					
Wood Industry															
Chipboard	1008.00	0.0	0.0	0	0	0	504.0							0.5000	
Paper Industry															
Paper Pulp	1031.00	0.0	0.0	0	0	0	515.5							0.5000	
Cellulose Pulp	567.00	0.0	0.0	0	0	0	283.5							0.5000	
TOTAL			**802271.2**				**13271.2**								
NDUSTRIAL PROCESSES GROSS TOTAL	**58416.52**	**75013.0**	**10602720.0**	**8107**	**12918**	**39508**	**61786.0**		**1.28**	**185.50**	**0.14**	**0.22**	**0.68**	**1.0576**	

* (Wine, ~~Beer, Spirit Beverages~~) production in thousand hecto-litre, emission factors in kg/hl, emission in Mg

b.d. - no data available

Summary of the results of estimating emissions from industrial processes

The estimation of emissions from industrial processes was a difficult research subject on account of the fact that these processes were both numerous and complex. Reliable values for emission factors were hard to obtain and the list of industrial processes drawn up and subject to analysis is certainly incomplete, in spite of the fact that it has more than 70 items. Data were available to allow emissions from 42 industrial processes to be calculated.

A basic conclusion for future research concerns the need to work on the systematics of those industrial processes other than combustion which result in the emission of greenhouse gases. A second step in the development of future research would be the determination of emissions by type of greenhouse gas in each industrial process. A third procedural step is the carrying-out of analysis of the weight of emissions of the different greenhouse gases in the set of emissions from industrial processes, and the organization of these according to these weights. The preparation of an ordered presentation of industrial processes would define the ones requiring the most urgent further in-depth research, and would also take account of those (like organic chemical processes) which were not estimated in the Study on account of the current lack of data. Such an ordered list of industrial processes would also make possible co-operation with foreign scientific centres and the division of research tasks.

Table 78 presents comparisons of the estimated emissions from industrial processes organized by the subcategories under consideration.

Analysis of the aforementioned table 78 points to the directions that further research tasks should take:

- work on emissions of CO from metallurgical industries,
- a need for more in-depth work on emissions of CO_2 from the Polish industries producing minerals and inorganic chemicals, as well as in relation to those in the category "other industrial processes", including the food industry in particular,
- work on emissions of CH_4 in the organic chemicals industry and the iron and steel industry,
- work on emissions of N_2O in the inorganic chemicals industry,
- in both the inorganic chemicals industry and the iron and steel industry, work on emissions of NO_x,
- work on emissions of NMVOCs from all categories except the non-ferrous metals industry.

There are varied levels of uncertainty inherent in the estimations done for the different subcategories and the processes embraced by them. Nevertheless, in the opinion of the authors, the estimations were moderately certain in the majority of the industrial processes considered. Furthermore, estimations were carried out with a low degree of uncertainty in some cases where the results of measurements provided a basis.

Table 78. Comparision of GHG Emission ordered by Subcategories.

			EMISSION									
Subcategories	CO		CO_2		CH_4		N_2O		NO_x		NMVOC	
.	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%
A. Iron and Steel	42.2	56.3	301.4	2.8	0.55	6.8			8.84	22.4	11.38	18.4
B. Non ferrous Metals	32.8	43.7	35.1	0.3					0.13	0.3	0.04	0.1
C. Non Organic Chemisrty			1493.1	14.1	7.56	93.2	12.92	100.0	30.54	77.3	8.34	13.5
D.Organic Chemistry			0.1								12.81	20.7
E. MIneral Products			7970.8	75.2							15.94	25.8
F. Others			802.3	7.6							13.27	21.5
Total	75.0	100.0	10602.8	100.0	8.11	100.0	12.92	100.0	39.51	100.0	61.78	100.0

C.9. The use of solvents - (3)

Estimations of emissions related to NMVOCs only. The breakdown within this category of emissions was made in accordance with the IPCC methodology set out in [2]. Distinguished in the first stage of the work were:

- the use of paints,
- degreasing and chemical cleaning,
- the emission of NMVOCs during the production of chemicals with a large involvement of solvents,
- others.

The subcategory -the use of paints- was in turn divided into 7 operations, of which one - the renovation of vehicles - was included in the -degreasing subcategory-, thus creating a joint group -degreasing of metals and the renovation of vehicles.

Taken into consideration under -the use of paints- were the car industry, shipbuilding, the industry involving metals and machines, the timber industry, the construction industry and the use of paints in the home.

Arising in the course of the determination of the activeness of paint use in the car and shipbuilding industries were difficulties in defining the level of use. From the activity estimated for these operations, the two methods of calculation involved values for consumption assessed by experts.

In the face of the lack of any Polish data from measurement, it was decided to take emission factors for the use of paints from CORINAIR, on the basis of EEC reports (1991-1993). The results of estimations of emissions in this subcategory are placed in Table 79. This includes all of the operations using paints which were taken into consideration. Table 9 gives a summary of emissions of NMVOCs from the subcategory -the use of paints.

As mentioned previously, the subcategory -degreasing and chemical cleaning- came to be extended to -degreasing and the renovation of vehicles as well as chemical cleaning. Detailed results of the estimation of emissions of NMVOCs are presented in Table 79, while Table 9 includes summary data for emissions in this subcategory. Degreasing and the renovation of vehicles took emission factors from CORINAIR, while chemical cleaning was addressed by reference to data in the literature.

Emissions of NMVOCs during the production of chemicals involving a significant participation of solvents were related to:

- the production of paints,
- the production of dyes and stains,
- the production of printing inks,
- the production of glues,
- the production of pharmaceutical products.

The activity (production) of these industries was determined using official statistical data [15]. Additional verifications were made with a view to eliminating the manufacture of products which did not involve solvents (e.g. in the industry involving the production of pharmaceuticals). Emission factors used were from CORINAIR, with the exception of those for NMVOCs from the production of paints, glues and pharmaceutical products, which were determined on the basis of research done specially for the needs of the study.

It was not however possible to estimate emissions from the production of dyes, in the face of a lack of data on emission factors.

The results of estimations of emissions in this subcategory have been placed in Tables 79 & 9.

Considered under the subcategory -others- was the use of solvents in the home, in printing and in the preservation of timber. When it came to the home, estimations of emissions were confined to the use of solvents (without emissions from the use of paints which were taken into consideration in the first subcategory). The emission factor used was on a per inhabitant basis and the activity corresponded to the 1992 population of the country.

The research done for the needs of the study made possible the use of Poland-specific emission factors for NMVOCs in three cases. It was stated in the results of the research that future tasks to be undertaken were:

- the systematization of operations involving the use of paints of solvents,
- the drawing-up of a procedure by which to separate out these operations in statistics for the determination of activity,
- the determination of the technological conditions under which paints and solvents are used.

The preparation of future databases for the inventory will in particular require:

- work on the systematics of processes and operations characterized by the use of paints and solvents,
- the determination of the reductions in emissions resulting from the application of new technologies, processes and operations,
- the determination of the level of reductions in emissions achieved by protective installations,
- work on integrated emission factors conditioned by the applied technologies of operations and processes and giving consideration to fitting with protective installations.

The results obtained from the inventorying of emissions in different operations and processes are considered good, on account of the verified way of determining activities and the selection of emission factors for NMVOCs from available foreign sources as well as on the basis of the authors' own research. The certainty of estimations is defined as moderate on account of the limited scope of the verification of emission factors (taken from the available literature) for the use of paints and solvents under Polish conditions. Summary results of estimations are not fully complete because of the omission (due to lack of data) of the already-separated operations and processes in Polish conditions, as well as on account of the probable omission of other surface sources of emission (organized and non-organized).

Table 79 Solvent Use (3)

Process	Production/USE Mg	Emission Mg	Emission Factor kg/Mg
A.Paint Aplications			
1.Paints use by car industry	2746	1373	500
2.Paint use by shipyard	12915	6458	500
3.Paint use by metal products industry	14343	7172	500
4.Paints use by wood industry	3252	1626	500
5.Paints use in construction sector	13447	6724	500
6.Paints use in car renovation	na	-	500
7.Paints use in households	76836	38418	500
TOTAL		**61771**	
B. Degreasing and Dry Cleaning			
1.Degrieasing in metal products industry and car renovation	13600	12240	900
2. Chemical dry cleaning	12006	9605	800
TOTAL		**21845**	
C. Chemical Products Manufacture/Processing			
1. Paints production	209444	2090	10
2. Dyes production	7788	-	na
3. Print ink and paint production	6000	180	30
4. Glue production	189762	3795	5
5. Pharmaceuticals production	1237	680	550
TOTAL		**6745**	
D. Others			
1. Solvent use in households	38.418	76836	2 kg/Ma
TOTAL A-D		**167197**	

- Emission Factor in subcategory 3.A. related to Mg of used paint
- Emission Factor in subcategory 3.B. related to Mg of used sovent,
- Emission Factor in subcategory 3.C. related to Mg of product,
- Emission Factor in subcategory 3.D. related to Mg of used solvent by one inhabitant; activity expressed population of inhabitants.

C.10. Agriculture - (4)

In 1992, Polish agriculture occupied 18,664,000 ha of the country and generated 7.3% of its gross domestic product. 76.4% of the land used in agriculture was in private ownership, and the average number of people working in agriculture was 22 per 100 ha (or 25 if private agriculture was considered alone). The last figures attest to the low efficiency of the work done. The mean number of head of livestock in 1992 was around 60 per 100 ha and the mean yield of the main cereals amounted to 24.6 quintals per hectare. The mean availability of tractors was 6.3 per 100 ha (7.5 in private agriculture), while the mean use of artificial fertilizers (showing a declining trend) was 62 kg of pure ingredients per hectare in 1992 (and 55 kg in private agriculture). Meadows covered an area of 2,444,000 ha and pastures some 1,600,000 ha.

This brief characterization of Polish agriculture should be completed by following information:

- there is a predominance of private farms which have a mean of 6.3 ha in agricultural use. 17.8% of farms cover 2 ha or less, 35.3% cover 2-5 ha and 6.0% cover more than 15 ha;
- there is over-employment in agriculture (with 4-5 ha per employed person);
- the efficiency of agriculture (as defined conventionally) is low in comparison to that in developed countries;
- agriculture requires the restructuring of ownership and modernization.

The information for the above description was taken from [15]. Along with data from specialist publications, it constituted the main source of information upon which to work out emissions from the agricultural category.

In accordance with the IPCC methodology, 4 subcategories of emission were distinguished:

- (4.A) - Enteric fermentation in livestock animals,
- (4.B) - Animal wastes,
- (4.D) - Agricultural soils,
- (4.E) - The burning of agricultural wastes.

Subcategories (4.A), (4.B) and (4.D) were the subject of special research addressed by the UNEP project. In contrast, subcategory 4.E - emissions from the burning of agricultural wastes - was estimated expertly with a view to obtaining a complete inventory of the emissions of greenhouse gases from this category.

C.10.1. Enteric fermentation in livestock animals (4.A)

Emissions of methane as a result of the digestive processes of livestock animals constitute the greatest source of the emission of methane in agriculture. On account of their numbers, and of the types and quantities of fodder consumed by them, it is cattle which are the greatest producers of methane among the ruminants. Emissions from sheep are of much smaller significance.

Nevertheless, research embraced a full set of livestock animals, including cattle, sheep, horses, pigs, poultry and fur-bearing animals.

The research team considered various methods of estimating emissions of methane from enteric fermentation, before deciding upon the use of that advocated by IPCC. In accordance with this method, the team undertook an appropriate programme of research and method of procedure. The mean 1992 populations of each type of animal were determined on the basis of official statistics in [15] as well as additional Results of the 1992 GUS Agricultural Inventory and the GUS Inventory of Livestock Animals.

The total populations of cattle and sheep were divided into structural categories on the basis of representative animals described in terms of:

- mean body mass,
- level of production (mean production of milk for cows and mean increase in body mass for the others),
- the system of maintenance (with or without bedding),
- a division into those not using or using pasture (for 165 days per year in Polish climatic conditions).

Assessments of emissions of methane from fermentation in representative animals were carried out using the formula 1÷ 7 & 10 - ÷ 13 given in [2]. Report [16] gave formulae for calculations, sets of input values and additional assumptions (e.g. in the calculation of the energy needs for the development of foetuses, the mean production of calves was assumed to affect 70% of all cows).

Lastly, coefficients for energy requirements were calculated in terms of the energy for:

- survival,
- the increase in body mass,
- the production of 1 litre of milk,
- the development of a foetus.

This allowed for the determination of total energy as well as for the defining of emission factors for CH_4 per head per year. The emission factors determined were different from those given by IPCC in [2].

Table 10 presents summary results for the emission of methane from enteric fermentation in livestock.

Considered in the calculation of emissions of CH_4 were:

- cattle, with a division into dairy cattle and others,
- sheep,
- pigs,
- horses.

Table 80 presents a comparison of the results of calculations done with emission factors worked out by the team or taken from the IPCC data in [2].

Table 80 CH_4 Emission from Enteric Fermentation in different kinds of livestock (4.A.)

Animal Group	CH_4 Emission [Gg]	
	[16]	IPCC
Dairy Cattle	396.5	363.1
Beef Cattle	184.9	209.5
Sheep	16.6	15.0
Horses	16.2	16.2
Pigs	32.7	32.7
TOTAL	646.9	636.5

It follows from the table that, in comparison with the results obtained using the IPCC methods, the figures generated by the team were:

- 8.4% higher in the case of dairy cattle,
- 13.3% lower in the case of other cattle,
- 9.6% higher in the case of sheep,

only 1.6% higher for all livestock combined.

The research team did not do original research of its own on enteric fermentation in livestock animals. However, particularly valuable output is the Polish work on a set of livestock animals by structural category, the establishment of input data and the assumptions for the calculation of emission factors for CH_4 in Polish conditions.

Considering the significant differences between the body masses, productivity and feeding of different groups of livestock, as well as the types and quality of fodder in different countries (and especially different regions), it would seem to be of value to do Poland-specific research on emission factors for future inventories. This is all the more justified when it is recalled that the structural and economic transformation of Polish agriculture is entailing a trend towards smaller numbers of more productive livestock. The research topics presented above should be developed and co-ordinated systematically within the framework of co-operation amongst higher institutions devoted to the nutrition and physiology of nutrition of animals - namely the Institute of Zootechny in Krakow and the Institute of Animal Nutrition and Physiology of the Polish Academy of Sciences (based in Jablonna). The authors postulated that statistics on the rearing of livestock should be introduced with all animals emitting methane taken into account, along with the season of the year, the system of maintenance and the level of intensity of production.

C.10.2. The emission of methane from animal wastes (4.B)

The principal process leading to the emission of methane from animal wastes is the development of anaerobic methanogenic bacteria in substrates containing large amounts of undigested organic substances, including carbohydrates. The intensity of transformations is dependent on two factors: oxygen and temperature. The presence of oxygen usually terminates the release of methane, and it is for this reason that the method of gathering and storing wastes is of such decisive importance in this subcategory. Favouring the emission of methane to the greatest extent (on account of the generation of anaerobic conditions) is the method of accumulating and storing wastes in deep containers in the form of slurry (a mixture of faeces and urine). In Polish conditions, there is no other way of collecting and storing slurry which leads to the production of methane.

Widespread in Poland is maintenance using straw and the turning-out to pasture of cattle, sheep and horses. In such situations there is a large degree of contact between faeces and the air, and hence a level of production of methane that is less than that seen in those countries where the slurry system is used.

It has already been noted that temperature is the second factor which has a significant influence on the methanogenic fermentation of animal wastes in Polish conditions. Between 1981 and 1990, the mean annual air temperature in the warmest (north-western) region of Poland was about 8.9 C. This compared with a temperature of 9.8 C for the same area in 1992. Such temperatures qualify Poland for inclusion in the cool climatic zone characterized by mean temperatures of less than +15 C. As a result, it can be assumed that the processes transforming organic substances in animal wastes into methane will be of lesser intensity in Poland.

The methodological approaches for determining the production of methane from animal wastes were adopted from IPCC methodology set out in [2]. Research centered on the establishment of mean values from data from digestibility studies done by the authors for cattle and pigs. Use was made of coefficients for the emission of volatile substances (VS) and for the maximal production of methane (Bo) per unit of VS, as well as of the methane conversion factor (MCF) from IPCC in [2]. Factors for the amounts of methane produced by sheep, horses and poultry were also taken from IPCC [2], because the results of specially-done research were not available.

Correct estimation of emissions of methane is dependent upon the determination of the quantities of animal wastes. The basis for the determinations of these is the establishment of the populations of the different species of livestock animal. The results of the head counts made (including the divisions into structural categories) were the same ones used to determine emissions of methane from enteric fermentation in livestock animals (category 4.A, presented already in chapter C.10.1). 1992 populations of cattle, sheep and pigs were established on the basis of quarterly lists organized by the Main Statistical Office and taking account of ages and breeds. Counts of horses were done on the basis of the mid-year (June) inventory, which is drawn up without division by age and breed. Numbers of poultry were obtained from GUS inventories organized by species, and were set against reports from the Ministry of Agriculture and the Food Economy, the Institute of Agricultural Economics and the Agricultural Market Agency. Counts of fur-bearing animals were derived from data from the Central Station for Animal Husbandry, which was also consulted when it came to estimating populations of the other animals. Finally, data from the Department of Animal Production at the Ministry of Agriculture provided a further source of information.

As a final step, head counts for the different species were compared with FAO statistics, and it was found that there was general agreement between data from the two sets.

In the order established by reference to species of animal, the head counts were divided into sub-groups in relation to the system of maintenance (and in effect therefore the system of collecting and storing animal wastes) and the level of intensity of production on the basis of the results of the authors' own experiments.
Differences between the methodological assumptions made by the research team and those recommended by IPCC in [2] lie in:

- the higher level of detail of the data used,
- the greater number of species taken into consideration.

The worked-out systematics are more detailed than those of IPCC [2] in that structural categories are considered for the populations of cattle and pigs. Fur-bearing animals are also taken into account, but were not mentioned by the IPCC in [2]. The index for the release of volatile substances (VS) was calculated from formula 14 of the IPCC in [2], with the application of the authors' own Poland-specific factors for the digestibility of the energy taken in and the amounts of fodder given. The calculation of VS was done for representative individuals of milking cows, other cattle and pigs, and the weighted mean values were then determined. The amounts of volatile substances released by the other kinds of livestock animal were adopted from the IPCC methodology set out in [2].

The amount of emitted methane (EFi) was in principal calculated from formula 15 from IPCC [2] which was simplified. Team Report [17] presents and discusses the form of the simplified formula and the procedure for the determination of MCF $_{jk}$ emissions of methane in relation to j (the system of storing wastes), k (the climatic region involved) and i (the percentage share of the different animal species in the population.

As given above, the team justified the inclusion of Poland to the cool climatic zone. The choice of values for MCF took account of this and was made on the basis of analysis done for the needs of the study.

