REPUBLIC OF POLAND

THIRD NATIONAL COMMUNICATION TO THE CONFERENCE OF THE PARTIES TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

THIRD NATIONAL COMMUNICATION TO THE CONFERENCE OF THE PARTIES TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

REPUBLIC OF POLAND

THIRD NATIONAL COMMUNICATION TO THE CONFERENCE OF THE PARTIES TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

WARSAW 2001

Report published under financial sponsorship
of the National Fund for Environmental Protection and Water Management

The report was elaborated in the Polish UNFCCC Executive Bureau, National Fund for Environmental Protection and Water Management, in co-operation with Ministry of Environment, and:

- Ministry of Economy,
- Governmental Centre for Strategic Studies,
- Ministry of Transportation and Marine Management,
- Office for Housing and Urban Development,
- Ministry of Agriculture and Rural Development,
- Ministry of National Education,
- Ministry of Finance,
- Central Statistical Office,
- University of Mining and Metallurgy,
- Institute of Meteorology and Water Management,
- Institute of Environmental Protection.

Translation: Contact Service

Editorial elaboration:

Maciej SADOWSKI, Anna OLECKA, Anna ROMAŃCZAK, Marta RADWAN-RÖHRENSCHEF, Alicja SIENKIEWICZ

Design, layout and printed by: Gabriel Borowski Publishers

Photo on the cover: Siekierzyńskie Forests – Świętokrzyskie Mountains (photo: Krzysztof Bujnowski)

Publishing by:

Instytute of Environmental Protection, Warsaw
e-mail: asienk@ios.edu.pl; www.ios.edu.pl

ISBN 83-85805-73-7

Further information:

Department of Ecological Policy
Ministry of Environment
Wawelska 52/54
00-922 Warszawa
Poland
Tel. (0 22) 57 92 761
Fax: (0 22) 57 92 217
e-mail: mklokock@mos.gov.pl
www.mos.gov.pl

The Polish UNFCCC Executive Bureau
Department of International Cooperation
National Fund for Environmental Protection and Water Management
Konstruktorska 3A
02-673 Warszawa
Poland
Tel: (0 22) 849 00 79/80 ext. 552, 536
Fax: (0 22) 853 6192
e-mail: M.Sadowski@nfosigw.gov.pl

CONTENTS

INTRODUCTION

On 26 October 1994 Poland became a party to the United Nations Framework Convention on Climate Change (UNFCCC), hereinafter referred to as the Convention or Climate Convention, thus joining the group of countries, who committed themselves to protect global climate. Continuing these activities, on 15 July 1998, Poland signed the Kyoto Protocol to the Convention, and preparations are currently under way to ratify that document.

The major objective of this Report is to present to the Conference of the Parties to the UNFCCC the policy pursued by the Polish Government in the scope of counteracting the enhancing greenhouse effect, as well as the actions undertaken with the aim to fulfil the obligations resulting from the Convention.

The basic part of this Report contains the results of inventory of greenhouse gas emissions and removals in Poland for 1988 as the base year, and for the period of 1990–1999, as well as the predicted greenhouse gas emissions by 2020. Also information is presented here on the undertaken and planned activities aimed at both the emission reductions and the capacity to enhance their removals, as well as on the potential effects of climate change, and on the activities to adapt the Polish economy to changed climate conditions.

The ratification of the United Nations Framework Convention on Climate Change imposed on Poland the same obligations as those committed by the other countries listed in Annex I to this Convention. The most important commitment is to return by the end of 2000 to earlier levels of anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol. For this group of countries this would mean a return to the 1990 emission levels. However, Poland has recognised the right of a flexible approach to fulfilling its commitments resulting from the Convention concerning the adoption of 1988 as the base year for the assessment of Poland's commitments. The 1990 emissions can be used only to assess the state-of-global-emission; but they cannot provide the basis for appraisal of Poland's fulfilment of its commitments resulting from the Convention.

1. SUMMARY

1.1. National circumstances

Since 1989, the Polish economy has been undergoing its essential transformation changes from centrally planned economy to free market economy. Among others, the privatisation process, as well as price and economy liberalisation processes have been set up. After two-year recession (1990–1991) caused by the transformation shock, and following the period of gradual economic recovery (1994–1995), in 1995, the Polish economy reached the highest GDP growth rate amounting to 7%, with a further drop in energy intensity of GDP, falling inflation and unemployment. That was accompanied by firm Governmental policy for the implementation of measures supporting or correcting the already existing solutions, appropriately to ongoing social and economic transformation and in accordance with transformation experience gained. After 1997, economic growth rate slowed down and it accounted for 4.1% in 2000.

The service sector becomes to play the more and more important role in creation of GDP (52.6% in 1999), while the industry share in the growth rate still continues to be high (23.6% in 1999). A positive tendency of changes in industry has become stable that demonstrates as the growth in production share of processing industries in the total production sold, and as the drop in share of capital- and energy- consuming raw-material section. The share of agriculture and forestry fell to 3.4% GDP in 1999.

Since 1988, considerable changes have occurred in balance of primary energy consumption. In 1999, the amount of energy consumption decreased as much as by 30%, with yet more considerable drop in consumption of solid fuels (mostly hard coal), that accounted for 40%. Consumption of hydrocarbon fuels in 1999 increased by almost 5% in relation to 1988. In that changed structure of primary energy consumption carriers – although hard coal still predominates – its share decreased in favour of both hydrocarbon fuels and renewable energy sources.