Done within the framework of research work was:

- elaboration of
  - the numbers of cattle organized by structural category (on the basis of representative individuals)
  - stock quantity organized by system of maintenance (with or without straw) and level of production (intensive, moderately intensive or extra intensive),
- work on the population of pigs organized by reference to the same parameters as for cattle,
- work on the populations of sheep, horses, poultry and fur-bearing animals in thousand head,
- the compilation of values of calculated or adopted indices for volatile substances (VS), for structural categories of cattle, and weighted means for pigs,
- the compilation of indices VS, Bo, MCF and EF for the species of animal under consideration,
- the calculation of the overall 1992 production of methane from the fermentation of the wastes of Poland's livestock animals.

The compilations of VS, Bo, MCF and EF indices for the species of livestock under consideration done within the framework of the Study are to be found in Table 81.

Table 82 presents the results of calculations of the total 1992 production of methane from the fermentation of the wastes of Poland's livestock animals. Summary results for emissions of methane from the fermentation of wastes are also contained in Table 10, with the layout recommended in IPCC [2].

Table 81. (4.B) Specification of Factors VS, Bo and EF adopted in calculation of CH4 Emission from Animal Wastes

	VS - organic volatile substance excretion in kg/head/day	Bo- maximum CH4 producing capacity in m 3 CH4 / kgVS	MCF - CH4 conversion factor in weighted av. %	EF- CH4 emission factor in kg/head/year
1. Dairy Cattle - av. weight 546 kg	4.78 x	0.24	1.036 x	2.90 x
2. Beef Cattle - av. weight 246 kg	2.49 x	0.17	1.18 x	1.22 x
3. Sheep	-	-	-	0.19
4. Horses	-	-	-	1.39
5. Pigs - av. weight 57.7 kg	0.43 x	0.38 x	3.57 x	1.43 x
6. Poultry	-	-	-	0.078
7. Others	-	-	-	0.01 x

x - own estimation and calculation
other - according to IPCC [2] table B-1, B-2, B-7.

Table 82. (4.B) Total CH4 Emission from Animal Manure in Poland in 1992.

Animal Group	Mean Number of Animals thousand heads	CH4 Emission	
		Annual Emission Factor EF kg/head/ year	From Animal Group Gg/year
Dairy Cattle	4202.6	2.90	12.19
Beef Cattle	3741.8	1.22	4.56
Sheep	1869.5	0.19	0.36
Horses	899.5	1.39	1.25
Pigs	21777.5	1.43	31.14
Poultry	76472.0	0.0078	5.96
Other	12168.0	0.001	0.12
TOTAL			55.58

The output of the team was in the form of detailed analysis relating to Polish systems for the maintenance of livestock, the methods of accumulating and storing wastes (manure management) for all of the species under consideration and the structural categories of animals used. The team did not carry out its own biochemical research in the field of the fermentation of the wastes of livestock animals.

The results relating to emissions of methane from the wastes of cattle and pigs require comment. The values of emission factors for the production of methane from the wastes of these animals are significantly lower than those given by IPCC in [2]. Three factors were identified to account for these differences:

- **the actual structure of the Polish system for the maintenance of milking cattle** - at 1.035%, the MCF conversion factor calculated on the basis of the authors' own analysis is 2.5 times smaller than that given by IPCC in [2] for Eastern Europe as a whole (a figure of 2.62%); the team nevertheless expressed the conviction that the calculated value for MCF was reliable.

- **the actual requirement for fodder (and in consequence for total energy)** - was determined for cows with a daily production of 8.26 kg of milk, while IPCC [2] makes use of a daily production determined at 7.0 kg. As a result the VS value for volatile organic substances was higher.

- **the lower actual average weight of representative Polish cattle individuals** - at 246 kg, the mean body mass for representative Polish cattle differed by 145 kg from the 391 kg adopted by IPCC in [2]. This influenced the value of the methane conversion factor MCF. At 1.22 kg/head/year for this structural category, the authors' own estimates for the unit production of methane EF was considered to be justified.

The certainty of the estimation of emissions of methane from the wastes of cattle and pigs is considered high. In contrast, the figures for the other animals may be considerably less reliable, since - although numbers of head were determined with certainty - the main coefficients used were taken straight from the IPCC [2] and were given for large areas characterized by considerable internal differences in the systems of maintenance, the methods of collecting and storing animal wastes, the mean weights of representative animals and the climatic conditions.

Considering the above comments it is postulated that the further development of Polish research in the field should be directed towards:

- determining or checking the values of VS indices for the emission of volatile organic substances,
- the determination of Bo - the maximal production of methane per unit of volatile substance,
- the establishment of values of methane conversion factors MCF,

in the Polish conditions under which livestock animals are raised.

C.10.3. Emissions of nitrous oxide N_2O from soils used in agriculture (4.D)

The analyses and estimations of greenhouse gases related solely to nitrous oxide N_2O. The subcategories recommended by IPCC [2], namely:

- emissions from the application of mineral fertilizers,
- emissions from organic fertilizers,
- emissions from the cultivation of leguminous plants,

were joined by an additional subcategory:

- **emissions from soil humus.**

To work out a more discriminating basis for estimating emissions of N_2O in 1992 and following years, analysis was carried out in relation to denitrification in Polish soils used agriculturally. Emissions of N_2O in the years 1989 and 1992 were also estimated.

The analysis of the process of denitrification gave consideration to the following factors: the presence of denitrifying bacteria, the presence of organic substances in soil, the limited availability of oxygen, the humidity of the soil, the temperatures reached in the soil and soil reaction. The influence of the different factors - and especially those in which denitrification ended in the release of N_2O - were considered in the selection of factors for the emission of N_2O to the atmosphere from soils, in the subcategories considered in research.

The selection of emission factors also made use of data in the literature.

C.10.3.1. Emissions of nitrous oxide - N_2O - from the use of mineral fertilizers (4.D.i)

From comparisons of the conditions of estimates *in litt.* for losses of gaseous nitrogen in relation to doses of nitrogen in soils, it follows that these refer to compact, moist soils in which anaerobic conditions prevail. Noting the granulometric composition of Polish soils, it may be assumed with a high level of probability that in only half of them may there prevail - in the growing season during which mineral fertilizers are used - the anaerobic conditions bringing about denitrification. This fact was taken into consideration in the selection of emission factors for N_2O. Such an approach to the assessment of emission factors found its justification in IPCC data [2]. Table 83 (Table 1 in [18]) presents the results of estimates of coefficients for losses of gaseous nitrogen under Polish conditions, in relation to the doses of nitrogen in mineral fertilizers. The table also gives the consumption of mineral fertilizers as well as the calculated emissions for 1989 and 1992, expressed in weight units of nitrogen.

Table 83. (4.D.i) N_2O - N Emission from Fertilizers

Fertilizer	1989			1992		
	Consumpt. N Gg	Emission Factor %	Emission N_2O-N Gg	Consumpt. N Gg	Emission Factor %	Emission N_2O-N Gg
Ammonium Sulfate	84	0.87	0.73	79	0.87	0.69
Ammonium Nitrate	674	0.78	5.26	318	0.78	2.48
Nitro-chalk	174	0.78	1.36	66	0.78	0.51
Carbamide	422	0.80	3.38	180	0.80	1.44
Multicomponent	124	0.78	0.97	34	0.78	0.26
Total	1478	-	11.70	678		5.38
Average kg N/ha	79	-	0.63	36		0.29

C.10.3.2. Emission of nitrous oxide N_2O from the application of organic fertilizers (4.D.ii)

Organic fertilizers (manure, slurry and others) contain both organic substances and easily-soluble mineral compounds of nitrogen. Both of these ingredients can undergo denitrification with the release of N_2O. After analysis of data and conditions of their definition, it was decided to use in Polish conditions those data determined in research using the ^{15}N isotope. Finally accepted was a mean value for the loss of N_2O-N from the use of organic fertilizers that was equal to 1.15% of the total amount of nitrogen in these fertilizers. This result from the literature was obtained in the most closely similar conditions to those pertaining in Poland, and involved doses of manure of the same order as are used here.

The procedure for estimating emissions of N_2O from this subcategory required the establishment of:

- the production of manure resulting from the populations of livestock animals expressed in "Manure Units" -SO (where SO = 500 kg of animal body mass),
- the unit production of manure by 1 Manure Unit (the figure adopted was 10 Mg annually, in accordance with Polish publications),
- the contents of nitrogen in the manure (a figure of 0.5% was adopted on the basis of Polish data).

It should be emphasized that, in determining the mass of Manure Units, the numbers of livestock animals were taken from [16] and [17], as were the body masses of the different species.

Table 84 (table 2 in [18]) presents the results of the estimations.

Table 84. (4.D.ii) N_2O-N Emission from Manure.

Specification	1989	1992
Number of Animals calculate for SO in thousand pieces	12427	10475
Manure Production in Gg	124270	104750
N contents in Manure in Gg *	621	524
Average N contents in kg N/ha	33.2	28.0
N_2O-N Emission in Gg (1.15%)	7.14	6.03
Average N_2O-N Emission in kg N_2O-N/ha	0.39	0.32

* manure contains 0.5% N

C.10.3.3. The emission of nitrous oxide N_2O from the cultivation of leguminous plants (4.D.iii)

Research gave consideration to the emission of N_2O in connection with the binding of nitrogen from the air by leguminous plants (i.e. the creation of inorganic nitrogenous compounds through the activity of symbiotic Rhizobium bacteria), and the subsequent denitrification of these compounds.

The determination of an emission factor for N_2O was based on the results of research presented in various publications. It was accepted - for calculations in Polish conditions - that 1% of the nitrogen bound up in leguminous plants was re-released to the air as a result of denitrification. Table 85 (table 3 [18]) presents the results of the calculations done, along with other important data. It should be stressed that the amount of nitrogen left in post-harvest residues of leguminous plants was evaluated on the basis of Polish research and amounted to 90 kg N/ha. This was the figure adopted in calculations of emissions of N_2O. The collected data and results are presented in Table 85, and relate to the years 1989 and 1992.

Table 85. (4.D.iii) N_2O-N Emission from Leguminous Plants.

Specification	1989	1992
Cover of Leguminous plants in thousand ha.	1928	1679
N content in postharvest residues (kg N/ha)	90	90
Total N contents of postharvest residues in (Gg)	173.5	152.7
N_2O-N Emission in Gg (1%)	1.73	1.53
Average N_2O-N Emission in kg N_2O-N/ha	0.90	0.90

C.10.3.4. The emission of nitrous oxide N_2O from the mineralization of organic substances in soils (4.D.iv)

The matter of the emission of N_2O from the mineralization of organic substances in soils was introduced by the research team as a new subcategory of the emission of N_2O. Research in the field is currently at the exploratory stage and there was thus a lack of precise results from research on emission factors for N_2O or for the emissions arising as a result of the denitrification of mineral nitrogen from mineralized organic substances in soils. However, on the basis of analysis of an expert nature, it was accepted that the emission factor was equal to 1.0% of the nitrogen accumulated in soil.

The following procedure was applied to calculate emissions:

- on the basis of Polish research, it was accepted that the mean content of nitrogen in soils was 0.096%,

- it was further accepted that 1 ha of land had 4000 Mg of soil,
- in consequence of the above, it was calculated that 1 ha of land has 3480 kg of N,
- it was assumed that - each year - 1% of the nitrogen accumulated in the organic substances in each ha of land underwent mineralization. A figure of around 38 kg of mineral nitrogen was therefore obtained,
- finally, it was assumed that 1% of the aforementioned nitrogen was subjected to changes leading to the emission of N_2O to the air. This gave an emission factor equal to 0.38 kg N_2O-N/ha.

The emission of N_2O-N from Poland's 18,700,000 ha of actively-cultivated agricultural land was therefore given by the following formula:

Annual emission of N_2O-N = 0.38 N_2O-N/ha x 18.7 $\times 10^6$ ha = 7.106 x 10^6 kg = 7.11 Gg

It is the figure of 7.11 Gg for the emission of N_2O-N from the mineralization of organic substances in soil that is given in Table 86 (table 4 in [18]).

The total emission of nitrous oxide N_2O from land used in agriculture

Table 86 (Table 4 in [18]) presents the emissions of N_2O-N in 1989 and 1992 from the use of mineral fertilizers, the use of organic fertilizers (manure and slurry), the production of leguminous plants (beans, green fodder and vegetables) and the mineralization of organic substances in the soil. All of these were calculated in accordance with methodology of estimation discussed above.

Table 86 (4.D) N_2O-N Emission from Soil

Emission Source	1989		1992	
	Gg	kg/ha	Gg	kg/ha
Fertilizers	11.70	0.63	5.38	0.29
Manure	7.14	0.38	6.03	0.32
Leguminous Plants	1.73	0.09	1.53	0.08
Soil Organic Matter	7.11	0.38	7.11	0.38
TOTAL	27.68	1.48	20.05	1.07
Subtotal from Manure, Leguminous Plants and Soil Organic Matter	15.98	0.85	14.67	0.78

The separation of the total emission of N_2O-N as a result of the use of organic fertilizers, the cultivation of leguminous plants and the mineralization of organic substances in soil was of value because it allowed for the formulation of the following conclusions:

- the years 1989 and 1992 differed considerably in the total emission per ha of agricultural land from all four subcategories of source. The figures were 1.48 and 1.07 kg/ha respectively,
- the years 1989 and 1992 differed only slightly in the emission from three of the subcategories of emission (excluding the use of mineral fertilizers). The figures were 0.85 and 0.78 kg/ha respectively,
- there were but minor changes in the area of land in agricultural use in the two years. Statistical Yearbooks from the Main Statistical Office gave a figure of 18,720,000 ha for 1989 and 18,660,000 ha for 1992, suggesting a decline of 0.33%,
- of decisive importance in accounting for the reduced total emissions between the two years were:
  - significant changes in the use of mineral fertilizers above all,
  - to a limited extent, the reduction in the production of organic fertilizers as a consequence of a decline in the national populations of livestock animals, and to an even more limited extent a fall in the production of leguminous plants.

Formulated on the basis of the above conclusions was an approximating empirical formula allowing for the determination of a coefficient for the mean total emission of N_2O-N as a function of kg/ha doses of nitrogen only. The formula took the following form:

$$\mathbf{N_2O\text{-}N\ [kg/ha/yr] = 0.82 + 0.008 \times N,}$$

where N = dose of nitrogen in kg N/ha

For the next few years, this simple formula should allow for the approximate determination of total emissions of N_2O in relation to the area of agricultural land with an error of the order of $\pm$ 4% only.

Summary

The research work done provided for the widening of the list of source categories for N_2O from the use of soils to include a new subcategory not anticipated by IPCC in [2]. Accepted in calculations was a value for the loss of nitrogen from soils in gaseous form which differed from that recommended by IPCC in [2]. The value was based upon analysis of the properties of the Polish soils used agriculturally (of which the majority are sandy and in areas of relatively low rainfall). On the other hand, the IPCC recommendations were followed in that it was accepted that 10% of losses of nitrogen form denitrification were in the form of N_2O emissions.

C.11. The burning of plant wastes (4.E)

Estimations concerned the emissions of greenhouse gases other than CO_2 and NMVOCs (i.e. of CH_4, N_2O, NO_x and CO) as a result of the burning of plant wastes in cultivated areas.

This category of emission was not subject to special agricultural research within the framework of the UNEP project. There was thought to be a need to estimate emissions from this source category in order that a complete inventory for 1992 might be obtained.

A simplified methodological approach was applied. A list was made of 43 crops whose wastes might be burned. Separated out from this list were the wastes of crops which have traditionally been composted or used as fodder in Poland. Created in this way was a new list of 38 crops which were subjected to analysis. It should be noted that Polish regulations do not recommend the burning of agricultural wastes. Given consideration in the list of crops were grain crops, vegetables and the leaves of trees, as well as fruit trees. Polish data were used to determine the amounts of plant wastes in soil and the amounts that have traditionally been burnt. The results of the estimations were expressed in dry mass amounts along with the shares of elemental carbon on the basis of Polish and foreign data. The values of emission factors for CH_4, N_2O, NO_x and CO were then determined to allow emissions to be calculated, and this was done with the aid of nitrogen/carbon (N/C) ratios given in Polish and foreign literature.

Table 12 presented summary results of calculations with the layout recommended by IPCC. The uncertainty of estimates must be regarded as high on account of the simplified methodology which was adopted and the significant influence of approximate estimations of the amounts of the wastes of particular species of plant burnt on the values of emissions from the burning of plant wastes.

C.12. Land use (5)

This division of the inventory of emission sources was not included in the research tasks of the UNEP project. However, for the sake of completeness in the inventory of 1992 sources and sinks of greenhouse gases, work was done on an approximate estimation of emissions. Available input data allowed for the estimation of emissions in the following categories:

- forest clearing (5.A)
- the transformation of meadows (5.B),
- forestry management and the cutting of timber (5.C)

It is recognized that Poland's geographical location puts it within the temperate climatic zone. This was distinguished appropriately in Tables 13-21, which present the results of calculations of emissions and captures of greenhouse gases in section 5 - Land Use.

Summary results for the 1992 emissions of the greenhouse gases considered in the inventory have been included in Table 3 by categories of emission and capture in division 5 - Land Use.

Emissions and captures within subcategory 5.D - the Abandonment of Cultivated Land - were not taken into consideration in estimations. This omission was justifiable in the light of the fact that - as mentioned in chapter C.10 - the changes in the area of land used in agriculture were minimal in the three years (down by less than 0.33%). Analysis shows that changes in the area of forest, meadow and pasture in the period were also small (at +0.13, -1.4 and +1.9 % respectively). The overall change (of +0.06%) was effectively equivalent to constancy. These findings further justified the omission from the inventory of detailed estimation within the framework of subcategory 5.D.

C.12.1. Forest clearing (5.A.)

Adopted in estimations of the emissions associated with sanitary operations in forests were the calculation procedure recommended by IPCC in [2] and the results of estimations presented in the form of tables taken from [2]. Input quantities for coniferous and broadleaved forests were taken from the available Polish forestry statistics. They allowed for the determination of:

- the area of forest subject to clear,
- the annual removal of dry biomass,
- the quantities of biomass burnt in situ or elsewhere.

Use was made of Polish indices defining the share of each of the two methods of burning identified in the last point. Calculated on the basis of the indices were the contents of elemental carbon in dry biomass (45%) and the summed amount of carbon liberated in the course of the combustion process in situ or elsewhere (with consideration given to a conversion factor of 0.9). Figures were obtained for coniferous and broadleaved forests and emissions of CO_2 were calculated.

Table 13 presents the results of the estimations of **emissions of CO_2 from the burning of biomass obtained in the course of sanitary work in forests.**

The procedures and mean emission factors given by IPCC in [2] were used in the calculation of emissions of CH_4, CO, NO_2 and NO_x from the **burning of biomass in situ or elsewhere**, for coniferous and broadleaved trees combined.

The results of estimations are presented in Table 14. It follows from the analysis of levels of emission given in the table that the emission of N_2O is zero, because the calculated value was equal to 0.00003 only.

The next subcategory of emission source for CO_2 to be subject to calculation was the **process of decomposition of above-ground biomass.** Used in this case too was the IPCC procedure set out in [2]. However this made use of Polish emission factors and input quantities with a division into coniferous and broadleaved forests. The results of calculations of emissions of CO_2 from the decomposition of above-ground biomass were presented in the form of the table recommended by IPCC in [2] and appended as Table 15.

The last subcategory of emission source for CO_2 released during sanitary work in forests is **the emission of CO_2 from soils in areas where forests are converted into cultivated fields or pastures**. Emissions were calculated separately for coniferous and broadleaved forests using the 25-year mean figures for the areas of the two types of forest converted to other land uses, and applying the assumption that 50% of the elemental carbon accumulated in soils is released in the form of CO_2. the results of the estimations of emissions are presented in Table 16, in the layout recommended by IPCC in [2].

Total emissions of CO_2 from category 5A - Sanitary work in forests- have been added together in Table 17, which compiles the results from Tables 13, 15 and 16.

C.12.2. Emissions of CO_2 from the conversion of meadows into agricultural land (5.B)

The conversion of meadows into agricultural land is associated with the disturbance of the structure of the soil and resultant oxidation of carbon accumulated in it. The procedure employed to calculate emissions of CO_2 in this category was in accordance with that recommended by the IPCC in [2]. Polish national statistics were used to assess the total area of meadowland converted into agricultural land in a period of 25 years and the assumption was made that the content of elemental carbon was equal to 70 Mg/ha. The annual level of release of elemental carbon adopted was 0.02 and the results of the subsequent calculations have been presented in Table 18.

C.12.3. Emissions of CO_2 from forest management (5.C)

Applied in estimations of the emission of CO_2 from this category was the IPCC procedure set out in [2]. Details of the areas planted with special species of coniferous tree were taken from forestry statistics, as was information on the trade in cultivated coniferous and broadleaved trees. An index for the annual increase in the content of elemental carbon in the dry mass of tree stands was taken from Polish data and this was used as the basis for the calculation of the capture of elemental carbon resulting from increases in the masses of tree stands.
Table 19 presents the results of estimations of captures of elemental carbon resulting from the growth of tree stands. Data are laid out in the manner recommended by the IPCC in [2].

Data on planned afforestation, and estimations of the quantities of new trees planted in non-forestry areas (agricultural areas and other green spaces), led to the determination of Poland-specific indices for the growth of stands (in a temperate climate) as well as the content of

elemental carbon in the dry mass. Calculated from these was the annual increase in the amount of elemental carbon bound up in this category of sink.
Table 19 gives the results concerning this sink of elemental carbon in planted areas outside forestry.

Data on the cut of timber from forests were taken from statistics in [15]. It was accepted that the index of dry mass in timber was 0.75 Mg dm/m^3, and also that the index for the content of elemental carbon in this mass was 0.45. On the basis of these figures, calculations were done to determine the amounts of elemental carbon accumulated in the cut timber.
The results of these calculations have been presented in Table 20 (with no separation of the wood that was destined for burning).

Presented at the end (in Table 21) is a balance between emissions and captures of CO_2 resulting from the growth of tree stands in forestry and other areas planted with trees, and the cut of traded timber from forests.

The indicated capture of C (11,115.45 Gg C) represented the sum of the separate specified captures from the annual growth of tree stands under forestry management (10,649.7 Gg C) and from other areas planted with trees (465.75 Gg C). Multiplied by 44/12, this gave a value for the capture of CO_2 as such, of 40,756.65 Gg.

In accordance with Table 20, the amount of accumulated elemental carbon in the timber cut from managed forests was 6306.71 Gg, which represents 23,124.60 Gg of CO_2 when multiplied by 44/12. The result of deducting this figure from the one given above is a net capture of 17,632.05 Gg of CO_2 as a result of forestry management

Summary of the division -Land Use-

As mentioned at the beginning, the estimation of emissions of greenhouse gases within the framework of the 1992 inventory had not been the subject of specialist research as part of the UNEP project. It is for this reason that - for the sake of completeness in the inventory - the only categories given were 5.A - Sanitary work in forests, 5.B - the Conversion of meadows and 5C - Forestry management. Category 5.D - the Abandonment of Cultivated Areas was omitted.

The results obtained may be assessed as moderately certain.

Estimations made use of available input data published in [15], as well as certain unpublished sources. Indices for the content of dry biomass and the amount of elemental carbon within it were taken from Polish data which are in general in agreement with those available in the literature on the subject.

The capture of CO_2 has a significant impact on the overall balance in the full inventory of emissions of greenhouse gases. As a consequence it is proposed that future inventories should be preceded by a programme of new research. A further argument in favour of this is the fact that parts of the afforested area in Poland are now being reprivatized or privatized - a process which is likely to make the resources of statistical information less available in the initial period.

The research referred to should take in:

- the development of a system for the collection and storage of information relating to the use of forests which should include all owners of land whose use or changes in use may lead to changes in emissions and captures of greenhouse gases;
- the establishment of a set of necessary input data and emission factors appropriate to the categories of emission and capture (sanitary work in forests and changes in land use in meadows, agricultural land, marshes etc) which condition the reliability of estimates of emissions and captures.

C.13. Emissions of CH_4 from wastes - (6)

Emissions of methane from wastes were not embraced by the UNEP research programme. On the other hand, in accordance with recommendations of that project, research tasks were distinguished with a view to estimating selected emission sources using the CORINAIR methodology. The category of emissions of CH_4 from wastes - with a subdivision into dumps for solid wastes and wastewaters - was subject to estimations within the framework of higher research tasks using both the CORINAIR method and others. The results presented here were taken from the report of this research group [19].

C.13.1. The emission of CH_4 from dumps for solid wastes (6.A)

The calculation of emissions of CH_4 made use of a simplified method. The volume of accumulated waste was estimated to be 47,000,000 m^3. [15] gives most recent data for the wastes accumulated in 1991 of 40,715,000 m^3 and it was therefore recognized that the volume of wastes was about 15% greater and was estimated at 47,000,000 m^3.

Obtained from the assumed density of wastes of 0.2 Mg/m^3 was a mass of accumulated wastes of 9400 Gg.

Accepted in the calculation of emissions of CH_4 were:
- quantity of accumulated solid municipal waste MSW = 9400 Gg,
- an index for organic compounds in MSW undergoing decomposition and expressed as elemental C of 0.175,
- an index for the transformation of organic substances in elemental C into biogas of 0.77,
- a weighted mean for CH_4 in biogas of 0.5 expressed in terms of elemental C,
- an index for conversion to CH_4 of 16/12.

Obtained as a result of the calculation was

Emission of CH_4 = 844.433 Gg

The above value was presented along with other data in Table 22 and is also appended to the summary Table 3.

As mentioned at the beginning, the estimation of emissions of CH_4 was carried out using various methods. For example, the emission calculated using CORINAIR methods worked out at 670 Gg. However the value recognized as suitable for inclusion in the 1992 inventory balance was the production of 844.433 Gg of CH_4 mentioned above. This figure was chosen for the following reasons:
- because wastes in Poland contain more organic substances than those on dumps in Western Europe,
- because Polish wastes are wetter and thus have greater methanogenic properties.

C.13.2. The emission of CH_4 from sewage works.

In comparison to those of Western Europe, Polish wastewaters have considerable amounts of organic substances - above all sewage and some industrial effluent coming from technologies used in the food and papermaking industries. These wastewaters represent the greatest potential source of the emission of methane.

Data taken from [20] suggest a total discharge to surface waters of 10,048,100 m^3. Of this, industrial effluents made up 79% and sewage 21%. To be counted within the total amount of wastewater are 6,586,800 m^3 of cooling waters (considered clean by convention), and the remaining 3,461,300 m^3 requiring treatment. Of the latter 1,385,900 m^3 is industrial and 2,075,400 municipal.

In 1992, Poland was equipped with sufficient capacity in sewage works to treat

- 1,104,500 m^3 of effluent in industry,
- 1,329,900 m^3 of municipal sewage.

Emissions of CH_4 from sewage works were estimated on the basis of a simplified formula forming part of the IPCC methodology set out in [2]. Calculations were done by applying the following procedures and assumptions:

- the amounts of treated wastewater for each branch of industry and for municipal management were determined on the basis of statistics in [20],
- kg/l biochemical oxygen demands (BODs) were estimated and accepted according to IPCC [2] for each branch of industry, while values of BOD for municipal sewage were based on Polish estimates [at 263.5 mg/l].
- the proportion of anaerobic sewage treatment in Polish conditions was estimated at 12% (with consideration having been given to the types of fermentation chamber and climatic conditions),
- the emission factor for conversion to methane was assumed to equal 0.22 kg CH_4/kg BOD.

The results of the estimations are presented in Table 87, where they are organized by branch of industry, and as a whole for municipal management.

Table 87. (6.B) CH_4 Emission from Wastewater

Specification	BOD_5	Amount of wastewater	CH_4 Emission
	kg/l	10^6 mln m^3	Mg
Energy Industry	0.001	421.1	11117
Refinery	0.004	30.7	3242
Metallurgical Industry	0.001	135.4	3575
Electrical and Machine Industry	0.001	36.1	953
Chemical Industry	0.001	229.9	6069
Minerals Industry	0.001	43.5	1148
Wood-Paper Industry	0.004	146.5	15470
Light Industry	0.001	11.9	314
Food Industry	0.035	49.4	45646
Total Industry			87534
Municipal Wastewater	0.2635×10^{-3}	1329.9	9251
Total Emission from Wastewater			96785

The assumptions made and the results obtained and presented in Table 87 were used as a basis for the additional calculations allowing for the drawing-up of Table 23, in accordance with the recommendations of IPCC set out in [2].

Table 23 gives a value for the emission of CH_4 from industrial effluents that is equal to 87.194 Gg. This is different to the calculated emission of CH_4 of 87.534 Gg (given in Table 87) and implies an extra emission of methane from industrial wastewaters of 0.340 Gg. The latter value is also included in the last column of Table 23.

The emission of CH_4 from municipal sewage which is introduced into Table 23 is the same value as is given in Table 87 and is equal to 9251 Gg.
The first column of Table 23 includes the overall value fo BOD calculated as appropriate for industrial and municipal wastewaters.

The last few years have seen significant changes in the management of wastewaters in Poland compared to that witnessed in 1992. These changes have been brought about by new legal regulations increasing ecological requirements, as well as by continuing reconstruction and modernization of the treatment works for both industrial and municipal wastewaters.

The undertaking of the following activities is essential for increased reliability in future inventories of CH_4 emissions from wastewater management is :

- scientific research determining:
  - representative values for the BOD of the organic substances in industrial and municipal wastewaters, with account taken of the types of fermentation installation, the manner in which they are operated and Polish climatic conditions,
  - the proportion of wastewater treatment that is anaerobic,
  - Polish factors for conversion to methane,
- work to perfect the statistical system for the collection and storage of data on the management of wastewaters, with account taken of all users, including the increasing numbers off private and dispersed users.

C.14. Assessment of the reliability of the results of the inventorying of greenhouse gases

Presented in subchapters of chapter C are detailed estimates of emissions in the different categories, subcategories, and in some cases the different sources, which are discussed in the following sequence:

- the characterization of categories of emission source,
- the methodological approach,
- the completeness of the estimation of emissions, with account taken of the division into subcategories and different sources, giving the manner by which categories were aggregated,
- a definition of activity, with the detailing of the source of the information,
- the selection of emission factors, with account taken of research done for the needs of the Study,
- the scope of the documentation possessed or produced for the final report of the Study,
- evaluation of the quality of the estimates made.

The recommendations of the IPCC methodology set out in [2] obliged those carrying out an inventory to evaluate the reliability of estimations of emissions in detailed conception, recommending the formal procedure used, or in review conception. Presentation in the present report is restricted to the evaluation of reliability in a review conception, because detailed assessment with the use of the recommended procedures was impossible and uncertain for all categories with the level of research in Poland being as it is at present.

The bases upon which to carry out detailed assessments of reliability are always unambiguously identified datasets obtained on the basis of repeated measurement carried out in accordance with standardized methods in a large number of experiments. Percentagewise expression of the overall reliability or uncertainty of estimations of emissions from the sources considered is a function of the reliability or uncertainty of definitions of a figure for the activity of the source and of the emission factor. The activity of sources was determined with a high degree of accuracy in the majority of cases in the presented Study which related to quantitatively-significant categories.

The greatest cause of uncertainty must therefore be the emission factors selected within the framework of the study. Polish emission factors given in the Study may be considered rather reliable because they were obtained from either measurement or balance analyses. However, a reservation should be noted in relation to the fact that values were most often based on single measurements, or at most small numbers of measurements. On the other hand, the selection from sources in litt. of emission factors for greenhouse gases (particularly those other than CO2) does arouse considerable doubts. These result from two factors:

- the non-indication of the methods of measurement used to obtain the factors or the energetic characteristics of the emission sources (particularly the technology of combustion and capacity)

- the provision of emission factors with wide ranges of values.

The aforementioned problem has been discussed in chapter D.3. - The selection of emission factors.

To sum up it can be said that the combination of the frequent one-off determination of national emission factors and the uncertainty of those taken from the literature leads to the lack of a reliable reference base for numerical analysis - by the IPCC's formal procedure - of the uncertainties in the emission factors used in the inventorying of the majority of categories.

The aforementioned statements therefore justify only a general assessment in the form of the appended table 88 with a review conception. This is in spite of the fact that such an assessment does not entirely fulfil the conditions of objectivity. The table 88 also gives one column concerning the assessment of the certainty of estimations of source activity, which is considered to be high.

Table 88 OVERVIEW TABLE for NATIONAL GREENHOUSE GAS INVENTORY

Greenhouse Gas Source and Sink Categories	CO_2		CH_4		N_2O		NO_x		CO		NMVOC		Documentation	Disaggregation	Notice
	estimate	quality	estimate	quality	estimate	quality	estimate	quality	estimate	quality	estimate	quality			
Total National Emission and Sink	ALL	H	ALL	M	ALL	M	ALL	M	ALL	M/L	ALL	L	H/M		
1. All Energy(Fuel Combustion+Fugitive)	ALL	H	ALL	M/L	ALL	M/L	ALL	M	ALL	M/L	ALL	M/L	H	3	A-H
A. Fuel Combustion	ALL	H	ALL	M/L	ALL	L	ALL	M	ALL	M/L	ALL	L	H	3	A-H
B. Fugitive Fuel Combustion	ALL	H	ALL	H/M	NO	-	NO	-	NO	-	ALL	H	H	3	A-H
2. Industrial Processes	PART	M	PART	M	PART	L	PART	M	PART	M	PART	M/L	H	3	A-H
3. Solvent and Other Product Use	NO	-	NO	-	NO	-	NO	-	NO	-	PART	M	M	3	A-H
4. Agriculture	NO	-	ALL	H	ALL	H	ALL	L	ALL	L	NO	-	H/M		
A. Enteric Fermentation	NO	-	ALL	H	NO	-	NO	-	NO	-	NO	-	H	3	A-H
B. Animal Wastes	NO	-	ALL	H	NO	-	NO	-	NO	-	NO	-	H	3	A-H
D. Agricultural Soils	NO	-	NO	-	ALL	H	NO	-	NO	-	NO	-	H	3	A-H
E. Agricultural Waste Burning	NO	-	ALL	L	ALL	L	ALL	L	ALL	L	NO	-	M	3	
5. Land Use Change and Forestry	PART	M	PART	L	PART	L	PART	L	PART	L	NO	-	L	3	
6. Waste	NO	-	ALL	M	NO	-	NO	-	NO	-	NO	-	M	3	

Estimates
ALL - Full Estimate of all possible sources
PART - Partial Estimate
NO- Non Occuring

Quality:
H- High Confidence in Estimation
M- Medium Confidence in Estimation
L- Low Confidence in Estimation

Documentation:
H- all background information included
M- some background information included
L- only emission estimates included

Disaggregation:
1- Total emissions estimated
2- Sectoral split
3- Sub-sectoral split

Notice:
A-H
activity determination
high

PART D.

COMMENTARY ON THE IPCC METHODOLOGY - PROBLEMS ENCOUNTERED

D. COMMENTARY ON THE IPCC METHODOLOGY - PROBLEMS ENCOUNTERED

D.1. The problem of bunker fuels

Polish principles for energy statistics provide an unambiguous definition of the concept of bunker fuels [6]. Bunker fuel is understood to be fuel (mainly in liquid form) which is bought directly by units of air, sea or vehicular transport while they are abroad. Statistics do not extend to the last of these three types [6].

In contrast, the IPCC methodology presented an approach to the definition of bunker fuels that is at variance with that employed in Poland. IPCC considers bunker fuel to be fuel supplied in a given country to units of international air or sea transport irrespective of the flags flown. The quantities of fuel involved are therefore considered to be a component of the balance of the country supplying them. As a consequence, the emission of greenhouse gases from the combustion of fuels defined in this way should be included within the inventory of the supplier country (in spite of the fact that the majority of emissions actually arise outside the territory of the country in question).

For the purposes of international information, the IPCC procedure in [2] also recommends that amounts and types of bunker fuel should be separated from inventory reports of emissions of greenhouse gases. However, the above definitions and methodological recommendations are not in fact final. The IPCC guide to inventorying [2] stated unambiguously that the final solution regarding the approach to bunker fuels (and the allocation of the emissions they cause to the inventories of participating countries) would be decided upon in renewed international accords.

In studies and inventories of Poland's 1992 emissions of greenhouse gases, bunker fuels gained consideration in the category concerning emissions from mobile sources [1.A.3] - specifically in the subcategories concerning air transport (1.A.3.a) and marine transport (1.A.3.e).

The approach applied was at variance with the general methodological guidelines from IPCC, because it accepted the Polish definition of bunker fuels. In consequence of this, it should be restated that bunker fuels were considered to involve the quantities of fuel bought directly abroad by Polish units of air and sea transport. The quantities involved were introduced to the national fuel balance, and the associated emissions were included within the Polish national inventory.

However, in deference to the general recommendations of IPCC, the present chapter presents a separated balance for bunker fuels together with estimated emissions associated with them. This balance is an extract from the data included in Table 89 - The Consumption of fuels, emission factors and emissions.

The amounts of bunker fuels accepted into the inventory of 1992 emissions of greenhouse gases were as follows:

1. Aviation fuel - PL - 88 Gg according to the official source of Polish energy statistics,
2. Diesel - ON - 216.9 Gg in total, with a subdivision into:
   a. Seagoing vessels and those using inland waterways - 138.0 Gg
   b. Seagoing fishing vessels - 78.9 Gg

Energy statistics in [6] give a value for bunker diesel of 132.0 Gg, with the difference resulting from the fact that data used in the Study concerning the purchase of fuels abroad was derived directly from enterprises involved in inland, seagoing and ocean-going navigation, and related to:

- 131.9 Gg of type II diesel and 2.1 Gg of type I diesel, in the case of seagoing vessels, as well as 4.0 Gg in the case of inland navigation;
- 28.0 Gg of type I diesel and 50.9 Gg of type II diesel, in the case of vessels belonging to enterprises involved in long-distance ocean transport.

3. Fuel oil - OP - 899.9 Gg, with a division into:
   - 778.9 Gg for seagoing vessels;
   - 121.0 Gg for long-distance, ocean-going vessels.