A decline tendency in demand of transport in the conditions of growing economy appeared during the recent decade. The changes tend to rationalise the conveyance in terms of quantity and assortment of commodities transported, and in selection of transportation mode. The drop in commodity-mass transported is estimated at 19%, however prevailing majority of conveyance has been overtaken by automobile transport. Essential changes appeared in transport behaviour of the public; following initial drop in communication mobility, a boom was noted with the increase in travel quantity, including up-to 33% share of cars.

Less and less waste is produced from business activity, however the quantity of municipal waste has risen, with 8.5% growth in average quantity of waste generated annually by 1 inhabitant since 1995. In waste management policy for wastes generated from business activity, waste utilisation is preferred, whereas 24.2% of wastes is subject to waste treatment processes. For municipal waste, the mostly common waste disposal method is waste deposition on landfills (95% of waste), but only 3% is recovered as reusable raw materials.

Agriculture has mostly preserved its traditional nature featuring by multi-modal production and application of extensive methods. Agricultural crops are the prevailing production mode in 33% of farms, whereas 20% is specialised in animal breeding and housing. Animal production predominates in commercial production, mainly pigs, cattle and poultry. The basic agricultural crops are cereals, potatoes and industrial crops, those accounted for almost 87% of total arable crops in 2000.

In Poland, forests occupy 28.3% of total national territory. Compared with 1988 (27.7%), it indicates that the proportion of the national territory occupied by forests continues to grow. The average annual wood harvesting accounts for 1.5% of the standing biomass of forests, never exceeding the current increase in the treestand capacity. An unfavourable feature of forests in Poland from the point of view of biological diversity is the slight differentiation of the treestand composition in terms of species as coniferous treestands dominate (77% of the total forest surface area). However, the species structure of forests changes significantly towards an increase in the proportion of deciduous species.

In environmental protection, the favourable tendencies, which were initiated in the beginning of the nineties, have stabilised, that is the evidence of improving the state-of-the-environment. It is the Act of 31 January 1980, on Environmental Protection and Management, that is the legal Act passed to regulate the fundamental issues of environmental protection and that ensures a uniform policy in relation to these issues. That Act was many times amended in the past years. On 1 October 2001, the Act of 27 April 2001, on Environmental Law entered into force, that introduces general principles concerning all of the environmental legal acts, as well as it indicates the principles according to which specific regulations shall be laid down concerning the protection of particular environmental components, including air.

1.2. Inventory of greenhouse gas emissions and removals

Inventories of anthropogenic emission sources and sinks of greenhouse gases provide the basis for an appraisal of the performance of the Parties to the Convention as listed in Annex I to this Convention, including Poland, in fulfilling their commitments imposed on them by the Convention. This report presents inventories of emissions and removals of the basic three greenhouse gases, i.e. carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), and of industrial gases emissions: HFCs, PFCs and SF_6.

The changes in the emissions of greenhouse gases between the base year (1988) and 1999 are shown in table 1.1 and they indicate a systematic drop in CO_2 emissions, that was particularly significant after 1988, resulting from restructuring processes in the Polish economy. This falling trend yet intensified in 1998 and 1999 – emission reached the level of 71% of the base year emission. The changes in quantity of greenhouse gas emission was accompanied by decrease in energy consumption in the national economy and by change in fuel consumption structure in favour of hydrocarbon fuels containing less carbon content.

The inventories of greenhouse gas emissions and removals were prepared following the methodology recommended by the Conference of the Parties to the Convention. The inventories for 1988, 1990, 1994 were prepared pursuant to the previous version of the IPCC methodology – IPCC Draft Guidelines for National Greenhouse Gas Inventory (1995), and the inventory for 1992 was prepared following the OECD/IPCC methodology recommended by the Conference of the Parties to the Convention and published in 1994 in the Greenhouse Gas Inventory Workbook. IPCC Draft Guidelines for National Greenhouse Gas Inventories. The results of those inventories were presented in the Second National Report for the Conference of the Parties to the Convention. The inventories of greenhouse gas emissions and removals for 1991, 1993, 1995, 1996, 1997, 1998 and 1999 were prepared in accordance with the basic principles included in the mandatory version of the IPCC methodology – Revised 1996 IPCC Draft Guidelines for National Greenhouse Gas Inventories with application of specific methods (Tier 2/3), and of simple methods in some few cases. The factors applied to greenhouse gas emissions and removals in the inventories for all the years are given in Annexes B–L to this Report.

1.3. Policies and measures to reduce greenhouse gas emissions

Presented in this report the Government's policies and measures aimed at greenhouse gas emissions reduction and removals enhancement covered the following sectors of the Polish economy, mainly responsible for emission of these gases: power generation, hard coal mining, cement industry, metallurgy, refrigerating engineering, transport, building and housing, waste management, agriculture and forestry.

Many actions were undertaken in these sectors, including those aimed at improving the efficiency of energy use, and thus reducing greenhouse gas emissions and enhancing their removals. They include:

- the reduction of energy- and material-consumption in industries by means of their restructuring;
- a change in the structure of fuel use towards the increase of the hydrocarbon fuels share;
- the reduction of production capacity of hard coal mining, hence reduction of environmental impact from this sector;
- an increase of use of renewable energy sources;
- promotion of railway, combined and public transport, and introduction of instruments focused on sustainable development of transport;
- the enhancement of heat-insulation capability of buildings, that allows to use heat energy more rationally;
- an increase of use of landfill gas and biogas from wastewater treatment plants;
- intensification of breeding outputs by changing cattle housing structure and by wider application of methane capturing techniques from litter-free rearing system of ruminants;

Table 1.1. Emission of carbon dioxide, methane and nitrous oxide (CH_4 and N_2O expressed as CO_2 equivalent) in 1988–1999 [Gg]

Years	1988	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	477 584	381 482	367 689	372 311	363 980	372 293	348 926	373 202	362 300	338 095	329 739
CH_4	65 961	58 821	54 369	51 954	51 072	51 807	51 597	47 292	47 838	49 035	47 250
N_2O	21 700	19 530	16 120	15 500	15 500	15 500	16 740	16 740	16 740	16 120	23 250

Source: MŚ.