Energy statistics in turn give a value of 779.0 Gg

From the analysis presented above it can be concluded that the official energy statistics take account of:

- all quantities of aviation fuel PL (88 Gg);
- the quantities of type II diesel used by seagoing vessels (132.0 Gg)
- the quantities of fuel oil used by seagoing vessels (779.0 Gg)

It has been postulated that the IPCC methodology involves the consideration - as bunker fuel - of amounts of fuel bought abroad by the transport enterprises of a given country. In consequence, the emissions should be included in the inventories of the given country in the categories dealing with emissions from air and sea transport (with the latter involving vessels involved in trade and long-distance fishing) - albeit with no consideration given to motor vehicles, whose purchases of fuel abroad are very difficult to determine

Table 89. (1.A.3.a and e) Bunker Fuels Balance and Emission

Vehicle and fuel type	Fuel consupm. Gg	Emission Factors [g/kg]						Emission [Gg]					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1.A.3.a.i. PL	88.0	3153.0	0.087	0.20	12.50	5.20	0.78	277.4	0.008	0.0176	1.10	0.458	0.069
1.A.3.e.i ON	138.0	3153.0	0.360	0.20	58.40	8.00	6.00	435.1	0.050	0.0276	8.06	1.104	0.828
1.A.3.e.ii ON	78.9	3153.0	0.360	0.20	58.40	8.00	6.00	248.8	0.028	0.0158	4.61	0.631	0.473
1.A.3.e.i. OP	778.9	3117.0	0.360	0.20	58.40	8.00	6.00	2427.8	0.280	0.1558	45.49	6.231	4.673
1.A.3.e.ii OP	121.0	3117.0	0.360	0.20	58.40	8.00	6.00	377.2	0.044	0.0242	7.07	0.968	0.726
Total	1204.8	3126.0	0.340	0.20	55.05	7.80	5.62	3766.3	0.410	0.2410	66.33	9.392	6.769

Notice:
1. 1.A.3.a.i. PL - Aviation - Jet Fuel,
2. 1.A.3.e.i ON - Marine Ships - Diesel Oil ,
3. 1.A.3.e.ii ON - Marine Fishing - Diesel Oil,
4. 1.A.3.e.i. OP - Marine Ships - Fuel Oil ,
5. 1.A.3.e.ii OP- Marine Fishing - Fuel Oil.

D.2. The estimation of the amounts of carbon sequestered in industrial products made by using fossil fuels or their derivatives as technological raw materials.

The 1992 inventory of Poland's emissions and captures of greenhouse gases was drawn up in accordance with the IPCC's methodological principles. Categories of emission associated with the use of fossil fuels may be divided into main groups:

- emission sources associated with the combustion of fossil fuels to generate electrical energy energy carriers, and derivative fuels (1.A.1),
- emission sources linked to the combustion of fossil fuels for the direct supply of energy to consumers (1.A.2., 1.A.3.,1.A.4.,1.A.5. i 1.A.6.).

Subject to estimation of emissions, in addition to these two main sources linked with the use of fossil fuels and their derivatives, were the fossil fuels used as solvents (category 3), in industrial processes (category 2) and lost in the form of fugitive emissions (category 1.B.).

Estimations of emissions from these sources were made on the basis of the bottom-up method.

A proportion of the fossil fuels and their derivatives is also used as a raw material in the technological generation of various industrial products. Polish energy statistics bring the fossil fuels and fossil fuel derivatives used as raw materials in industry under the heading of "non-energetic consumption".

Products and materials created using fossil fuels and their derivatives are divided into two groups:

- products oxidized in the course of their use, in ways that lead to the emission of greenhouse gases in the short-term, and taken mainly into the categories "industrial processes" (2) and the use of solvents (3),
- products not undergoing oxidation for long periods of time (conventionally about 20 years).

Carbon bound up more permanently in products and materials from the second group represents a source of "potential" emission, known as a sequestered emission. The estimation of sequestered emissions is related solely to carbon, and is based on datasets on industrial processes and statistical data collected cyclically by the Main Statistical Office.

In the reconnaissance phase of research on a Polish method for estimating sequestered emissions of carbon, analysis of the methodology of the IPCC [2] was carried out and the following conclusions were drawn:

- the calculation formula for sequestered carbon emissions recommended by IPCC was expressed as the product of:

  the non-energetic consumption x the content by mass of elemental carbon x the proportion of carbon bound up in a product

  This did not include all the components of the elemental balance in Polish conditions (it did not consider the import and export of products binding up carbon more permanently),

- factors for the share of carbon bound up in products, as given by IPCC [2], did not correspond to values determined in Poland,

- non-energetic consumption in Polish energy statistics includes both products oxidized in the short term and those binding up carbon in a more permanent way,

- the IPCC systematics set out in [2] for the fuels and fuel derivatives giving rise to sequestered emissions are different to those applied in Poland. This makes it impossible to create identical groups on the basis of the statistical data available in Poland.

The above conclusions were set against the contents of a publication [(1) appendix 2.11] which proposed modifications to the methodologies for estimating sequestered emissions of C on the basis of detailed balancing of the groups of products derived from fossil fuels and remaining oxidized for longer periods of time.

Carried out on the basis of the above assumptions were:

- analysis of all branches of Polish industry involving this group of products,

- evaluations of the possibilities for defining the proportion of elemental carbon in these products,

- estimations of the amounts of carbon locked up in products that form the subject of international trade (with estimates relating to monomers).

The results of the analysis of all branches of Polish industry allowed for the presentation of the production of industrial goods for the calculation of sequestered emissions of C in 1992 are presented in Table 90 (Table 5.2. in [21]).

Estimates of the import and export of monomers containing sequestered elemental carbon are presented in Table 91 (Table 5.3. in [21]).

Data collected in Tables 90 and 91 made it possible to produce Polish estimates of sequestered emissions of elemental carbon in industrial products derived from fossil fuels. The following formula was applied:

national sequestered emission $= \Sigma\ (P_i \times w1_i \times w2_i) - \Sigma\ (M_{imp.i} \times w3_i) + \Sigma\ (M_{exp.i} \times w4_i)$

where:

- P_i = production of the given product [Gg/year],
- $w1_i$ = content of elemental carbon in the product [Gg C/Gg],
- W2i = the proportion of carbon more permanently bound up in products (the mass of a given product not oxidized in the course of use as related to the total mass of a given product) [Gg/Gg]
- $M_{imp.i}$ = the mass of imported raw material (monomer) used in production [Gg/year],
- $w3_i$ = content of elemental carbon in the given raw material (monomer) produced in the country [Gg C/Gg]
- $M_{exp.i}$ = mass of exported raw material (monomer) produced in the country [Gg/year],
- $w4_i$ = content of elemental carbon in exported raw material [Gg C/Gg].

Calculations were done with the aid of the data in Tables 90 and 91, and the results of these calculations were used to draw up Polish sequestered emissions of elemental carbon from industrial products. These are in turn presented in Table 92 (Table 5.1. in [21]).

Detailed analysis of industrial products was combined with data on the import and export of monomers to provide a basis for the determination of the amount of carbon bound up in products which constituted a source of sequestered emission. The total figure was 1567.3 Gg C.

Also calculated for the purposes of comparison was the content of elemental carbon in different types of fuel included within Polish energy statistics under the heading "non-energetic use". The figure obtained from this was 85.68 PJ.

At 1567.3 Gg C, the size of the sequestered emission represented 72% of the estimated amount of elemental carbon in the fuels said to have been used non-energetically (which amounts to 2182.47 Gg C).

Also calculated, on the basis of data in Table 2, was the content of elemental carbon in direct emissions of greenhouse gases (CO_2, CH_4, CO and NMVOCs) from category 1 (the combustion of fuels and fugitive emissions of fuels). The figure for this amounted to 100,057.6 Gg C.

The percentage of the level of sequestered emissions in relation to the content of elemental carbon in direct emissions thus amounted to 1.57%.

Noting that the inventorying of greenhouse gases was mainly done by the bottom-up method, it should be said that the estimated level of sequestered emission may only serve orientational purposes, taking the form of an extra piece of information. The quantity was not used in the correction of direct emissions.

The accepted methodology for the estimation of sequestered emissions is considered to have been correct. Future inventories intending to widen the set of information should see the improvement of the method. It is anticipated that the main directions of activities in this area will involve:

- a transition from the national system of products (SWW) to the international system (CN),
- annual augmentation and updating of the set of products (including those imported and exported),
- determination of the contents of elemental carbon in products (W1i) as well as of the carbon more permanently bound up in products (W2i)
- analysis of other factors like: the way in which a product is used, the degree of recycling of the product (as a secondary raw material in the production of new products) and the degree of oxidation of the wastes of a given product.

Table 90. Specification of Industrial Products for Sequestered Carbon Estimation in 1992 year

No	Symbol SWW	Specification	Production [Mg]	Carbon contents [%]	Carbon contents [Mg]
1	2	3	4	5	6
1		Coke chemistry		5.0	
	0213-1	Crude tar converted to tar with 5% H2O contents	562100		**477785**
2		Refinery		85.0	
	243	lubricating and special oils	211133		-
	244	plastic lubricants	10226	85.0	-
	0245-1	paraffins and their products	19782	85.0	-
		lubricants, lubricating oils and paraffins subtotal	241141	85.0	**204970**
3	0245-5	asphalt	578200	85.0	**491470**
4		Iron and Steel Metallurgy		85.0	
	i)	steel melt without scrap use	5878600		11757
	0611	iron casting	550000	0.2	16500
	0612	steel casting	69000	3.0	207
		iron and steel metallurgy subtotal	6497600	0.3	**28464**
5		Black Production		-	
	1249-6	technical blacks	25877	~95.0	**24583**
6		Plastics Production			
	1262-2,3	phenoplasts	1860	~77.0	1432
	1262-5,6	aminoplasts	6779	~42.0	2847
	1262-7	polyester plastics	12881	~57.0	7342
	1262-8	phtal plastics	28486	~57.0	16237
	1262-91	silicones	418	~30.0	125
	1262	other plastics	15726	~60.0	9436
	1263-1	polyolefines	250775	85.7	214914
	1263-21	polyvinyl chloride	219963	38.7	85126
	1263-22	polyvinyl acetate	12184	60.0	7310
	1263-25	vinyl copolymers	1224	42.0	514
	1263-3	styrene polymers	33323	92.5	30824
	1263-4	acryl polymers	1784	~60.0	1070
	1263-8	polyamides	6599	63.7	4204
	1263	other polymers	1553	~60.0	932
	1268-1	polyurethanes	44769	62.6	28025
	1268-2	epoxide plastics	6640	76.0	5046
	1262/63/68	synthetic plastics subtotal	644964	-	**415384**
7		Synthetic Rubber Production			
	1269	synthetic rubber and latexs	88861	89.5	**79630**
8		Synthetic Fibre Production			
	1272-1	polyamide fibre	25021	63.7	16448
	1272-2	polyester fibre	55063	56.6	31166
	1272-3	acryl fibre	5177	67.9	3515
	1272-7	polyurethane fibre	-	62.6	-
	1272	synthetic fibre subtotal	86061	-	**51129**

Table 91. Monomer Imoprt-Export Balance for Carbon Sequestered Estimation in 1992 year [21]

No.	Products				Carbon contents		
	Symbol CN	Specification	Import Mg	Export Mg	%	Import Mg	Export Mg
1	2	3	4	5	6	7	8
1	2901 24 00	butadiene	18151.7	-	88.9	16136.9	-
2	2902 50 00	styrene	3877.3	1563.8	92.3	3578.7	1443.4
3	2902 60 00	ethylbenzene	20641.3	20.7	90.6	18701.0	18.8
4	2903 21 00	vinyl chloride	7567.9	79.5	38.4	2906.1	30.5
5	2926 10 00	acrylonitride	786.3	7.2	67.9	533.9	4.9
6	2933 71 00	caprolactam	1100.0	72568.7	63.7	700.7	46226.3
				total		**42557.3**	**52228.5**

Table 92. Carbon sequestered balance in Poland for 1992 in products manufactured using fossil fuels [21]

No.	Products	Production Gg	Carbon contents Gg	Share of arbon bounde %	Sequestered emission Gg C
1	Crude far	562.1	477.8	72	344.0
2	Lubricants, lubricating oils, paraffin	241.1	205.0	60	123.0
3	Asphalt	578.2	491.5	100	491.5
4	Iron and steel products	6497.6	28.5	100	28.5
5	Technical blacks	25.9	24.6	100	24.6
6	Synthetic plastics	645.0	415.4	100	415.4
7	Synthetic rubber and latexs	88.9	79.6	100	79.6
8	Synthetic fibre	86.1	51.1	100	51.1
			Total		**1557.7**
9	Monomer import				(-) 42.6
10	Monomer export				(+) 52.2
			Gross total		**1567.3**

D.3. The selection of emission factors

The basic task of the research teams, apart from estimating the accuracy of determinations of activity and choosing the manner of calculation, was to justify the selection of emission factors for CO_2, CH_4, N_2O, NOx, CO and NMVOCs, for each category of emission source of greenhouse gases.

The following criteria directed the choice of emission factors for each of the greenhouse gases:
- characteristics of the emission source,
- the type of fuel,
- the technology of combustion,
- the capacity of the emission source.

The sources of information on methodologies for the determination of emission factors and their values were:
- The **IPCC** Guidelines for National GHG Inventories [2]
- **FEWE** - Determination of emissions for a set of fossil fuels [5]
- **RADION** - Emission and Cost Estimates for Globally-significant Anthropogenic Combustion Sources. 1990 [appendix 2.1. (4)].
- **USEPA** - Emission Factors, Argonne II, 1992 [appendix 2.1 (5)].
- **CORIN**-CORINAIR Default Emission Factors Handbook. 1992 [appendix 2.1. (6)]
- work done for the needs of the study by particular research teams [3], [8], [9], [10], [11], [12], [13], [14], [16], [17], [18], [19] and [21].
- other publications used by different research teams and mentioned in the literature lists of the different reports (see Appendix 2).

The analysis of the emission factors applied (which is presented below) is organized according to the structure of categories of emission sources and sinks set out by the IPCC in [2].

D.3.1. Stationary sources of emission associated with the production of electrical energy and heat (1.A.1.b and 1.A.1.c)

CO_2 - The majority of the emission factors used were taken from Polish studies [5]. Only the emission factor CO_2max for the burning of wood (110 kg CO_2max/GJ) was taken from IPCC [2]. Values used in calculations were modified in relation to the technology of combustion and the capacity of boiler units.

CH_4 - Emission factors were taken from RADIAN [appendix 2.1 (3)]. The team's own estimations applied only to emission factors for CH_4 from spent licquor, and these made use of data from CORIN [appendix 2.1 in (3)] and the recommendations of the US EPA. The value derived was 10g CH_4/GJ.

N_2O - Emission factors for N_2O were those from IPCC [2], with no distinctions made in relation to the technology of combustion.

NO_x - Emission factors were taken from CORIN [appendix 2.1 (6)], with the exception of that for spent black licquor, which was estimated at 20g NO_x/GJ.

CO - All emission factors were adopted from RADIAN [appendix 2.1. (4)], except for that dealing with spent black licquor, which was estimated at 50g CO/GJ.

NMVOCs - Emission factors were determined in relation to previously-defined emission factors for CH_4, with use being made of ratio of NMVOCs to CH_4 given by CORIN [appendix 2.1 (6)]. Only for large oil-fired boilers were values for emission factors calculated (at 2.1 g NMVOCs/GJ) on the basis of the US EPA data set out in appendix 2.1 of (5) for the ratio of NMVOCs/CH_4 (=3) and the factor for CH_4 (0.7g/GJ). (Note: according to CORIN, the emission factor is 3 g/GJ irrespective of the capacity of the boiler)

The drawn-up set of values for emission factors was set against the results of a special survey from the Energy Information Center in the Power Supply Industry which concerned measurements in heat-and-power plants. A high degree of accord between the values compared was noted for emission factors for NO_x and CO.

D.3.2. Refining (1.A.1.d), the production of converted solid fuels (1.A.1.e), other energetic industry (1.A.1.f) and industry (1.A.2.)

The working-out of emission factors for the list of types of fuel used in Polish industry was divided into two parts: the determination of CO_{2max} emission factors and the determination of emission factors for the other greenhouse gases.

CO_2 - carbon dioxide

Polish energy statistics were used to order the calorific values of the list of types of fuel according to economic sectors and branches of industry. Collected for each type of fuel were details of the chemical composition corresponding to a calorific value. Regression analysis was then used to draw up formulae defining emission factors for elemental carbon as a function of calorific values. The set of formulae are presented along with the methodologies for their use in the chapter devoted to industry (1.A.2.). Carried out next were calculations of values of emission factors in kg C/GJ and kg CO_2/GJ. The results, ordered by type of fuel, economic sector and branch of industry were presented in tables. Elaborated on the basis of the results obtained was a special report [5] containing tables of emission factors for CO_2, explanations and the methodology applied in the choice of emission factors. The report [[5] was distributed for use by all research teams working on the project.

Other greenhouse gases

To make available to the research teams the fullest possible set of data for inventorying greenhouse gases, work was done on a set of emission factors for CO, CH_4, NMVOCs and NO_x. Collected and presented were emission factors for these gases taken from the following sources:

- measurement data from the services of environmental protection of branches of industrial enterprises,
- data from the national reports of branch institutes,
- data from the available foreign and Polish literature.

It should be made clear that the elaborated set of emission factors is incomplete and orientational in character, giving an idea of the range of values set out in various sources. The set can only serve as a basis for comparison of values for emission factors in particular subcategories of emission which are accepted on the basis of detailed analysis.

Table 93 is a presentation of the collected emission factors for CO, CH_4, NMVOCs and NO_x, which are organized by subcategory of emission source in which the combustion of fuels is used for heating technological purposes.

Though somewhat incomplete, the elaborated set of emission factors for greenhouses gases from combustion processes did play an important role in the realization of the Project. This role involved:

- the supply of emission factors for CO_2, and of a uniform method for determining these factors on the basis of realistic characterizations (by calorific value and chemical composition) of the types of fuels used in Poland, including the types occurring in Polish conditions which depend on the technology applied. This related to:
    - nitrified natural gas,
    - spent black licquor in the cellulose and papermaking industry,
    - refinery gas, whose chemical composition varies with the technology of processing of oil.

- the facilitation of the choice of emission factors for CO_2 in relation to the technology of combustion in different subcategories of emission source,

- the provision of a set of emission factors for CO, CH_4, NMVOCs and NO_x, whose values were organized by subcategory of emission source given in many cases with numerical ranges enabling values of emission factors to be chosen on the basis of analysis of the technological conditioning in precisely considered sources of emissions.

Table 93. Statement of CO, CH_4, NMVOC and NO_X emission factors for comparising analysis

	EMISSION FACTOR [kg/GJ]				
	CO2	CO	CH_4	NMVOC	NOx
STEAM BOILERS					
Coal					
Pulverized		0.014-0.05	0.0006		0.132-0.857
Stoker		0.093-0.121	0.0024		0.094-0.32
Fluid			0.0006		0.255
Other boilers					
Gaseous fuel		0.017	0.0014	0.0019	0.049-0.067
Oil fuel		0.015	0.0029		0.161
Local boilerhouse:					
Coal		0.093	0.0024		0.094
Gaseous fuel		0.017	0.0014		0.067
Oil fuel		0.015	0.0029		0.161
INDUSTRY					
High temperature process > 800 °C					
Blast furnance		1.59		0.0002	0.00028
Converter steel		8.37			0.045
Electric steel		13.68		0.266	0.152
O.H. furnace steel				0.053	0.6-0.7
Ferroalloys					0.042
Cooper		5.746			0.125
Aluminium		1.35	0.002-0.003	0.012	0.015
Electric zinc		1.212		0.003	0.062
Sinter zinc		1.648			
Glass and Ceramics		0.004-0.006			0.026-0.048
Heating stove		0.011-0.026		0.0006	0.013-0.037
Coke		0.094	0.103-0.147	0.047-0.162	0.011-0.024
Clinker - wet		0.239			0.230-0.906
Climker - dry		0.406			0.213-2.287
Lime and gypsum		0.6-1.53			0.0048
Middle temperature processes 200-800 °C					
Heating stove		0.015		0.0012	0.06
Low temperature processes <200 °C					
Drying		0.011-0.179		1.0-1.1	0.064-0.226
Heating treating furnace		0.009		0.0023	0.043
Chemical processes					
Refining		0.0248	0.002-0.008	0.018-0.072	2.48
Organic chemistry				0.08-1.30	0.156-1.7
Non organic chemistry			0.136-0.185	0.0024	0.028-3.054
HOUSEHOLD					
Boilers		0.008		0.0024	0.05
Stoves		0.015		0.0023	0.12
Kitchen		0.045-0.058		0.0023	0.037-0.039
PUBLIC					
Boilers		0.008		0.0024	0.05
Stoves		0.015		0.0023	0.12

Augmenting information

- Accepted in calculations for refinery gas were the following values for emission factors in categories (1.A.1.b.ii) and (1.A.1.d.)

Table 94. Applied Emission Factors of Refinery Gas.

GHG TYPE	CHP (1.A.1.b.ii) [kg/GJ]	TECHNOLOGICAL INSTALATIONS (1.A.1.d) [kg/GJ]
CO_2	57.2700	57.5600
CH_4	0.0014	0.0014
N_2O	0.0001	0.0001
NO_X	0.1400	0.0580
CO	0.0190	0.0170
NMVOC	0.0014	0.0019

- Accepted for spent black licquor were the following emission factors in category (1.A.1.b.ii) - industrial heat and power plants:

  CO_2 - 94.770 kg/GJ
  CH_4 - 0.010 kg/GJ
  N_2O - 0.002 kg/GJ
  NO_x - 0.020 kg/GJ
  CO - 0.050 kg/GJ
  MVOCs - 0.030 kg/GJ

- In the inventorying of emissions in industry (1.A.2.), the accepted values for emission factors for nitrified natural gas were differentiated in relation to a division into:
- typical technologies used in the majority of branches of industry,
- special technologies is selected branches of industry for which additional information was obtained.

In the second group of analyses, the selection of emission factors for nitrified natural gas was made in a more detailed way in relation to the set of additional data obtained.

For the non-ferrous metals industry, use was made of the results of measurements of gaseous emissions from combustion in technological processes of nitrified natural gas. These were worked out by the specialist BIPROMET centre in Katowice.

Data used for the chemical industry were supplied by the Institute for the Ecology of Industrialized Areas in Katowice. These data concerned emission factors and were set against the results of measurements made at the Nitrogen Plant in Kedzierzyn.

For the building materials industry the emission factors for nitrified natural gas were obtained from the Institute of Building Materials in Opole.

The accepted values of emission factors in the glass industry were based on measurement data from glassworks.

Table 95 presents the values of emission factors for nitrified natural gas arranged by branch of industry.

Tabela 95. Applied Emission Facstors of Nitrified Natural Gas.

GHG TYPE	NON-FERROUS METALURGY [kg/GJ]	CHEMISTRY INDUSTRY [kg/GJ]	BUILDING MATERIALS INDUSTRY [kg/GJ]	GLASS INDUSTRY [kg/GJ]	OTHER INDUSTRY [kg/GJ]
CO_2	54.9400	53.4800	54.5400	54.9900	54.9700
CH_4	-	0.1600	0.0012	0.0012	0.0014
N_2O	0.0001	0.0001	0.0001	0.0001	0.0001
NO_X	0.0550	1.2350	0.4730	0.0370	0.0670
CO	0.0185	0.0100	0.2902	0.0050	0.0170
NMVOC	0.0060	0.3460	0.0014	0.0014	0.0014

D.3.3. Transport (1.A.3)

Special research was carried out to determine emission factors for greenhouse gases from transport. The results of this work are discussed in chapter C.3. in the part entitled "Analysis defining emission factors in transport - *the role played by research done specifically for the needs of the study.*

On the basis of the research done, emission factors were provided for CO_2, CO, NMVOCs and NO_x in the subcategories road transport (1.A.3.b) and agriculture/forestry (1.A.b.). Values of these factors, expressed in kg/GJ and ordered by means of transport and fuel used, are presented in Table 43.

In contrast, emission factors for CO, NMVOCs and NO_x from air transport were taken on the basis of analysis of data from 5 sources in the literature for turbo-jet engines and 2 sources for piston engines. Table 38 presents the collected data from the literature, along with identification of the source of information as well as the values for emission factors adopted on the basis of it.

Emission factors for CH_4 and N_2O for all subcategories of transport and taking account of the type of fuel were also accepted on the basis of analyses of data in the literature. These are presented in Table 39, along with the apprporiate sources of information compiled in appendix 2.3.

Stress should be laid upon the high reliability of the emission factors used in the inventory of greenhouse gases in the transport category (1.A.3), which were based on research done by the authors. These relate to Polish conditions for the activity of transport (the number of vehicles, type of transport work and type of fuel).

D.3.4. Municipal management (1.A.4), housing management (1.A.5) and agriculture/forestry (1.A.6).

Used to define emission factors for greenhouse gases in these categoris were data in a special report [5]: for housing and municipal management in the section "Municipal Management" and for agriculture and forestry in the section entitled "Agriculture". Research was not done specially to define emission factors in these categories for the needs of the study, but the value of the emission factor for CO_2 was corrected on the basis of a balance for elemental carbon (reducing the value of the factor for CO_2 in relation to emissions of CH_4, CO and NMVOCs in accordance with the methodology of the special report) [5].

D.3.5. Fugitive emissions from the oil system (1.B.1.a.1.)

Work on the structure of the Polish oil system allowed subcategories of fugitive emission source to be identified. These were:

- the extraction of oil: emission of CH_4 and NMVOCs from the release of associated gases to the atmosphere, and releases of CO_2 from the combustion of some gas in gas flares,
- the transport and storage of oil: emissions of NMVOCs from the unloading in port and from the transport by pipeline and cisterns,
- refineries: emissions of NMVOCs from operational and storage tanks, from loading facilities,from processing installations and from the technical infrastructure of refineries,
- wholesale distribution: emissions of NMVOCs,
- retail distribution: emission of NMVOCs from the distribution of petrol and diesel.

Each of these subcategories has its own internal technical structure and differentiated technological infrastructure as described in chapter C.7.1. Estimations of emissions, done using the bottom-up method and using Polish emission factors corresponding to subcategories and their installations and technological operations, are presented in Tables 53, 54, 55, 56, 57, 58, 59, 60, 61, 62 and 63.

In the face of - on the one hand - detailed determinations of structures, technical installations and technological operations for each of the subcategories of fugitive emission in Poland's oil system, and - on the other hand - generalized determinations for these subcategories in the IPCC guide [2], it can be seen that there was no real justification for comparing the emission factors used in the Study with those given by IPCC.

At the end it should be mentioned that fugitive emissions of NMVOCs estimated using the CORIN method [19] were equal to 4.668 Gg, and were thus more than 7 times lower than the value of 33,788 Gg estimated in a detailed way in the Study. In contrast, the value determined for CH_4 from CORIN (0.519 Gg) is almost equal to that estimated in the study (0.517 Gg).

D.3.6. Fugitive emissions from the gas system (1.B.1.b)

The Polish gas system has three gas supply subsystems, involving:

- high-methane natural gas,
- nitrified natural gas,
- coke-oven gas.

This distinguishes the Polish system from the classic one found in the majority of countries which involves one type of gas, namely high-methane natural gas.

Appropriately for the IPCC methodology set out in [2], the inventory of greenhouse gases in the different subsystems took account of various subcategories of source:

- emissions during exploratory work,
- emissions during the testing of successfully drilled bores,
- emissions in the extraction of gas,
- emissions from installations processing gas,
- emissions from the transmission of gas,
- emissions from the operation of gas stores,
- emissions from the distribution of gas to consumers.

The majority of cases of analysed segments and operations in subsystems involved the use of emission factors worked out especially for the needs of the study on the basis of the analysis of losses (measurement and reports) and through the determination of representative emission factors, determined in detailed research. Remaining cases made use of emission factors from the U.S. E.P.A. (1993).

The specifics of the Polish gas system make it at present impossible to compare foreign emission factors with Polish ones for fugitive emissions from the systems involvingh nitrified natural gas and coke-oven gas. Polish emission factors used in these subsystems and determined from the results of research within the framework of the UNEP Project are presented in:

- Table 70, in the case of CH_4,
- Table 71, in the case of NMVOCs,
- Table 72, in the case of CO_2.

The results presented in the tables should be regarded as a Polish contribution increasing knowledge of fugitive emissions from the subsystems of nitrified natural gas and coke-oven gas. It is the first time that emission factors for CH_4, NMVOCs and CO_2 have been related to different segments and subsystem operations, or to these subsystems as a whole.

Comparisons of emission factors for the subsystem involving high-methane natural gas may be made, but only in relation to emissions of CH_4, as data on emissions of NMVOCs and CO_2 are very limited in the available literature.

It is this which entitles us to recognize the emission factors defined in the present study for NMVOCs and CO_2 from the whole subsystem of high-methane natural gas, and from its segments and operations, as a Polish contribution to the improvement of the datasets in the IPCC methodology. The values of the Polish emission factors for NMVOCs and CO_2 are presented in Tables 71 and 72. The emission factors for CH_4 from the subsystem involving high-methane natural gas are presented in Table 96, which also includes data from IPCC [2 vol.2. tables 1-8] for the purposes of comparison.

Table 96. Comparative Specification of CH_4 Emission Factor for Natural Gas System (High Methane)

SUBCATEGORY	POLAND [kg/PJ]	US and CANADA [kg/PJ]	EASTERN EUROPE [kg/PJ]	REST OF THE WORLD [kg/PJ]
Wydobycie	100848	39500-104000	218000-568000	40000-96000
Przeróbka, przemysł, magazynowanie, dystrybucja	452880	60000-117000	340000-716000	117000-340000

It follows from analysis of the values of emission factors for CH_4 given in Table 96, that:

- The Polish emission factor for extraction is close to the upper value noted for this in the USA, Canada and other countries, but is half the size of the lower value of the emission factors given for the countries of Eastern Europe;

- The Polish emission factor for CH_4 from processing, transmission, storage amd distribution is 4 times greater than the upper value given for the USA and Canada and more than 30% greater than the upper value given for the rest of the world and the lower value given for the countries of Eastern Europe.

D.3.7. Fugitive emissions from the system involving brown coal and hard coal (1.B.2.)

The framework of the UNEP Project saw detailed research done on emissions which involved all active mines working hard coal (70 in all) as well as one open-cast mine working brown coal.

It has been recognized that Polish values for emission factors for CH_4 are well documented [12] because they are based on study measurements of methane capacities of seams in relation to their sorptiveness.

Detailed values for emission factors for CH_4 are given in Table 74 for each mine working hard coal.

Summary results relating to emission factors for CH_4 are presented in table 75, where they are arranged by subcategory of the coal system (ventilation, post-extraction processes and spoil heaps with wastes) in underground mining for hard coal, and by the subcategories ventilation of deposits and ventilation of surrounding rocks, in the case of the open-cast mining of brown coal.

It should be noted that emissions of CH_4 from degassing systems at mines working hard coal were determined by a balance method, without resort to emission factors.

Table 76 is arranged by subcategory, and presents a comparison of the Polish methods of estimating emissions of CH_4 from the coal system, with the global average method of OECD/IPCC.

Comparisons of the values obtained for hard coal make it possible to state that:

- at 6.0 m^3 CH_4/Mg, the emission factor for CH_4 obtained from research in the extraction subcategory is lower than the lowest value in the range given by IPCC in 2 vol. 2 (at 10 m^3 CH_4/Mg),
- at 1.481 m^3 CH_4/Mg, the emission factor calculated for CH_4 from post-extraction processes is higher by about 64% than the 0.9 m^3 CH_4/Mg given as the lowest value by IPCC in [2] volume 2, tables 1-7.

On the other hand, comparison of the overall value for the emission factor for CH_4 obtained in research (the 5.4 m^3 CH_4/Mg obtained for all underground mining of hard coal), with the limit values of 6.8 to 12.0 m^3 evaluated for Poland by Pilcher (1991) in IPCC [2] vol. 3, table 1-36, allows it to be stated that the value for the emission factor in Poland is lower than the lowest limit value, and is only 45% of the upper value given.

D.3.8. Industrial processes (2)

The bases for the choice of emission factors were:

- registers of emissions, the results of measurement and sets of emission factors from industrial enterprises,
- data taken from foreign or Polish sources in the literature.

The values of emission factors for different greenhouse gases are arranged by type of fuel and branch of industry in Table 37.

The iron and steel industry and the non-ferrous metals industry (2.A. and 2.B.)

All of the factors in these subcategories of emission were based on Polish data from industrial enterprises, or from Polish literature. They represent the national output in the determination of emission factors as well as a Polish contribution to the international set of such figures.

The processes in the inorganic chemicals industry (2.C.)

The sizes of emission factors were determined on the basis of Polish data, although foreign data were used in the following cases:

- for emissions of NO_x in the production of nitric acid, from the U.S. E.P.A. [appendix 2.7.B. (1)]
- for emissions of CH_4, from CORIN [appendix 2.7.B. (11)]
- for emissions of NMVOCs, from CORIN [appendix 2.7.B. (11)]
- for emissions of CO_2 from agricultural liming, from the Norway SFT Report [appendix 2.7.B. (11)]

The processes in the organic chemicals industry (2.D.)

Foreign emission factors for NMVOCs were applied in the majority of subcategories of this category: for propene, styrene and butadiene, for ABS resin and for rubber. The source of data was the CORIN set [appendix 2.7.B. (11). Other subcategories were estimated using Polish emission factors for NMVOCs, which are higher than those of CORIN. These cases related to vinyl chloride, light polyethylene, heavy polyethylene and ethylobenzene.

Non-metal mineral products (2.E.)

Adopted in this category were Polish emission factors for CO_2, and CORIN emission factors for NMVOCs [appendix 2.7.B. (11)].

Other industrial processes (2.F.)

Used in the estimation of emissions in this category were Polish factors, albeit with comparisons made with the values in the CORIN set of factors [appendix 2.7.A. (3)]. It results from the comparison that the Polish factor adopted for NMVOCs from the food industry was around 30% lower, while the Polish factor for CO_2 was twice as high.

D.3.9. The use of solvents (3)

The lack of Polish research on emissions of NMVOCs for most of the subcategories of the use of solvents gave rise to a need to use the data from CORIN [appendix 2.7.B.(11)] more or less in their entirety. Exceptions related to the subcategories involving:

- the use of paints in the construction industry,
- the production of paints,
- the production of glues,
- the production of pharmaceutical products.

In these cases, use was made of Polish factors whose values are presented in Table 97, along with the values of emission factors from CORIN.

Table 97. NMVOC Emission Factor values Comparison.

Process	Emission Factor - kg/Mg	
	Polish	CORIN
Paints use in construction sector	500	300
Paints production	10	15
Glue production	5	20
Pharmaceuticals production	550	435*

* - emission factor evalued in kg/Mg from factor expressed in 18g/person/year in CORIN.

D.3.10. Agriculture - enteric fermentation in livestock animals (4.A.)

The emission factor for CH_4 in kg/year/head was calculated in accordance with the IPCC method set out in [2] volume 3. Detailed results of the calculation of emission factors for CH_4 were averaged and compared with interpolated means (based on the mean mass per head) for emission factors for CH_4 taken from IPCC [2]. The comparison is presented in Table 98.

Table 98. Average CH_4 Emission Factor Comparizon from Country Study and IPCC.

Animal Groups	Mean number of Head	Emission Factor [kg CH_4/head/year]	
	[ths. head]	Polish	IPCC
Dairy Cattle	4202.6	94.3	86.4
Non-Dairy Cattle	3741.8	49.4	56.0
Sheeps	1869.5	8.9	8.0
Horses	899.5	18.0	18.0
Pigs	21777.5	1.5	1.5

D.3.11. Agriculture - emissions of methane from animal wastes (4.B.)

The emission factors for CH_4 from the fermentation of the wastes of milking cows, other cattle, pigs and other animals were calculated within the framework of the Study, while those for sheep, horses and poultry were adopted from IPCC figures given in [2 vol 3, tables B-1, B-2 and B-7] for the cool climatic zone.

Comparisons were made between the emission factors for methane determined in the course of the Study and those given by IPCC in [2. vol. 3, tables B-3, B-4 and B-5]. The comparative data are presented in Table 99.

From analysis of the values for emission factors for CH_4, it can be seen that the figures obtained from calculations and estimates carried out for the needs of the Study were lower than those from IPCC in the cases of the wastes from milking cows, other cattle and pigs.

Table 99. CH_4 Emission Factor Comparizon from Animal Manure.

Animal Group	Emission Factor [kg CH_4/head/rok]	
	Polish	IPCC
Dairy Cattle*	2.90	6.00
Non-Dairy Cattle*	1.22	4.00
Sheeps	0.19	0.19
Horses	1.39	1.39
Pigs*	1.43	4.00
Poultry	0.08	0.08
Other*	0.01	-

* - polish estimates

D.3.12. Emissions of N_2O from soils used in agriculture (4.D.)

An important result of the research on N_2O from soils was the drawing-up of a simplified formula for average total emissions on the basis of the analysis in three years of the use of artificial fertilizers and manure, the cultivation of leguminous plants and emissions from organic substances in soil. The formula expressed the national emission factor for N_2O-N as a function of the doses of nitrogen added in kg/ha. The form of the formula was as follows:

N_2O-N [kg/ha/rok] = 0.82 + 0.008*N

where:

- N was the dose of nitrogen in kg N/ha
- the constant 0.82 considered emissions from manure, the cultivation of leguminous plants and organic substances in soils.

The formula may be used in future inventories on the assumption of small changes in the area of land used in agriculture and in the national herds and flocks of livestock animals.

PART D.I.