- the change in fertilisation system with the view to rationalise the consumption of mineral fertilisers (including nitrogen fertilisers) and to increase the proportion of organic fertilisers;
- the enhancement of CO_2 absorption and accumulation in forests by enlargement of the ratio of forest cover and by improvement on health condition of forests.

1.4. Emission scenarios and the overall effect of the actions implemented

In Chapter 5, the updated in relation to the Second National Report, potential future projections of greenhouse gas emission and removals by 2020 are presented, conditional upon domestic measures undertaken and policies adopted, as well as likely emission and removal paths are shown in case of absence of such policies and measures. Scenarios for emission change are presented for six economy sectors: power generation, manufacturing industry, transport, agriculture, forestry, as well as service and household sector.

Additionally, greenhouse gas emission projections are presented for the entire energy system, and macro-economic scenarios for greenhouse gas emission reduction on the national level.

Analysis of predicted emission changes by particular sector indicates its slow growth in 2000–2020. However, the prediction results of carbon dioxide emissions for the whole economy, as obtained from macro-economic reference scenarios are: from 408 thousand Gg for passive scenario (assuming decreasing rate of economy restructuring and privatisation) up-to 413 thousand Gg for the baseline scenario (assuming intensification of economy restructuring and privatisation) in 2010, and from 421 thousand Gg up-to 464 thousand Gg in 2020, respectively. This means, that in case of each scenario, the level determined by the commitments in the Kyoto Protocol will not be exceeded.

In Chapter 5, also scenarios for nitrous oxide emissions are presented by 2020, by the following source categories: agriculture, chemical industry and fuel combustion, as well as the proposal for actions aimed at emission reduction in sectors responsible for emission of this gas. According to all of the scenarios, slight growth in N_2O emissions could be expected from 77 Gg in 2000 up-to: 81 Gg (reference scenario – stable economy growth), 78 Gg (survival scenario – passive economy growth) or 86 Gg (progress scenario – active economy growth) in 2010.

1.5. Vulnerability assessment, climate change impacts and adaptation measures

It was estimated in agricultural sector, that the expected rise in air temperature could cause prolongation of the climate vegetation period by 30–40%. The consequence of this would be acceleration by about 3 weeks of the seed time-limit for all of the plants, and acceleration of the harvest period. Generally, the climate heat resources useful for agricultural production would grow in Poland, but their effective utilisation will depend upon the opportunity to secure water needs of the plants under cultivation. It could be water deficit, that will appear as the factor reducing the future agricultural production (according to scenarios of the future climate change), and that will force to seek for new solutions. Future agro-climate conditions, given the more favourable water conditions, would produce favourable conditions for plant production in Poland. Thermophilous plants (maize, soybean, oilseed sunflower) would react with their highest crop growth rate (likely even about 30%). The efficiency of grasslands could grow by at least 25–30%. The period when animals are kept on pastures would prolong considerably.

Some of common crops could react with a drop in their yield, that to the highest extent possible would relate to potato crops. However, it would be necessary to introduce appropriate changes into plant production structure and technology in order to make the production growth a reality. If no adaptation actions are undertaken, the total plant production might even drop by 5–10%.

Selection of adequate plant species, change in soil use and crop structure patterns, progressive production zoning and introduction of technologies applying water resources in rational manner, as well as prolonged vegetation period, would be of the basic importance for the adjustment of agricultural production to expected climate change.

The actions leading to the assessment of the vulnerability of the Polish coastal zone to sea level rise, as well as those aimed at the protection of the Polish coast against the sea level rise, have been supervised by the Ministry of Transport and Marine Management, and they have included, inter alia:

- Prediction of the impact from the groin system on riparian processes in the circumstances of sea level rise;
- Determination of the safety profiles for the coastal zone;
- Estimation of the storm impact range alongside the Southern Baltic Coast;
- Estimation of risk to hazard from climate change impact and establishment of procedures for littoral zone management;
- Classifying the erosion and flood hazards along the coastal line;
- Elaboration of long-term seashore protection and beach preservation programmes;
- Assessment of safety conditions for the Helski Peninsula and of the effects from its artificial replenishment in the period of 1997–2000, as well as the proposals for the protective works planned for the period of 2001–2005;
- Preparation of seashore protection strategy;
- Elaboration of guidelines for the adoption of the magnitude of hydrological and meteorological phenomena

for the design of the seashore protective projects and methods for restoration of beaches in the area of the locality of Ustronie Morskie;

- Participation to Integrated Management of Riparian Zones in the group of the Baltic States;
- Elaboration of the concept to reinforce the cliff in the area of the locality of Jastrzębia Góra.

The consequences of climate impact on domestic water resources include: reduction of water outflow, soil moisture, and water retention in the catchment area, and of real evapo-transpiration, particularly in Western Poland, in the periods, when temperature increase is higher and precipitation reduction is heavier. A shift is also expected in the occurrence of the spring high water stages from March–April to January–February, caused by earlier melting of accumulated snow. Moreover, it is estimated, that the area of irrigated areas in agriculture should enhance from the current level of 1.5% up-to about 4% in 2050.