RECOMMENDATIONS IN RELATION TO THE IPCC METHODOLOGY

D.I. RECOMMENDATIONS IN RELATION TO THE IPCC METHODOLOGY

The Core Team co-ordinating and steering the UNEP-backed "Country Case Study" considered, among many research tasks, the following:

- the use of the third version of the IPCC methodology [2] in the inventorying of Poland's 1992 emissions and captures of greenhouse gases,
- the extension of the list of Polish emission factors on the basis of research,
- the improvement of the method for determining the activity of different emission sources from data in Polish statistics,
- the enhancement of the reliability of the results of current and future inventories through the application of better, more-unified methods.

The tasks to work out proposed modifications to the IPCC methodology are important on account of the basic aim of the UNEP project, which is to improve the international methodologies for inventorying continually.

The proposals for modifications to the IPCC methodology relate to those selected categories of emission source for which the research team successfully applied their own methodological approaches in the course of inventory work. Discussion of the proposed modifications is presented below in order of the IPCC structure for categories of emission and capture.

In relation to categories: **(1.A.1.) industry involving energy and its conversion, as well as (1.A.2.) - industry**, the methodology of the IPCC was applied with full success. In consequence no proposals for its modification have been made. However, conclusions concerning Polish conditions for enhancing the reliability of estimates have been drawn. These are presented for the different categories and subcategories of the subchapters of chapters C and D.3. The proposals contained in the conclusions concern the need to determine - on the basis of Polish measurements - emission factors for those greenhouse gases for which the values applied were of low reliability, with consideration given to the type of fuel, the technology of combustion and the requirements of the bottom-up methods applied.

The IPCC methodology in emission category **(1.A.3.) - transport** - is clear and unambiguous and does not give rise to difficulties when applied in Polish conditions. A basic condition in the reliability of the inventorying of transport is the availability of Polish data on the technical structure of the vehicle fleet, the types of fuel used and the activity of transport, as well as the availability of emission factors mostly determined on the basis of research done for the needs of the Study.

On the other hand, it is postulated that the methodology of the IPCC for the transport division (1.A.3.) should come to embrace two groups **(1.A.3.1) - mobile sources of emission - and (1.A.3.2.) - stationary sources of emission**. This division was applied in the present inventory and this is refelected in Table 3. The need to separate out a subcategory (1.A.3.2.) results from the fact that large transport enterprises have technical back-up (operational, repair-related and test-related) which is equipped with special (fuel-burning) equipment different from that in industrial heat plants (1.A.1.c.ii). In Polish conditions, this equipment includes installations for the de-icing of vehicles and loads carried on open wagons, heating equipment for technological renovation, test sites for engines and other heating equipment.

Lack of detailed data made it impossible to employ the bottom-up method in the categories of emission source **(1.A.4.), (1.A.5.) and (1.A.6.) (respectively municipal management, housing and agriculture/forestry)**. In consequence, the top-down method was used in estimations.

The development of the IPCC methodology is directed towards the wider use of bottom-up methods and it is therefore necessary to do work within the IPCC framework with a view to working-out methodological bases and checked sets of emission factors. From Poland's point of view these studies should first embrace housing (1.A.5.) which emits 29% of all the emissions of CO_2 from the power supply industry (1.A.1.). Centralized heating plants should also be taken into account as these supply the needs of residential heating in part.

Research for housing should develop with the following factors taken into account:

- the systematics of emission sources,
- the types of fuel used,
- the technology of combustion,
- the aims of the energy consumption (heating, use of warm water, preparation of food),
- definitions of energetic activity.

Poland is ready to participate in co-operative international research on housing as a source of emissions, because work in this area has just begun within the framework of research to develop methods to reduce emissions of greenhouse gases.

It is postulated that the IPCC methodology for the category dealing with **fugitive emissions from the oil system (1.B.1.a)** should come to include a requirement to work out (prior to the inventorying of emissions) a scheme for the system involving oil and its fuel derivatives. This would define in detail the sources of emission and the mutual links between them, and would allow for determinations in all subcategories, taking into account their allocation in the system and the technological operations and processes carried out. The maintenance of the fundamental structure of IPCC subcategories of emission source (the extraction, transport, storage and processing of oil and the distribution of fuels) for each of these would require the development of internal technological schemes which would make it easier to organize emission sources in accordance with technological processes and operations, along with the definition of their technical characteristics (e.g. type of technical equipment for the storage of fuels and technologies for loading and unloading).

The systemic schematic presentations applied would bring in unambiguous systematics ensuring the completeness of the list of emitters and the possibility to create aggregate subcategories for which emission factors would be defined on the basis of familiarity with those factors for the part-operations taking place in the sources of emission, or else on the basis of losses determined in the course of measurement while operations are in progress.

The fulfilment of the above proposal for modifying the IPCC methodology (by working out a schematic representation of the system and segments of it) calls attention to the possibility of applying a market model in the subcategory of the wholesale distribution of oil products of the kind that was used successfully in the present study.

It should be stressed that the adaptation of the IPCC methodology to Polish conditions, within the framework of the research done, allowed for the first inventory at the presented level of detail to be carried out in relation to fugitive emissions from the oil system.

The proposal to draw up a schematic representation is all the more justified in the case of the inventory of **fugitive emissions from the gas system (1.A.1.b.)**, on account of the **network-like nature of this system** which (as Chapter C shows) has three subsystems (involving high-methane natural gas, nitrified natural gas and coke-oven gas). The schematic representation of the system that was applied in the inventory of fugitive emissions served not only in the identification of all the emitters presented in a systematic way in [11], but also in the working-out and full application of an **algorithmic method for calculating emissions**. Such an approach to inventory work made it possible to create an ordered list of input data for the calculation of each emission source (activity, the chemical composition and calorific value of gases, technological operations and their frequency of occurrence, etc.).

Analysis of the set of ordered input data was of value in the determination of the range of research which the authors needed to do in order to determine emission factors for the inventorying of fugitive emissions and in order to increase the reliability of future inventorying of the national gas system and its subsystems.

A further postulate for the improved inventorying of fugitive emissions from the gas system is the introduction - particularly in Polish conditions - of detailed research on emissions from subcategories and their segments which are considered to be representative of the national system. The aim here is to determine emission factors. The representative method may be applied where large numbers of subcategories with varied measuring equipment are the same or similar in terms of technology and structure. Selecting for study those subcategories with the best measuring equipment and the best-organized monitoring system during operations (e.g. in relation to losses) would provide results which could be considered more reliable than those of others in the same subcategory. The representational method was applied successfully in the presented inventory of fugitive emissions from the gas system, in the category involving the transmission of gas.

A large amount of research was required before estimating the **fugitive emissions of CH_4 from Poland's coal system (1.B.2.)**, which includes 71 mines differing in mining characteristics, including methane content. The results of the research done showed, amongst other things, that there are significant variations in the emission factors for ventilation systems in underground mines (from 0.030 - 31.135 m^3 CH_4/Mg). It was also shown that emissions from these systems accounted for 75% of the total. Research showed that the sources of emission detailed in the IPCC methodology should be augmented by sources comprising the spoil heaps of waste rock and post-production wastes.

On the basis of these results alone, it can be said that countries with a well-developed coalmining industry should base estimations of fugitive emissions on detailed research of their own. The application of emission factors from the literature cannot be justified. A further detailed argument supporting this idea is the observation that IPCC methodology assumes for **ventilation systems a linear relationship between emission factors and methane content**. This does not reflect the real dynamics of the degassing of coal deposits of different methane capacities and therefore leads to significant errors and overestimation in the assessment of fugitive emissions. Polish studies [12] working out a formula for the relationship between emission factors from ventilation and the methane content of seams of hard coal obtained a **parabolic form** which was confirmed by measurement but which is clearly related to Polish conditions and cannot be used more generally for the coal seams of other countries.

On the basis of the above, it is proposed that international co-operation in research be developed within the IPCC framework, amongst countries with well-developed coalmining industries. This research would have as its aims:

- the presentation of the results of the research in different countries,
- the elaboration and unambiguous identification of complete sets of subcategories of emission source,
- methodological improvement of relationships characterizing the emission capacities of seams of hard coal.

The results of Polish studies into the fugitive emissions from the coal system should be considered an important element in the methodological improvement and constructive correction of the IPCC methodology.

Emissions from industrial processes (2) are a difficult subject for which to estimate emissions because there are such a large number of processes, both contact and non-contact and because of the uncertain indication of emissions from these processes in the technology introduced in different countries (balance conditions). It is therefore proposed that the IPCC use international co-operation to work out the fullest possible systematics of those industrial processes which produce emissions of greenhouse gases other than those resulting from the combustion of fossil fuels.

A relatively well-determined process within the IPCC framework is emission from the production of cement. The CORINAIR system currently makes use of a larger set of already-worked-out industrial processes, so it is proposed that co-operation be developed between IPCC and CORINAIR in the organizing of sets of industrial processes with a view to organizing emissions by type of greenhouse gas in each industrial process introduced to the set, as well as to defining the principles for the determination of the appropriate emission factor in research done in the countries involved in this co-operation.

The Polish inventories of greenhouse gases from the **use of solvents, agriculture: enteric fermentation in livestock and agriculture: emissions of methane from animal wastes (categories 3, 4.A. and 4.B respectively)** made use of the guideline methodology given by IPCC. It is for this reason that no proposals are made for modification in relation to these categories.

Two proposals arise in relation to category **4.D. - agriculture**: emissions of **N_2O from agricultural soils**. First, category D should take on an additional subcategory involving emissions of N_2O from soil humus, as a result of the mineralization of organic substances in soil. The second proposal is based on a fact uncovered in the course of research, namely that doses of nitrogenous fertilizer added per hectare of agricultural land were the main factors in changes over three years in the values for the overall emission factor for N_2O from soils (i.e. including the use of mineral fertilizers and manure, the cultivation of leguminous plants and processes in soil humus). On the basis of analysis of this phenomenon and the finding that over an interval of three years, the calculated emission factors for other subcategories were almost constant with the exception of that for manure (where the difference was only one of about 15%), an empirical formula of the following form was calculated for the overall emission factor from soils:

$N_2O\text{-}N$ [kg/ha/rok] = 0.82 + 0.008 * N

where N is the dose of nitrogen in nitrogenous fertlizers [in kgN/ha/year].

As an approximation, this formula may be applied for the next few years in the inventorying of emissions of N_2O from soils. This assumption is made on the basis of the limited changes in Poland to the area of farmland, the cultivation of leguminous plants and the number of livestock, in comparison to the distinct changes noted in doses of nitrogenous fertilizer applied (which changed by a factor of two in the course of the years of studies). Of course it should be recalled that the conditions of functioning of agriculture are different in different countries, so it is proposed that consideration be given in each country to the use of the presented methodological approach in the creation of a formula by which to estimate emission factors for all N_2O from soils, for a period of several years. This would make the assessment of emissions easier, especially in cases like that of Poland where a computer model is used in inventory work. The labour-intensive and time-consuming research in calculating emissions (e.g. from manure) is limited, and quick work can therefore be done to estimate emissions, especially in the light of the fact that most countries have available data for annual doses of nitrogen in fertilizers applied.

At the end of the chapter on the recommended modifications to the IPCC methodology, it should be stated that the results of research for the inventorying of greenhouse gases allow it to be said that the IPCC methdology set out in [2 volumes 1, 2 and 3] and the accompanying guidelines does fulfil its function as a guide for teams involved in drawing up national inventories.

PART E.

A COMPUTER MODEL FOR INVENTORYING AND REPORTING

E. A computer model for inventorying and reporting

The inventory of emissions of greenhouse gases was carried out on the basis of research in different categories and subcategories of emission by Polish specialist teams, in order to ensure that the following were obtained:

- detailed methodologies for the estimation of emissions in each of the categories studied,
- a set of emission factors and of methods for defining them in the cases under consideration,
- practical knowledge of the application of the methodological principles worked out.

The requirements of the IPCC methodology also concern the manner in which reports and inventories are to be drawn up [2].

The aim of a uniform method of reporting is to present the results of inventories in a form which allows international comparisons to be made and regional and global inventories of emission of greenhouse gases carried out.

In relation to the needs of future inventories of emissions, work should be done to introduce computerization in the form of a mathematical model. Such an original model adapted to Polish conditions and fed with the information and data necessary for the inventory was created within the framework of the UNEP project.

The computer model for estimating emissions of the greenhouse gases CO2, CH4, N2O, NOx, CO and NMVOCs from all categories of emission in the IPCC structure constitutes a program which is a detailed database describing parameters characteristic of each emission source of these gases, together with algorithms for the calculation of emissions and captures. The computer model for estimating emissions and captures contains procedures for arranging the calculated emissions in each category, for balancing emissions of the different greenhouse gases from each category, as well as for printing out the report in accordance with the IPCC forms. Tables 2-23 appended to the final report are computer printouts generated by the model created.

The work on a Polish computer model for estimating emissions was dictated by the need to adapt to the conditions of the country the universal procedures set out for the collection and processing of input data in the three-volume IPCC guide [2].

In the majority of IPCC categories, the results of research made it possible to construct a computer model for the estimation of emissions that was in line with the IPCC methodology.

Use was made in this of:

- a Polish base for feeding in input data,
- methods for determining activity and emission factors in the categories under study, which were worked out by the research teams,
- methods for the calculation of emissions in the different categories,
- sets of emission factors obtained in relation to Polish conditions and ordered by category,
- methods for the drawing-up of balances for the different greenhouse gases, for the purposes of reporting the emissions and captures checked in the course of the inventorying work.

The computer program was based on the Quattro-Pro calculation sheet.

The input data are introduced to the different sheets at the "first level" corresponding to the different subcategories. Sheets at this first level contain appropriate relationships making it possible to calculated emissions at this point. Successive sheets are of the aggregate type, and involve the automatic summing of results from the given subcategory. This allows for emissions to be determined for aggregate categories, and for aggregate emission factors to be worked out. In the case of category (1) - Energy - the total emission is also separate for each type of fuel, taking into consideration their activities which allow for the calculations of aggregate emission factors for the different greenhouse gases in whole categories. Obtained, in effect, are the results for emissions presented in Table 4.

The highest level of aggregation is provided by the sheets for the final report (Tables 2-23) which are prepared in accordance with IPCC norms set out in [2, vol. 1]. These present detailed results obtained from the identified categories and subcategories, as well as national aggregate results of the inventories of emissions and captures (Tables 2 & 3).

The sheets of the first and second levels are produced in Polish, but the printouts of sheets of the final report are in both Polish and English.

A detailed description of the model for the estimation of emissions of greenhouse gases is given in Appendix 5, along with instructions for the use of the program.

PART F.

AN OUTLINE OF POLICIES AND STRATEGIES FOR THE REDUCTION OF EMISSIONS OF GREENHOUSE GASES

F. AN OUTLINE OF POLICIES AND STRATEGIES FOR THE REDUCTION OF EMISSIONS OF GREENHOUSE GASES

Poland's economic situation is presently one of transformation from a centrally-planned and steered economy to one based on the free market. As a result, the problems of economic development are of significantly greater priority than the stabilization and reduction of the emissions of greenhouse gases expected to cause climatic change. Nevertheless, it is still important to take note of two important facts:

1. that the estimated emissions of greenhouse gases in the study for 1992 include an emission of CO_2 that is 25% lower than that estimated for 1988 (Poland's reference year).
2. that analyses of programmes for economic development (and of changes already brought in) show that the greatest (non-recessionary) possibilities for development are conditional upon:

   - changes in the structure of primary fuels to increase the role of hydrocarbons at the expense of coal,
   - the rational and more efficient use of energy by those who use it,
   - the reconstruction of energy- and material-inefficient industry with its replacement by industry involving final products and a greater role for modern technology,
   - the development of low-energy services in the generation of the national income,
   - changes in the transport system, notably changes in means of transport to more efficient ones with lower indices for energy consumption,
   - reducing energy consumption in the residential sector.

It follows from this short outline of possibilities for adopting basic assumptions of economic development, that the priority balanced and energy-efficient development of the country's economy is in line with the actions needed to reduce emissions of greenhouse gases in order to allow Poland to meets its obligations under the Framework Convention on Climate Change (FCCC).

The government and parliament of Poland have adopted two basic documents on state policy containing elements of a policy for the reduction of emissions of greenhouse gases or for actions that will serve this aim. The policies referred to are:

- A Strategy for Poland 1995-1997,
- the State Environmental Policy,

In addition, the following are at various stages of drafting or enactment:

- the Industrial Policy,
- Poland's Energy Policy,
- the Transportation Policy,

- the Agricultural Policy,
- the Policy for the Housing and Municipal Sector.

Poland is also implementing a research programme entitled "A strategy for the reduction of greenhouse gases and for the adaptation of the Polish economy to climate change to the year 2030". The assumed results of this will be: a national strategy and senario for reducing emissions in the power supply industry, in industry , in transport and in housing; a strategy for the development of renewable sources of energy; a strategy for water management, agriculture and forestry; and a strategy for the management of the coast. These will be augmented on the organizational side by strategies for legal policy and for the application of financial mechanisms.

In accordance with the assumptions of the above programme directed by the Centre for Climate Protection, the policy and strategy for the reduction of emissions and for the adaptation of the national economy and biosphere will be presented at the beginning of 1996. It should be stressed that the inventories of emissions of greenhouse gases for 1988 and 1992 will be a fundamental information base on levels of emission in particular categories, on emission factors and on the methodology by which to assess emissions for the scenarios drawn up for their reduction in particular sectors of the economy.

The following review concerns the selected actions and factors for the reduction of emissions of greenhouse gases.

Industry

Reconstruction programmes for branches of industry proceed on the assumption that norms for the protection of the environment will be complied with, by way of the introduction of the new technology required by the Ecological Policy of the State.

Anticipated are:

- changes in the branch structure of the entire industrial sector,
- changes in the range of products in each branch, with the development of the production of equipment used in environmental protection,
- changes in the technology for generating products, with increases in the efficiency with which energy and materials are used, limitations to the negative impacts of technology on the environment and reduction in emissions of greenhouse gases through the cleanest possible, "ecological" technologies.

Preference will be given to the production of equipment and materials which will be of general use both within and beyond industry, and which will increase the efficiency of the transformation and consumption of energy. This will concern steam boilers, heating installations, electric engines, cookers, refrigerators and coolers, insulation materials etc.

There will also be a legal requirement for users to be supplied with a full energetic characterization of equipment which will allow them to choose the most efficient goods.

Power supply

Anticipated in this field (i.e. that generating electrical energy, heat and derivative fuels) are actions in relation to both the production (conversion) of energy and the use of energy.

A basic aim is to bring about a change in Poland's demand for primary energy relative to that in 1988, in such a way that - by the year 2000:

- the production of hard coal will have fallen by 11-23 per cent (*),
- the production of brown coal will have fallen by 13 per cent,
- the use of natural gas will have increased by between 29 and 7 per cent (*),
- the use of liquid fuels will have increased by 16 - 20 per cent (*).

(*) in relation to the scenario accepted for the macroeconomic development of the country

In the electricity industry, work has already been done on the modernization of coal-fired power stations, raising by several points their energetic efficiency and bringing in equipment for the reduction of SO_2. Preparatory work has begun on the construction of power plants and heat-and-power plants burning natural gas, with a view to reducing emissions of greenhouse gases. Further development of heat-and-power plants is anticipated to link the generation of heat and electrical energy, and thus to reduce unit consumption of fuel in covering the energetic needs in relation to electricity and heat.

A further important direction of action for the reduction of emissions, is the reduction of the demand for electrical energy among consumers. Anticipated is the application of demand-side management and integrated resource planning by energy enterprises in co-operation with consumers. Amongst other things, this will lead to reduced demands for energy through the use by consumers of high-efficiency electrical equipment (lighting, fridges, engines etc.) whose purchase will be encouraged by the energy suppliers themselves.

A second factor to lower energy consumption by consumers to rationally-justifiable levels is the policy in relation to the prices of energy carriers. Prices of the main energy carriers are currently regulated by the State, but the changeover to (higher) energy proces at world market levels has been in progress for several years - including through the use of a mechanism to limit State subsidies to energy producers.

Housing and public buildings

It is assumed that the following directions of action will be pursued with a view to reducing emissions of greenhouse gases in the sectors concerning housing and public buildings:

- the inclusion of buildings in the heating systems fed by heat-and-power plants,
- the reconstruction of local coal-fired heat plants, to allow them to use gas,
- the modernization of installations heating the interiors of buildings to ensure comfort with simultaneously-reduced use of heat,
- the automatic and steered supply of heat to buildings in amounts that relate to

external atmospheric conditions,

- the permitting for use of newly-erected buildings which will meet legally-defined lower indices for heat exchange.

The transportation of passengers and goods

Being introduced in stages are regulations to restrict road traffic to vehicles of higher standards (i.e. with reduced fuel consumption and equipment to limit emissions). Of assistance in such actions are higher road taxes for vehicles with larger engine capacities or for those of lower technical standards (without catalytic converters). The same fiscal mechanism is applied in relation to the obligation to ensure vehicles for civil liability in the case of accidents.
The limitation of the use of passenger vehicles in large towns and cities will be served by: the development of urban communication (by tram and bus) and by the introduction of fees for parking in city centres. The road transport of goods is expected to see preference given to heavy goods vehicles of higher technical and ecological standards as well as the development of a road network to prevent traffic jams featuring vehicles carrying heavy loads.

Agriculture

The 90% of Poland's farms are in private hands, so the behaviour of farmers as private operators on the market will determine the efficiency and competitiveness of Poland's agricultural output. Factors enhancing the economic efficiency of agriculture (besides its workforce), will be the efficiency with which the means of production (including energy and fertilizers) are used. Both of these factors give rise to emissions of greenhouse gases. Polish agriculture may also be a significant user of renewable source of energy, including:

- solar energy (e.g. in the drying of hay and crops)
- wind energy (e.g. in the turning of pumps and in other technological operations like the grinding of fodder),
- biomass energy (biofuels) (e.g. in the preparation of food for livestock).

It is assumed that such scenarios for the intensified use of renewable energy (within the framework of a research programme on a strategy to reduce emissions of greenhouse gases) will make it possible to implement a national programme to develop the use of technologies involving renewable sources of energy in agriculture. However, this will require support from the State by way of appropriate stimulatory mechanisms.

The improvement of the technologies of agricultural production - leading to the increased yield of crops per ha - should lead to rational management of fertilizers (i.e. reduced emissions of N_2O) and to the freeing of agricultural land of lower quality for the planting of trees (i.e. enlargement of the sinks for CO_2). The programme up to the year 2000 assumes the re-afforestation of 230,000 ha, or else their replanting with plants of new genotypes. Polish climatic conditions allow for consideration to be given to the following species, which have already been experimented with:

- amaranth (which binds atmospheric CO_2 intensively and which produces a large biomass yield),
- selected species of willow or osier (which also have a high biomass yield to be used in the generation of energy in agriculture),
- rape (which may be used in the generation of diesel oil),
- triticale (which may be used to produce ethanol as an additive for liquid fuels).

Forestry

The national programme for the development of forestry anticipates - first and foremost - an increase in forest cover and an improvement in the state of health of stands as ecosystems. Both tasks will be implemented with a view to increasing the size of the sink for atmospheric CO_2. An important factor in forestry management will be the restructuring of stands to give multi-species associations which will be more resistant to damage from pests and pathogenic fungi.

The obtaining of biofuels from forestry will be limited to amounts reasonable as part of the proper management of forests leading to an increase in forest cover and an improvement in the state of health of forest ecosystems.

Municipal management

A basic problem is the use of the greatest possible amounts of gas from dumps and landfills taking solid wastes and wastewaters. Plans for this are currently being drawn up. It estimated that several billion m3 of gas may be obtained from these sources, with the limits being imposed by the technology of dumping and recovery.

Legal and economic conditions for the implementation of the strategy to reduce emissions of greenhouse gases.

The basic legal document is the Statute on the Protection and Management of the Environment, which defines basic duties in relation to:

- the application of technologies and technical equipment to protect the environment,
- the obtaining of permits and concessions for the use of the environment,
- the measurement of the types and amounts of harmful substances introduced to the environment.

Non-compliance with these requirements lead to the administrative or penal sanctions defined in law.

The interdisciplinary nature of the actions to reduce emissions and increase captures ensures that legal conditioning of the implementation of strategies for the reduction of emissions will not be limited to the provisions of the Statute on the Protection and Management of the Environment. In fact, the set of enactments which needs to be considered in the implementation of the strategy should be extended to include the Statutes on Forests, on Spatial Management, on Geological Law, on Water Law, on Energy Law, etc. Two important Statutes are currently being amended: the Statute on the Protection and Management of the Environment and the Energy Law Statute. The first of these will - in its amended version - ensure that the principles of environmental protection are put into practice more effectively. The second of the aforementioned Statutes will have a particularly important role in limiting emissions of greenhouse gases.

The draft Energy Law Statute defines the principles by which the State energy policy is to be shaped as well as principles and conditions for the rational demand and consumption of energy and fuel.

The principles of the energy policy includes (in addition to other actions fundamental to power supply):

- actions in relation to environmental protection,
- the promotion of energy-saving construction,
- the development of alternative and renewable sources of energy,
- the rationalization of energy consumption,
- a policy for the concessioning of the activities of enterprises in the power supply industry.

The aforementioned actions will be taken account of in the strategy for reducing emissions of greenhouse gases which is being worked on in a special national study. The assumptions of the Statute include a proposal that an Office for the Regulation of the Power Industry be established with a view to issuing, exchanging and collecting concessions for the activities of enterprises in the power supply industry. A condition for the awarding of concessions will be the estimation of the anticipated effect of an enterprise's activities on the environment. This assessment will be carried out from the point of view of concordance with the regulations for the protection and management of the environment. Further elements of the assessment will be all the required environmental safeguards both in the course of the concessioned activity and after its cessation. The basis for the activities of an enterprise in the power supply industry will be a plan for the area of activity which will have been drawn up by the enterprise and approved by the Office for the Regulation of the Power Industry. The plans will also include developmental undertakings, including those relating to alternative energy sources or to reductions in the demand for energy through rationalization of the use of energy and fuels by customers.

Provisions anticipated in the Statute will establish that the tariffs introduced for energy and fuels should cover the costs of environmental protection and take account of the costs of co-financing undertakings linked to the development of the supply of alternative energy.

In addition, the draft Statute envisages that the planning, production, import, construction and operation of devices and installations for power supply will not only ensure the rational and economical use of energy and fuels, but will also preserve the safety of services and the surroundings, and meet requirements for the protection of the environment and the cultural landscape.

The aforementioned draft principles and regulations create a basis for: the implementation of a national strategy to reduce emissions of greenhouse gases, the taking of steps in the area of power supply to prevent climatic change as far as possible, and the adapation of the national economy and society to any changes that do occur.

APPENDIXES

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LIST OF TABLES

1. Introduction

A computer model for the estimation of emissions of the so-called "greenhouse gases" (e.g. CO_2, CO, CH_4, N_2O, NO_x and NMVOCs), released to the atmosphere in the course of combustion or various other chemical processes, constitutes a program which is a detailed database concerning the parameters characterizing the sources of these gases together with methods for the calculation of the sizes of emissions or captures of gas. The program must also make it possible to produce a final (i.e. annual) report in accordance with the norms of the IPCC. Output material of value in the creation of such a computer model is the three-volume publication of the IPCC entitled "Greenhouse Gas Inventory", which contains - among other things - a set of standard forms which make up the aforementioned report; an exemplary set of forms making possible the collection of input data and the making of the appropriate calculations as well as a volume devoted to the methods by which emissions of the different gases may be determined. The authors of the publication intended that it should be universal, but this has perhaps gone to excessive lengths, ensuring that the proposed methods are often abstract were national specifics are concerned and making it necessary for additional research to be carried out if reliable estimates of emissions and captures of greenhouse gases are to be made.

2. Categories of sources and sinks

The computer model for the inventorying of greenhouse gases is based on a list of sources of (and sinks for) emissions which is recommended by IPCC. It is therefore essential in discussing the construction of the model to present and discuss the aforementioned list.

Sources and sinks were divided into six categories:

1.ENERGY	The total emissions of greenhouse gases associated with the transformation and consumption of energy - the combustion of fuels and their production, transport, storage and distribution.
2.INDUSTRIAL PROCESSES	The total emissions of the greenhouse gases representing waste gases from many industrial processes.
3.THE USE OF SOLVENTS	This category is mainly concerned with emissions of NMVOCs produced in the course of the use of solvents and other products containing volatile organic compounds.
4.AGRICULTURE	The total emissions of greenhouse gases associated with this area of human activity. This concerns the production of both crops and livestock.

5.LAND USE AND FORESTRY	The total emission and capture of greenhouse gases which are associated with changes in land use and with forestry.
6.WASTES	The total emission and capture of greenhouse gases which are associated with solid wastes and with effluents.

The different categories are divided into the following series of subcategories:

1. **Energy**

1A. THE COMBUSTION OF FUELS	The total emission of greenhouse gases associated with the combustion of fuels.
1A1. ENERGY AND ITS TRANSFORMATION	The emission of greenhouse gases associated with the combustion of fuels in the production of energy and in the conversion of primary forms of fuels to secondary forms
1A2. INDUSTRY	Emissions connected with the final consumption of fuels in industry.
1A3. TRANSPORT	Emissions connected with the combustion and vaporization of fuels from all means of transport.
1A4. MUNICIPAL MANAGEMENT	Emissions connected with the combustion of fuels in office buildings.
1A5. HOUSING MANAGEMENT	Emissions connected with the combustion of fuels in housing.
1A6. AGRICULTURE & FORESTRY	Emissions connected with the combustion of fuels in agriculture and forestry.
1A7. OTHER	Other emissions from the combustion of fuels in the course of human activities not mentioned above.
1A.8. THE TRADITIONAL COMBUSTION OF BIOMASS FOR ENERGY PURPOSES	The emission of greenhouse gases in connection with the burning of wood, peat, agriculturalwastes and other fuels of these types.
1B. TRANSIENT EMISSIONS FROM FUELS	Total transient emissions of CO_2 and CH_4 associated with the production, transformation, storage and distribution of fuels
1B1. OIL & NATURAL GAS	Transient emissions not associated with the combustion of fuels and the production, processing, storage and distribution of oil and natural gas
1B2. THE COAL INDUSTRY	Total emissions of methane during the extraction and processing of hard coal.

2. Industrial processes.

- 2A. IRON & STEEL
- 2B. NON-FERROUS METALS
- 2C. INORGANIC CHEMISTRY
- 2E. NON-METALLIC MINERAL PRODUCTS
- 2F. OTHER

3. The use of solvents.

- 3A. THE USE OF PAINTS
- 3B. DEGREASING & CHEMICAL CLEANING
- 3C. CHEMICAL PRODUCTS - MANUFACTURING & PROCESSING
- 3D. OTHER

4. Agriculture

4A. ENTERIC FERMENTATION	Emissions of CH_4 associated with the processes of digestion in herbivorous animals.
4B. ANIMAL WASTES	Emissions of CH_4 from animal wastes in anaerobic conditions. These conditions arise in the course of the storing of manure.
4C. AGRICULTURAL SOILS	Emissions and captures of CH_4 and N_2O by agricultural soils
4D. THE BURNING-OFF OF AGRICULTURAL WASTES	Emissions of greenhouse gases other than CO_2 in fields, in connection with the burning-off of agricultural wastes.
4E. OTHER	

5. Land use and forestry

5A. CLEARING OF FORESTS	Emission and absorption of greenhouse gases as a result of burning and processes involving the decay of biomass, as well as the loosening of soil in connection with the transformation of woods into cultivated land or pasture.
5B. THE TRANSFORMATION OF MEADOWS INTO CULTIVATED FIELDS	Emissions of CO_2 as a result of the transformation of meadows into cultivated fields, and in connection with the oxidation of carbon in disturbed soil.
5C. FOREST MANAGEMENT	Emissions of CO_2 as a result of processes of decay in wood after cutting.
5D. THE ABANDONMENT OF CULTIVATED LAND	Emissions and absorption of CO_2 on abandoned cultivated land

6. Wastes

6A. WASTE DUMPS	The production of methane as a result of the anaerobic decomposition of organic substances by bacteria
6B. EFFLUENTS	The production of methane as a result of the anaerobic decomposition of organic substances by bacteria in sewer systems
6C. OTHER	

3. Data for the program and examples of algorithms

The presented diversity of areas - categories and subcategories - in which greenhouse gases are produced or absorbed gives rise to a wide variety of input parameters for the program.

In category 1A (Energy - the combustion of fuels) - essential data include the annual use of a defined type and assortment of fuel M_a (Gg), its calorific value W_{ua} (MJ/kg) and the types of installations in which it is burnt. Worked out for all greenhouse gases except CO_2 were emission factors E_{gpu} (g/GJ), which were dependent on the type of greenhouse gas ("g"), and which were a function of the type of fuel ("p") and the type of installation ("u"). Emissions for these gases are determined using the following formula:

$$m_{ga} = p*M_a*W_{ua}*E_{gpu} \quad (Gg)$$

where:

p - a unit conversion factor. In supply installations with many different fuels, the final value for the emission is the sum m_a (for all "a's"), which finally allows for the calculation of the so-called aggregate emission factor, which is given by:

$$E_g = \sum m_{ga}/\sum M_a \qquad (kg/Gg)$$

Necessary for the calculation of the emission of CO_2 is the prior determination of the emission factor for carbon, ECa (g CO_2/GJ), which for each fuel is a known linear function of its calorific value. Calculated next is an emission factor for CO_2 which takes account of the fact that a proportion of the carbon released is in the forms of CO, CH_4 or NMVOCs:

$$E_{co2} = \{E_c - [E_{co}*12/28 + E_{ch4}*12/16 + E_{nmvocs}*26.4/31.4]\}*44/12$$

The further procedure is the same as with the three other gases. A specific subcategory within this category is "Transport - mobile sources", for which data associated with the use of fuel by different means of transport require familiarity with the number of vehicles, the mean distances they cover annually, the mean use of fuel in road transport in urban and non-urban traffic (in dm3/100 km), the share of urban and non-urban traffic in the total distances covered by vehicles annually and the density of fuel. These calculations should therefore be made by experts.

The lack of detailed data on the assortment of different types of fuels burnt makes it necessary to introduce to the program data on the use of different fuels which are not broken down into assortments, along with (in this case) aggregate (mean) emission factors for the different greenhouse gases. The final report requires the determination of the respective emissions for the four basic groups of fuels, namely fuels derived from crude oil, natural gas and coal, as well as - in certain cases - the combustion of biomass (wood, peat etc.).

Category 1B is associated with overall emissions of CO_2, CH_4 and NMVOCs in the systems involving the extraction, processing, transport, distribution and storage of crude oil, natural gas and coal. Input data are the Eg emission factors (in g/GJ) for the aforementioned gases, as well as the amounts of fuel processed in energetic units [$Me=M*W_u$ (MJ)]. Essential here is a wide spectrum of data. For example, the emission of methane from underground mining is the result of four independent processes: ventilation, degasification, post-extraction processes and emissions from spoil heaps containing post-production wastes. Within the framework of these processes, the emission factors change from coalfield to coalfield, and even from mine to mine. In each case, the emission of the gases is determined in the following way:

$$m_g = p*Me*E_g \quad (Gg)$$

As in the previous case, it is possible to determine aggregate emission factors.

Categories 2 and 3 concern industrial processes and the use of solvents respectively. These require the working-out of E_g (g/Mg) emission factors which are obtained from the measurement of gaseous emissions in the course of different processes and which are defined here in relation to the masses processed and the level of production, M, in Mg. Emissions are determined in the same way as in the previous case.

Category 4 (agriculture), and its subcategories 4A and 4B, require the inputting of the number of livestock animals of each species (along with a breakdown into groups of defined average body mass). Also required for each of these subgroups are the appropriate emission factors for the emissions of methane associated with enteric fermentation and wastes. Inputted within the framework of subcategory 4C are g/ha emission factors for the emission of this gas as a result of the use of mineral fertilizers and manure and the cultivation of leguminous plants, as well as factors for the direct emission from soils. Put together with data on the area of cultivated land, these factors allow the emission of N_2O to be determined. Subcategory 4D is associated with the burning of agricultural wastes. This requires a knowledge of the production of different crops, a series of coefficients which make it possible to calculate the amounts of biomass burnt and successive coefficients enabling the released amounts of CO, CH_4, N_2O and NO_x to be determined.

Subcategory 5A1 of category 5 (land use and forestry) requires the inputting of areas of cleared forest, changes in biomass as a result of clearance and emission factors defining the amounts of biomass burnt and the releases of carbon and thence of all the greenhouse gases associated with this process. The determination of the amounts of CO_2 released by processes of decay requires a mean 10-year value for the areas of forest cleared as well as data on the amounts of biomass undergoing decay and the content of carbon within this biomass. A mean 25-year value for the area of cleared forest, the content of carbon in soils and the amount of carbon released from soils are all required if the emission of CO_2 is to be determined in this way. Required in subcategory 5A2 are 20-year means for the areas of meadows converted to cultivated land, data on the carbon content of meadow soils and amounts of carbon released annually from soils. Required for the determination of emissions (or captures) of CO_2 in category 5C is a knowledge of the area of land afforestated, the annual increment in biomass, the carbon content of biomass, the number of trees on unforested land and their annual increments in biomass, the felling of trees, the amounts of wood burnt, the amounts of waste timber removed from forests and the proportion of carbon in biomass. Subcategory 5D is associated with the abandonment of cultivated land and requires the inputting of several coefficients associated with the emission and absorption of CO_2.

Category 6 (wastes) requires the inputting of data on amounts of solid waste, sewage and industrial effluent, as well as factors expressing the anaerobic reaction of the breakdown of organic substances contained in wastes and effluents. The emission of methane is determined as a result.

The majority of the aforementioned factors have been introduced to the programme and the determination of values for emissions will only require a determination of the activity in a given area, i.e. for example the size of production in the case of the "Industrial processes" category.