Also, expected water temperature increase stimulated by the increase in air temperature under conditions of doubled CO_2 concentration in the atmosphere will have effects on shortening river icing period in Poland. The increase in mean annual air temperature could cause the exceedance of threshold water temperature above 26 °C, that in consequence would deteriorate water quality in the lowland river sections, where the occurrence of considerable water pollutant emissions is the reality already now. Higher water temperature means also an increase in concentration level of nutrients, thus leading to intensification of eutrophication processes in water reservoirs, particularly in shallow ones.

1.6. Financial resources, technology transfer and the Joint Implementation projects (AIJ/JI)

Poland is not obliged directly to render any financial aid, as well as to implement any actions aimed at technology transfer to developing countries, since Poland is not listed in the Annex II to the Convention, but it contributes to many international projects co-financed by the Polish Government.

Our country has actively participated in the implementation of the Joint Implementation mechanism by means of undertaking jointly with the other Annex I countries the actions in the territory of Poland, those result in greenhouse gas emission reduction. The willingness to implement jointly the Convention objectives was expressed by the Governments of Finland, the Netherlands and Canada (Memorandurus of Understanding were signed), and by the Norwegian Government. Eight Joint Implementation projects have been set-up so far, including 5 Joint Implementation (JI) projects and 3 projects in the framework of the pilot phase of the Activities Implemented Jointly (AIJ). The projects set-up in Poland cover primarily the change to fuel containing less carbon content, and the utilisation of renewable energy sources.

1.7. Research and regular observations

Research aimed at investigating the climate change and variability, and the climate processes, is carried out in numerous scientific institutions in Poland, including first of all the Polish Academy of Sciences, universities, agricultural and technical colleges, and research and development institutes subordinated to the Ministry of Environment, while the Institute of Meteorology and Water Management plays the major role among the latter. In this research, mainly over 100-year lasting measurement series of air temperature are applied, but to less extent those concerning atmospheric precipitation, air pressure and wind. The nature of homogenous sequences have the multi-year air temperature series for 6 meteorological stations in Poland. It is the Institute of Meteorology and Water Management, who is the unit responsible for organisational structure and operational performance of the observing system in terms of permanent monitoring of atmosphere and the hydrosphere.

In the framework of the GCOS Programme, the Polish institutions participate in the following observing systems world-wide: meteorological and atmospheric (64 stations and 978 meteorological and precipitation sites), oceanic (118 platforms and stations), Earth surface (300 measuring sites), and satellite observation of climate (participation in EUMETSAT Programme). Moreover, in two observing stations on Mount Kasprowy Wierch (in Tatra Mountains) and in the locality of Diabla Góra (in the Borecka Forest) atmospheric concentrations of carbon dioxide and other greenhouse gases (CH_4 and SF_6) are measured. Apart from GCOS, Poland participates also in the other international programmes: World Climate Programme, International Geosphere-Biosphere Programme, and Intergovernmental Panel on Climate Change.

1.8. Education, training and public awareness

Two Ministries are responsible for educational policy in the field of environmental protection: Ministry of National Education and Ministry of Environment. In 1995, these Ministries signed the Memorandum of Understanding on co-operation in the field of ecological education that resulted in elaboration of the National Strategy for Ecological Education. This document constitutes the basis for the implementation of tasks relating to ecological education within formal educational system (from kindergartens to universities) in major institutions, central administration agencies, and in the institutions, which act in favour of environmental protection in the Voivodships and Self-Governments. The provisions relating to the introduction of environmental education into educational system are included in the 1991 Act on Educational System, and in the Act on Environmental Law of 2001.

Based on the aforementioned Strategy, in 2000, a draft executive Programme was elaborated concerning both the National Strategy for Ecological Education and its implementation conditions. The aim of this Programme is to attribute an appropriate importance to ecological education thought as an indispensable condition to provide for sustainable development. The Programme is intended to prepare general public in Poland to join such actions which could serve to the protection of the environment in accordance with environmental protection and development standards mandatory in the European Union.

Environmental awareness of general public in Poland is being developed at schools and by means of various actions conducted by Governmental and public organisations and by the media. Also, training programmes dedicated to various professional and social communities are of specific importance. The aim of the Executive Programme for the National Strategy for Ecological Education is to integrate those various spheres of ecological education and hence to enhance the effectiveness of its social effects.

Raising the awareness of the public in favour of the environment, as well as its education with the aim to raise their concern about the environment has to begun with children in kindergartens, through six-year grammar school, then in three-year gymnasium, and also in three-year high-school. Such type of the overall educational system was initiated in 1999. A wide scope of ecological issues and the knowledge on climate change resulting from anthropogenic activities is promoted also by state-own universities providing education on environmental protection. Also non-state-owned universities are being established with the aim to provide education in the field of environmental hazards, including climate change.

Moreover, the issues of climate protection are the concern of a dozen of various non-governmental organisations in Poland, which conduct their activities first of all in favour of promotion of the activities to reduce greenhouse gas emission, inter alia, by means of efficient energy use and energy production from renewable sources, development and promotion of public transport, promotion of energy-saving illumination, or the improvement of carbon uptake by biomass. Those activity types are various information campaigns, seminars and regional actions.