4. The computer program - instructions for use

The computer program is based on the Quattro-Pro calculation sheet. Distributed across three diskettes, it takes up 4.5 Mb of memory. The set of files includes sheets for aggregated data as well as report sheets in Polish and English.

4.1 The installation and operation of the program

The installation requires the possession of the Quattro-Pro program. To install the program it is necessary to introduce diskette 1 to drive B and to run from it the INSTAL.BAT program with the parameter being the name of the drive of the hard disk on which the Quattro-Pro program is installed. For example, the following command is required from the level of the DOS system if the Quattro-Pro program is to be installed in drive C:

```
B:          ↵
INSTAL C:   ↵
```

The installation program assumes the usual situation, namely that the Quattro-Pro program has been installed in the QPRO catalogue - a subcatalogue of the catalogue on the main disk. In the course of the installation of the program it is necessary - in accordance with the intructions appearing on the screen - to introduce diskette 2 to the drive. Installation is followed by the automatic calling-up of the database.

In the case of the successive mobilization of (previously installed) bases it is only necessary to call up the Baza_dan.wq1 program on the calculation sheet of Quattro-Pro, i.e. after selecting the QPRO catalogue it is necessary to key in the command:

q baza_dan.wq1 ←

The base is called up with the aid of the [ALT] + [M] keys and the subsequent procedure simply follows the instructions which appear on the screen.

4.2. The use of the program

Choosing from the opening menu successive options - in accordance with the classification of sources and sinks of greenhouse gases referred to in paragraph 2 - allows for "descent" to the level of the data sheet. The choice of a given option may be made in two ways: through the use of the cursor to reach the level of the user's choice and then by pressing the [ENTER] key, or through direct pressing of the keys mentioned at the beginning of the given line. The different categories of emission source have between one and several such sheets and access to the next is achieved with the use of the keys [ALT]+[D]. Return to the main menu follows the last sheet in a given category. Besides the aforementioned six main categories of source, the main menu also contains two additional options which are for the printing of the final report or for the end of work on the database. The final report may be printed in both English and Polish versions.
Activation of the program using the keys [ALT]+[M] and subsequent pressing of the [C] key leads to the display on the monitor of successive screens of information finished ultimately with the window of the main menu:

A	Production and consumption of energy
B	Industrial production
C	Solvents and other uses of products
D	Agriculture
E	Land use and forestry
F	Wastes
G	Report
H	System

The choice of a defined item on the menu leads in a few steps to the appearance of the sheet on the screen and to the possibility of introducing the appropriate data. Each sheet has a series of columns and lines which may be accessed using only the keys for the movement of the cursor ([↑],[←],[↓],[→]). It should be stressed that the screen does not reveal the whole sheet, so movement of the cursor leads to the gradual "rewinding" of the sheet and makes it possible to view the data, and also to enter data in the appropriate places. Discussed below are successive items from the main menu.

4.2.1 .

A	**Production and consumption of energy**
B	Industrial production
C	Solvents and other uses of products
D	Agriculture
E	Land use and forestry
F	Wastes
G	Report
H	System

Selection of key [A] leads to the appearance on the screen of the next menu:

A	Combustion of fuels
B	Fugitive sources
P	Previous menu

4.2.1.1

A	Combustion of fuels

includes the following items:

A	Energy and its conversion
B	Industry
C	Transport
D	Office- and trade-buildings
E	Residential buildings
F	Agriculture and forestry
P	Previous menu

4.2.1.1.1

A	Energy and its conversion

An aggregate sheet associated with emissions of greenhouse gases as a result of the combustion of fuels in the production of energy and the conversion of primary forms of fuel to secondary forms. The successive sheets are concerned with:

- Municipal heat plants
- Industrial heat plants

- Commercial heat plants
- Industrial heat-and-power plants
- Commercial heat-and-power plants

The keying-in of emission factors and fuel consumption leads to the automatic determination of the sizes of the emissions of the different gases. Access to successive sheets is achieved by pressing the [ALT]+[D] keys.

4.2.1.1.2

B	Industry

This subcategory takes in emissions connected with the final consumption of fuels in industry. Successive sheets embrace:

- I.Industry - Iron and steel
- II.Industry - Non-ferrous metals
- III.The chemical industry
- IV.The papermaking and printing industries
- V.The food industry
- VI.Other industries

Sheet VI has data on:

1. The metals industry
2. The machines industry
3. Precision industry
4. The industry producing means of transport
5. The electrotechnical industry
6. The building materials industry
7. The glass industry
8. The ceramics industry
9. The timber industry
10. The textiles industry
11. The clothing industry
12. The leather industry
13. The fodder industry
14. Other branches of industry

Changes from sheet to sheet are achieved by pressing [ALT]+[D].

4.2.1.1.3

C	Transport

This subcategory is represented by two sheets:

- A3.1. Transport - mobile sources
- A3.2. Transport - stationary sources.

The first sheet includes the following types of transport:

Air transport
Road transport
Rail transport
Inland navigation
Marine navigation
Other types of transport
Agriculture and forestry

Taken account of in the sheet for each of the above types are a series of categories of means of transport. The type of fuel used by a given means of transport is abbreviated in accordance with the following scheme:

Motor spirits	BS
Aviation spirits	BL
Liquified gas	LG
Aviation fuel	PL
Diesel	ON
Fuel oil	OP
Hard coal	WK

Input data in this case are the consumption of fuel by mass in the given category and its calorific value (columns "C" and "D"). It should be recalled that the aforementioned data require expert calculation. The last category (Agriculture and forestry) includes the propulsion of tractors and agricultural machines and is not summed in the transport subcategory, but rather in the "Agriculture and forestry" category - section 4.2.1.1.6.

Access to the second sheet "Transport - stationary sources" is gained by pressing the [ALT]+[D] keys. Keying-in of fuel consumption and emission factors leads automatically to the determination of the emissions of the different gases. Subsequent selection of [ALT]+[D] or [ALT]+[M] transfers the user back to the main menu.

4.2.1.1.4

D	Office- and trade-buildings

A subcategory linked with the emission of gases as a result of the combustion of fuels in office buildings and trade buildings. There is one sheet, and the key combination [ALT]+[D] or [ALT]+[M] leads to a return to the main menu.

4.2.1.1.5

E	Residential buildings

A subcategory linked with the emission of gases as a result of the combustion of fuels in residential buildings. There is one sheet, and the key combination [ALT]+[D] or [ALT]+[M] leads to a return to the main menu.

4.2.1.1.6

F	Agriculture and forestry

A subcategory linked with the emission of gases as a result of the combustion of fuels in two industrial sectors: agriculture and forestry. There is one sheet, and the key combination [ALT]+[D] or [ALT]+[M] leads to a return to the main menu.

4.2.1.1.7

P	Previous menu

Return to the main menu - point 4.2.1.

4.2.1.2

B	Fugitive sources

A category linked with all fugitive emissions resulting from the production, transformation, storage and distribution of fuels. The making of this selection from the menu leads to the presentation of the following on screen:

A	The extraction of coal
B	The extraction of oil and natural gas
P	Previous menu

4.2.1.2.1

A	The extraction of coal

A category including emissions of methane as a result of the extraction and processing of hard coal. Distinguished within the framework of underground mining are the following emission sources:

- ventilation emissions
- emissions from degassing installations
- emissions in the course of post-extraction processes
- emissions from spoil heaps of post-production wastes.

Data for the sheets are the levels of emissions of methane from the aforementioned categories.

The following emission sources are distinguished in the case of surface (open-cast) mining:

- ventilation emissions from deposits
- ventilation emissions from the rocks surrounding deposits
- emissions from post-extraction processes

As previously, so here too, the input data are the sizes of these emissions (which require expert calculation). Access to the main menu is gained by using the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.1.2.2

B	The system involving oil and gas

This category takes in all fugitive emissions of CO_2, CH_4 and NMVOCs associated with the production, processing, storage and distribution of oil and natural gas or coke-oven gas. The sheet has four tables of which the first concerns the oil system and takes account of the following causes of emissions of greenhouse gases:

1. The extraction of oil
2. Transport
3. Refining
4. Wholesale distribution
5. Retail distribution

The extraction of oil is a source of the emission of all three of the aforementioned gases, while the other causes of emission are sources of NMVOCs only. Input data in this case are emission factors and the amounts of oil extracted or processed (i.e. data requiring expert calculation).
The next two tables are concerned with the systems involving natural gas and coke-oven gas. They take the following sources of emission into account:

1. The extraction of gas
2. The processing of gas
3. The transmission of gas
4. Underground storage
5. Distribution.

Points 1 to 4 do not relate to coke-oven gas, but point 5 does. Data here are levels of emissions of the different greenhouse gases. Access to the main menu is achieved using the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.2

A	Production and consumption of energy
B	**Industrial production**
C	Solvents and other uses of products
D	Agriculture
E	Land use and forestry
F	Wastes
G	Report
H	System

The selection of key [B] on the main menu indicates the choice of determining the total emission of greenhouse gases as waste gases in a series of industrial processes not involving combustion. The category includes two sheets, of which the first takes account of the following branches of industry:

2A. The iron and steelmaking industries
2B. The non-ferrous metals industry
2F. Other processes
  2F1. The food industry
  2F2. The timber industry
  2F3. The papermaking industry

In turn, the second sheet takes account of the following branches of industry:

2C. Processes in the inorganic chemicals iundustry
2D. Processes in the organic chemicals industry
2E. The industry involving mineral raw materials

Input data to both sheets are emission factors as well as levels of production. Emissions are determined automatically. Access to the second sheet from the first is achieved by pressing [ALT]+[D]. Access to the main menu is in turn achieved by pressing the key combinations [ALT]+[D] or [ALT]+[M].

4.2.3

A	Production and consumption of energy
B	Industrial production
C	**Solvents and other uses of products**
D	Agriculture
E	Land use and forestry
F	Wastes
G	Report
H	System

This category is concerned with emissions of NMVOCs as a result of the production and utilization of articles containing solvents. The sheet has five tables, including those devoted to:

- The use of paints
- Degreasing and dry cleaning
- The manufacture of chemical products
- The production of cleaning products and cosmetics

- Others

Input data are the level of production or use of the given product. In the case of solvents used in the household the input datum is the number of people, because the emission factor in this case is defined per head.

Tables include successive categories of emission source, levels of production, levels of emissions of particular gases and - at the end - their emission factors. Access to the main menu is gained by pressing the key combinations [ALT]+[D] or [ALT]+[M].

4.2.4

A	Production and consumption of energy
B	Industrial production
C	Solvents and other uses of products
D	**Agriculture**
E	Land use and forestry
F	Wastes
G	Report
H	System

The calling-up of this category leads to the appearance of the next menu giving the following:

A	Livestock inventory
B	Soils
C	The burning of agricultural wastes
P	Previous menu

4.2.4.1

A	Livestock inventory

This category involves emissions of methane arising from enteric fermentation and animal wastes. The sheet is divided into two parts. Of these, the upper part relates to enteric fermentation and the lower to wastes. The only essential data in both cases are the numbers of livestock in different categories. Access to the main menu is gained with the use of the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.4.2

B	Soils

This category relates to emissions of N_2O and has a sheet made up of the following four tables:

1. The emission of N2O from nitrogenous fertilizers
   Input data here are the amounts of nitrogen used in the form of different fertilizers.
2. The emission of N2O from manure.
   Input data here are the numbers and weights of livestock animals.
3. The emission of N2O from leguminous plants.
   Necessary here is a knowledge of the area of land under crops from this group.
4. The emission of N2O from the mineralization of organic substances in soils.
   The necessary datum here is the area of land used in agriculture.

Access to the main menu is gained by pressing the key combinations [ALT]+[D] or [ALT]+[M].

4.2.4.3

C	The burning of agricultural wastes

This category takes account of emissions of CH4, N2O, NOx and CO resulting from the burning of the wastes from a series of agricultural products. Data tables include a total of 43 such products and input data consist of the production of these. Access to the main menu is gained as usual by use of the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.4.4

P	Previous menu

Return to the main menu - point 4.2.1.

4.2.5

A	Production and consumption of energy
B	Industrial production
C	Solvents and other uses of products
D	Agriculture
<u>**E**</u>	<u>**Land use and forestry**</u>
F	Wastes
G	Report
H	System

The calling-up of this category leads to the appearance on the screen of a further menu including:

A	Clearing-up in forests
B	The adaptation of pastures
C	The abandonment of previously-used areas
D	Forestry management
P	Previous menu

4.2.5.1

A	Clearing-up in forests

This category is mainly concerned with emissions of CO2 and contains five sheets. Access to successive sheets is gained by pressing the [ALT]+[D] key combination, while return to the main menu is affected with [ALT]+[M]. The successive sheets are concerned with:

1. The release of CO2 through the burning of biomass.
   Data for this sheet concern the area cleared-up annually, the amount of biomass before and after cutting and the fractions of biomass burnt in situ and taken away for burning.

2. The release of CO2 as a result of the processes of decay.
   Input values to this sheet are 10-year means for the areas of forest cleared up as well as the amounts of biomass before and after cutting.

3. The release of CO2 from soils.
   Input values to this sheet are the 25-year mean figures for the areas of forest cleared up.

4. Total emissions of CO_2 - an aggregate sheet not requiring interventions.

5. The determination of emissions of CH_4, CO, N_2O and NO_x as a result of burning in forests - calculated automatically on the basis of the previous sheets and not therefore requiring interventions.

Access to the main menu is gained by means of the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.5.2

B	The adaptation of pastures

A calculation sheet involving the determination of emissions of CO_2 as a result of the transformation of areas not used in forestry into cultivated land. Input values here are the mean areas of land transformed in such a way over a 20 year period. Access to the main menu is gained using the usual [ALT]+[D] or [ALT]+[M] key combinations.

4.2.5.3

C	The abandonment of previously-used areas

Changes in the amount of C sequestered as biomass accumulates on abandoned land. The input value here is the mean area abandoned over 20 years. Access to the main menu is gained by using the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.5.4

D	Forestry management

A category relating to the emissions of gases in association with forestry management. There are two sheets, of which the first is linked with the increase in the amount of biomass as a result of increments to the masses of trees. Input data here are:

- the area of managed forest.
- the number of trees planted within the framework of afforestation programmes.
- the number of trees outside forest complexes.

The second sheet is entered by using the [ALT]+[D] key combination. It contains information in connection with the planned cut in forests. Access to the main menu is affected through the use of the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.5.5

P	Previous menu

Return to the main menu - see point 4.2.1.

4.2.6

A	Production and consumption of energy
B	Industrial production
C	Solvents and other uses of products
D	Agriculture
E	Land use and forestry
F	**Wastes**
G	Report
H	System

The calling-up of this category brings up the following menu:

A	Waste dumps
B	Wastewaters
P	Previous menu

4.2.6.1

A	Waste dumps

This category involves the determination of emissions of methane from waste dumps. The input datum here is the annual mass of communal wastes. Access to the main menu is gained using the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.6.2

A	Waste dumps

This category includes two sheets. The first sheet relates to emissions of methane from municipal sewage, while the second concerns industrial effluents. Access to the second sheet is gained by pressing [ALT]+[D]. The input datum in the first sheet is the amount of wastewater utilized, while the data for the second sheet are the amounts of effluent produced annually in a series of branches of industry which are mentioned. Access to the main menu is gained using the [ALT]+[D] or [ALT]+[M] key combinations.

4.2.6.3

P	Previous menu

Return to the main menu - point 4.2.1.

4.2.7

A	Production and consumption of energy
B	Industrial production
C	Solvents and other uses of products
D	Agriculture
E	Land use and forestry
F	Wastes
G	**Report**
H	System

The calling-up of this category leads to the appearance of a second menu offering:

A	Printing of the report - English version
B	Printing of the report - Polish version
P	Previous menu

The printout of the report begins with that of Table 4, and then proceeds in order to Table 23. Printed after this are Tables 3 and finally Table 2.

4.2.7.1

A	Printing of the report - English version

This option makes possible the printing of the report in English. It is necessary to switch on the printer and to ensure the supply of paper. The full report has 25 pages. After the first sheet of the report has appeared a printout of it can be obtained by pressing [ALT] + [P]. Successive pages require successive pressing of the key combinations [ALT]+[D] for access to the next sheet and [ALT]+[P] for printing. After the printing of the last sheet, return to the main menu is affected by pressing [ALT]+[D]. Interruption of printing and return to the main menu may be achieved by pressing [ALT]+[M].

4.2.7.2

B	Printing of the report - Polish version

A printout of the report in Polish. It is necessary to switch on the printer and to ensure the supply of paper. The full report has 25 pages. After the first sheet of the report has appeared a printout of it can be obtained by pressing [ALT] + [P]. Successive pages require successive pressing of the key combinations [ALT]+[D] for access to the next sheet and [ALT]+[P] for printing. After the printing of the last sheet, return to the main menu is affected by pressing [ALT]+[D]. Interruption of printing and return to the main menu may be achieved by pressing [ALT]+[M].

4.2.7.3

P	Previous menu

Return to the main menu - point 4.2.1.

4.2.8

A	Production and consumption of energy
B	Industrial production
C	Solvents and other uses of products
D	Agriculture
E	Land use and forestry
F	Wastes
G	Report
H	System

The calling-up of this category leads to the appearance on the screen of the next menu offering:

A	End
P	Previous menu

4.2.8.1

A	End

Closing all open files and returning to the system.

4.2.8.2

P	Previous menu

Return to the main menu - point 4.2.1.

4.3. Help Program

Found within the full package of files associated with the database is the file EMISJA.EXE which allows for the calculation of aggregate emission factors within the subcategory "Energy - the combustion of fuels". The program is put into operation from the level of the operating system. Data for the program are in the form of a detailed list including the types of fuel, the installations in which it is burnt, the amounts of fuel burnt and their calorific values. The results, i.e. the balance for the combustion of each type of fuel and an aggregate emission factor linked with each type of fuel - are put into the NAZWA.DAT set, where the use of the word NAZWA is understood to refer to the name proposed by the user of the program (and asked for by the program). Arising simultaneously is a set entitled NAZWA1.DAT, which makes possible the checking of the correctness of the data introduced to the program.

The running of the program (by the command EMISJA in the QPRO subcatalogue) is followed by the appearance on the screen of an information box. The pressing of any key results in the appearance of a second box asking for the name of the file of results. Subsequent pressing of any key of the user's choice results in the appearance on screen of a box containing lists of fuels as well as (in part) the installations in which they are burnt. Selection is made by introducing the appropriate number to the computer and pressing the [ENTER] key. Successive questions appear on the screen in relation to the consumption of the fuel and its calorific content. The final question to appear concerns the continued introduction of data which is accepted using key [T]. Any other key brings the working of the program to an end. A set may be obtained on the screen in the traditional way (e.g. by employing the instruction TYPE at the system level) or may be printed out.

5. Country Case on Sources and Sinks og Greenhouse Gases in Poland Report

LIST OF FIGURES

THE CONSTRUCTION OF COMPUTER MODEL FOR THE ESTIMATION OF EMISSIONS OF GREENHOUSE GASES

Project No. GF/0103-92-37

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