2. NATIONAL CIRCUMSTANCES

2.1. Geographical environment of Poland

Poland is situated in medium geographical latitude (49°00' – 54°50' N) of Central Europe, at the Southern coast of the Baltic Sea. Total national territory, including marine inland waters that comprise the Vistula and the Szczecin Lagoons and harbours, is 312 685 km^2. Terrain configuration is latitude parallel: from coastal lowlands at the Northern part of the country, through the lakeland highlands and wide lowland belt, to Southern highlands and mountains, where two main rivers originate to run throughout Poland: Vistula River (1047 km) and Odra River (854 km). Landscape in Poland is predominated by vast lowlands: 54% of the national territory is situated lower than 150 metres above sea level, almost 37% on the altitude of 150–300 metres. Highland and mountain areas (above 300 metres above sea level) occupy almost 8% national territory, including 0.1% covered by high mountains.

Such latitude parallel terrain configuration, while its altitude grows from the Baltic Sea basin towards the South, constitutes an important factor for the development of climate conditions in Poland, allowing for an unrestrained parallel exchange of air mass. Therefore, the characteristic of climate in Poland is its transience, i.e. impact of both marine and continental climate features is apparent, depending on current activity of atmospheric pressure configurations occurring over Central Europe. This in turn results in significant variation of climate and weather conditions, occurring year after year and day after day, respectively. Mean annual air temperature in Poland in the period of 1951–1980 was 7.4 °C, but during the decade of 1981–1990 it rose up-to 7.9 °C, whereas the next nine-year period was yet warmer, and mean annual air temperature in that period (1991–1999) rose up-to 8.0 °C. Maximum temperature in Poland in the period of 1981–1999 varied in particular regions of the country from 23.6 up-to 38.0 °C, whilst minimum temperature varied in the same period from –18.2 to –35.4 °C. Amplitude of extreme temperatures varied then from 51.9 °C in coastal zone up-to 70.9 °C in Eastern area. Most frequently, the warmest month is July, when mean temperature grows gradually towards the South, and it amounts from 16.3 °C in coastal zone up-to 18.1 °C in Southern lowlands (1951–1980), and it did not exceed 9 °C over the highest mountain areas. January usually is the coldest month of the year, with its mean monthly temperature varying meridionally from –0.1 °C in Western coast to –4.2 °C in the East. The influence of terrain configuration in Poland can be the most apparently perceived in the distribution of annual sums of precipitation. Mean annual sums of precipitation amount to 600 mm, whilst its minimum sums are noted in lowland Central Poland (about 500 mm), the maximum in high mountain areas (about 1500 mm), whereas summer precipitation is prevailing over winter precipitation. Precipitation can be characterised by its both significant spatial variation and strong fluctuation, year after year. Mean annual sums of precipitation in Poland in the period of 1951–1980 (excluding mountain meteorological stations) amounted to 611 mm, and in the decade of 1981–1990: to 578 mm, and in nine-year period of 1991–1999: to 615 mm.

Poland is one of the poorest countries in Europe as concerns water resources, resulting in about 1800 m^3 water per capita annually, that is three times less than the European mean, and more than four times less than a global mean. Additionally, the characteristics of these resources are their seasonal variation and territorial differentiation. This in turn leads to either periodical danger of water deficit or surplus in many regions of the country. The capacity of retention reservoirs in Poland is rather small, and they are able to retain only 6% of annual water outflow from the country territory, and therefore they do not provide for adequate protection against drought or flood.

Water uptake for public and economic purposes has apparently decreased. During the period of 1995–1999 it was as much as 21% lower than in 1988. This is due, first and foremost, to limitation of water use for industrial purpose (industries are responsible for 70% of overall water uptake), since the industries either undergo their restructuring processes or they have operated more efficiently. Another reason is a more economic water use by both the population and agriculture. More than 83% of water used has been abstracted from surface water resources, 15% from subterranean waters and 2% from post-mining waters.

They are farmland and forests which are the predominating forms of land use in Poland, and they account altogether for almost 89% of the national territory. Arable land

Table 2.1. Water uptake for national economy and public purposes

Years	Production purpose [hm^3]	Irrigation in agriculture and forestry and fishery ponds refills [hm^3]	Operation of water-supply network [hm^3]	Total [hm^3]
1980	10 137.6	1 323.4	2 722.6	14 183.6
1988	10 116.6	1 622.7	3 066.1	14 805.4
1990	9 549.4	1 693.7	3 004.6	14 247.7
1995	8 431.6	1 176.8	2 457.1	12 065.5
1996	8 573.2	1 057.5	2 377.5	12 008.1
1997	8 424.1	1 082.9	2 292.0	11 799.0
1998	8 125.2	999.2	2 189.0	11 313.4
1999	7 836.7	1 045.4	2 392.5	11 274.6

Source: GUS.

Table 2.2. Total surface area of the country by mode of its use

Type of surface use	Surface area in the year					
	1988		1990		2000	
	thousand ha	%	thousand ha	%	thousand ha	%
Farmland	18 835	60.2	18 784	60.1	18 537	59.3
Forests and wooded lands	8 864	28.4	8 884	28.4	9 094	29.1
Waters	823	2.6	826	2.6	833	2.7
Mining uses	42	0.1	42	0.1	38	0.1
Communication areas	986	3.2	989	3.2	959	3.1
Housing areas	932	3.0	952	3.1	1 050	3.4
Waste land	500	1.6	504	1.6	499	1.6
Other	286	0.9	288	0.9	259	0.7

Source: GUS.

prevails in farmland that occupies almost 48% of the area surface, the other 12% is occupied by permanent grassland to comprise both permanent meadows and pastures. Arable land is situated rather uniformly throughout the country territory, an its share is the least in typical highland Southern Voivodships and in dense forest areas. The surface area of arable land has regularly shrunk primary in favour of forestry, urban areas, waste land and communication areas. Poland is one of the countries characterised by insignificant territorial share of waste land which include also natural waste land such like littoral dunes or bare rocks in high mountain parts.

2.2. Social and economic characteristics

2.2.1. Political and administrative structure

The Republic of Poland is a constitutional republic ruled upon mixed model of presidential and parliamentary power. Legislative authorities are Sejm (Lower House of Parliament) and Senate, who jointly form the National Assembly. The supreme executive authorities are the President of the Republic and the Council of Ministers. Central Government, i.e. the Council of Ministers, who is directed by the Prime Minister, manages the State domestic and foreign policies. On territorial level, the governmental administration is represented by the Voivodes in the Voivodship (i.e. Provincial) system, and by the County Heads in the system of Counties, in the framework of responsibilities they execute.

On 1 January 1999, new three-level territorial system of the State administration authorities entered into force, i.e. the national territory has been structured into territorial units of the Municipalities, Counties and Voivodships. 16 new Voivodships replaced the 49 old ones, including 315 Counties and yet 65 cities, which the status of municipal boroughs has been conferred to. No change was introduced into the lowest, i.e. municipal system, and the Municipality has remained the basic unit of the national territorial structure. There are total 2489 Municipalities. The auxiliary units within Municipalities are the areas of the groups of villages, with 40 057 such groups established throughout the national territory.

This new territorial division and the structure of the public authorities correspond to solutions adopted in European Countries similar to Poland in terms of the population number and the surface area.

2.2.2. Social characteristics

Demography. After post-war demographic explosion, since mid eighties, population growth rate has declined in Poland. In the period of 1989–1998, population number grew by 782 thousand and it amounted to 38 667 thousand at the end of 1998, while the previously occurring decline tendency of the birth rate yet intensified, and it dramatically decreased in that period from 4.8‰ to 0.5‰. In 1999, for the first time in the post-war period, a real birth rate was negative, since it amounted to the level of 0‰ (0.6 thousand), while emigration intensity of the population retained. In subsequent years, population number decreased from 38 654 thousand at the end of 1999 to 38 644 thousand at the end of 2000.

Long-term demographic prognosis until 2030 anticipates insignificant variation in the population number, between 38–39 million with the tendency towards its decline. By 2005, a slight decline rate will be retained, and then the population number will begin to grow gradually to exceed the number of 39 millions in 2015. After 2020, a considerable decline in population number can be expected, that will result primarily from gradual decline in birth rate. In 2030, population number in Poland will amount to 38 025 thousand.

Unfavourable change occurs in age structure of the population. A decline in birth rate results in absolute drop in participation of people in "pre-productive" age in relation to total population number (from 29.8% in 1989 to 24.1% in 2000), while accompanied by growing participation of those in "productive" and "post-productive" age (from 57.6% in 1989 to 61.2% in 2000, and 12.6% in 1989 to 14.7% in 2000, respectively). As results from demographic prognosis until 2030, further transformation in age structure of the population can be expected, demonstrating a regular decline in the number of people in "pre-productive" age, with parallel considerable increase in those in "post-productive" age. The number of people in "productive" age would grow by 2010, and then it would have declined. During the entire prognosis period, a 30% decline in the number of people in "pre-productive" age can be expected. Favourable change in prolongation of life expectancy will cause, that participation of people in retirement age in relation to total population number will increase up-to 24% in 2030 (growth by more than 64%).

In the nineties, a stabilisation was noted of participation of inhabitants living in urban areas, amounting to 61.8%. The mostly urbanised areas are the Silesian Voivodship (79.6%) and Lower-Silesian Voivodship (71.6%). In 2000, there were 880 cities in Poland, including 19 cities of over 200 thousand inhabitants. Warsaw, the capital of Poland, and the biggest Polish city, has more than 1.6 million inhabitants.

Population distribution in Poland is diverse. Average population density amounts to 124 inhabitants per 1 km^2, but in the most densely inhabited Silesian Voivodship it amounts to 396. The North-Eastern, i.e. the Podlaskie and Warmińsko-Mazurskie Voivodships, where population density amounts to 61 inhabitants per 1 km^2, are the least inhabited regions in Poland.

Economic situation of households. There are over 13.6 million households registered in Poland, each of average number of 2.83 members. After high economic growth, which resulted in 1995–1997, a slowdown, effected in the growth rate in 1998, that was reflected in worsening income situation of families. As results from studies on household budgets, real income declined in households related to agricultural occupation and in those keeping up upon non-earning-making sources other than pension or annuity. Furthermore, the differentiation of income level between particular socio-economic household types has got deeper. The most significant changes were noted in households related to agriculture. In 1995, the level of disposable income in farmers' households was about 6% lower than average level of overall household income, whilst in 1999 this difference amounted to as much as about 26%. In households of the employees managing farms these indicators amounted to about 13% and about 22%, respectively. Only a slight improvement was noted of furnishing the household with household permanent use goods. Selected characteristics of household goods per 100 households in Poland are following:

- TV set – 114.4
  – including colour TV sets – 106.7
- TV–Sat equipment – 46.1
- personal computer – 11.7
- automatic washer – 70.3
- refrigerator – 98.6
- motorbike – 4.1
- car – 47.8

However, it is still the case, that the families used to allocate major part of their income for foodstuffs and permanent housing fees. In 1999, expenses for the aforementioned groups of needs accounted altogether from about 37% to over 56% of overall household expenses, including fees for energy carriers – from 8.4% to 13.5%.

Unemployment. Change in situation was significant in the labour market during transformation period of the Polish economy, and three time periods can be so distinguished:

1) 1990–1993: Characteristics of this period of economic change occurring during initial years of the transformation, and of adjustment of the employment magnitude and structure to market economy being introduced, is a considerable decline in labour demand, resulting in decline of employment number as much as by 2628 thousand people, and an increase in unemployment number. As late as in 1994, the tendency to diminishing demand for labour force was hampered.
2) 1994–1997: Characteristics of this period is a rapid economic growth, when GDP reached 6.8%. Situation

Table. 2.3. Selected demographic data for Poland

Years	Population number		Birth rate	Population in cities
	Total in thousands	per square km	[‰]	[%]
1950	25 035	80	19.1	36.9
1960	29 795	95	15.0	48.3
1970	32 658	104	8.5	52.3
1980	35 735	114	9.6	58.7
1988	37 885	121	5.7	61.2
1990	38 183	122	4.1	61.8
1995	38 609	123	1.2	61.8
1996	38 639	124	1.1	61.9
1997	38 660	124	0.9	61.9
1998	38 667	124	0.5	61.9
1999	38 654	124	0.0	61.8
2000	38 644	124	0.3	61.8

Source: GUS.

Table 2.4. Prediction of change in population number

Years	2005	2010	2015	2020	2025	2030
Population number in thousands	38 635	38 788	39 005	39 003	38 657	38 025

Source: GUS.

in labour market gradually improved being stimulated by favourable economic circumstances and by related growth in employment in private sector, as well as by slowdown of restructuring processes in the economy, affecting the limitation of employment reduction, as well as reduction of employment in the “grey zone”. Employment number increased by 1180 thousand people, and unemployment rate declined to 10.3%.

3) 1998–2000: Characteristics of this period is a strong decline tendency in employment. In 2000, the unemployment number increased up-to 2702.6 thousand people, and the unemployment rate grew up-to 15%. Situation in employment market worsened mainly in result of a slowdown in economic growth rate and an acceleration of restructuring processes in certain industrial branches, as well as of a considerable reduction of production, trade and service activity in relation to the Russian crisis. Situation in labour market was also made difficult by increased inflow of graduates, that was the first signal, that the demographic explosion is getting on the labour market.

The transformation period is characterised by continuous dynamic development of private sector, where in 1990–1998 the employment number increased by 3.1 million people. In the same period, the employment number in the public sector declined by 4.6 million people, and at the same time their participation to overall employed people declined from 53.4% in 1989 to 29.3% in 1998. The change in economy was apparently reflected by change in the employment level and structure in economic sectors, being the most intensive in industrial sector. Percentage participation of people employed in this sector reduced considerably from 35.7% in 1989 to 28.8% in 1998 in favour of service sector which share in the employment increased from 35.7% in 1989 up-to 43.8% in 1998. Employment in agricultural sector remains on similar level of 28–27%.

A negative feature of unemployment in Poland is a considerable differentiation of its intensity in regional aspect, that is caused firstly by uneven level of economic development of particular regions, and also by their differentiated demographic situation. The worst situation is in Northern and North-Eastern regions of Poland, those are weakly economically developed, and they are dominated by agricultural activity. Considerable share in generating the unemployment in those regions resulted from liquidation of their state-owned farms. The lowest unemployment rate is in the Voivodships with large urban agglomerations which are characterised by the highest degree of urbanisation and development of industry and services. A feature of rural labour market is its growing tendency of unemployment number, that accounts for almost 44% of total unemployment in Poland (in December 2000). In the Southern and South-Eastern Poland, where rural population predominate, this percentage is 52–62%.

Irrespective of any tendency in development of overall number of unemployed people, the following the most important problem areas in the labour market still remain: high percentage of young unemployed people (31%), people who face unemployment longer than for a year (44.7% in December 2000), that of unemployed people characterised by low educational level (70.4% of overall unemployed in December 2000), and of people, who have been registered as unemployed, but who have had no right to the unemployment allowances (79.1% in January 2000). Long-term unemployment grew to particularly large extent in the regions which are economically outdated, i.e. typically agricultural regions, in the areas of the former state-owned farms.

Table 2.5. The number of registered unemployed and the unemployment rate

Years	1990	1995	1996	1997	1998	1999	2000
Unemployed [thousand]	1126.1	2628.8	2359.5	1826.4	1831.4	2349.8	2702.6
Unemployment rate [%]	6.5	14.9	13.2	10.3	10.4	13.1	15.0

Source: GUS.

Stable reduction of the unemployment rate and reduction of the unemployment size (less than 2 million people) will be difficult to attain in the forthcoming years if the economic growth rate is not speeded up considerably. Additionally, demographic situation will badly affect the labour market. An increase by 860–890 thousand people who are professionally active is expected in the next five years. Implementation of a set of measures presented (on 6 March 2001) in governmental document titled The Time-Schedule for Actions Aimed at the Support to Enterprise and the Creation of New Jobs could be in favour of an enhancement of the workplace number and include: alleviation of the burden of taxes, making the labour law more flexible, supporting small and medium-sized enterprises, and facilitation of investment in and creation of exports.

Active forms of counteraction the unemployment, those are financed by the State with the resources from Labour Fund, are undertaken with the aim to improve situation in labour market. These actions include training courses, intervention works, public works, loans, and also professional activation of the graduates. Relatively low percentage of unemployed people benefited from the counteraction the unemployment, and it amounted to 782.3 thousand individuals in 1998–1999. However, in the presence of high unemployment, the majority of resources coming from the Labour Fund is consumed in the form of allowances being paid directly to unemployed people, and as pre-retirement benefits. The low share of the Fund’s resources in the expenses allocated to active forms of counteraction the unemployment was subject to significant fluctuation, amounting from 11.9% in 1995 up-to 19.2% in 1999. The effectiveness of active market labour programmes, that is defined as a percentage

Table 2.6. Dynamics of Gross Domestic Product – percentage of growth or decline (–) in relation to previous year

Years	1988	1990	1995	1996	1997	1998	1999	2000
GDP [%]	4.1	–7.5	7.0	6.0	6.8	4.8	4.1	4.1

Source: GUS.

Table 2.7. Gross Domestic Product per capita expressed in PPP (Purchase Power Parity)

Years	1990	1995	1996	1997	1998	1999
GDP [USD]	4466	6350	6350	6663	7320	8167

Source: GUS.

share of the number of people, who participated to a programme in question and obtained permanent job on its completion, to overall number of participants, indicates, that the most efficient instruments for the counteraction the unemployment are inventory works, refunding insurance premiums paid in virtue of employment, and training courses.

A chance for new jobs in rural areas is the Programme for Re-orientation of and Change in Professional Skills, that was set up in 2001 as a part of a larger programme for activation of rural areas under joint auspices of the World Bank and the Polish Government. Training courses, guidance, professional information and assistance in obtaining periodical employment beyond agriculture – these are only few of the instruments under preparation, those are to assist in activation of the unemployed and farmers, who manage small farms, and to support development of small enterprises in rural areas.

2.2.3. Economic characteristics

The aim of the process of deep social and economic transformation that began in 1989 was to initiate radical ownership transformation, to implement active antimonopoly policy, liberalisation of prices and adjustment of their structure to that functioning in world-wide market, world-wide opening of the Polish economy, setting-up the capital market and allowing for foreign investment in Poland. During the first two years of the transformation (1990–1991) a transitional collapse of the Polish economy occurred. Then, recession breakthrough came in 1992, since that economic situation improved and restructuring processes gradually strengthened. Economic growth continued during the next years. In 1995, the Polish economy achieved the highest growth rate and this growth continued yet for two years. The growth phase still continues, however since 1997, economic growth rate has slowed down.

Gross Domestic Product. Since 1994, Gross Domestic Product (GDP) has reached high growth rate, being the highest (7%) in 1995. The subsequent two years were equally prosperous, and GDP reached 6.0% and 6.8% percent, respectively. That resulted mainly from growing domestic demand, in terms of both consumption and investment. An additional stimulator for economic growth in that period was an increase in the number of employed people linked to the growth in labour efficiency, as well as considerable slowdown of inflation growth rate and boom in international commodity turnover in the conditions of progressing liberalisation of trade turnover. After 1997, GDP dynamics gradually slowed down from 4.8% in 1998 to 4.1% in 2000. Decline of the growth rate was caused by reduction of demand both domestically and world-wide.

Participation of particular sectors in generation of GDP. The importance of service sector is growing in generation of GDP, that share grew from 47.2% in 1995 upto 52.6% in 1999. Industry still retains its considerable influence on the growth rate, and its share amounted to 23.6% in 1999, that is about 4.0% less than in 1995. A tendency to positive change in industry has persisted, that appears as the growth of the share of processing industry in production sold, and as a decline of the share of capital- and energy-consuming raw material section. The share of agriculture and forestry dropped from 6.0% in 1995 to 3.4% in 1999.

Foreign trade. Commodity turnover with foreign countries grew 2.5 times as much in the period between 1991 and 1998 that resulted from considerable, threefold growth

Table 2.8. Structure of Gross Domestic Product generation in 1995–1999

Specification	Structure in current prices [percentage]				
	1995	1996	1997	1998	1999
Gross value added, including:	87.1	86.9	87.4	87.6	87.2
❑ agriculture, hunting and forestry	6.0	5.5	4.8	4.1	3.4
❑ Industry, including:	27.6	26.1	25.7	24.2	23.6
– mining	3.6	3.3	3.1	2.5	2.3
– manufacturing activity	20.6	19.5	19.6	18.9	18.3
– electric energy, gas and water supplies	3.4	3.3	3.0	2.8	3.0
❑ Construction	6.3	6.5	6.9	7.6	7.6
❑ Services, including:	47.2	48.8	50.0	51.7	52.6
– trade and repairs	17.4	18.2	18.4	18.1	18.2

Source: GUS.

in import and a slower growth in export. 1999 appeared as a year, which was difficult for the Polish foreign trade, since for the first time during the transformation processes a decline of the turnover was noted, in terms of both exports (by 2.9%) and imports (by 2.4%).

Commodity export is predominated by electric and machine industry and metallurgical industry products, as well as textile materials and products, agricultural products and foodstuffs, and chemical industry products, those account altogether for 73.6% of total exports. The most important commodities in the Polish exports in 1999 were furniture, garments and clothes, cars, ships and floating equipment, and metallurgical products. Poland's imports are primarily the products of electric and machine industry, chemical and metallurgical products and mineral products, particularly fuels, those account altogether for 74.5% of total imports. The most important import products included automobile parts and accessories, petroleum and its derivatives, cars, telecommunication equipment, medicaments, computers and computer equipment, and special purpose machines and facilities.

Energy sector. Energy sector, in terms of its activity scope covers electric energy supplies, heat supplies and the supplies of gaseous fuels. The structure which relates to electric energy supplies includes the sub-sectors for electric energy generation, transmission, distribution and sales.

The Polish Electric Energy Networks Inc. is responsible for power transmission from the generation plants and its dispatching. Power distribution and sales are managed by 33 electric energy distribution companies, and by about 200 other companies, who hold relevant licenses. In 1999, total installed (i.e. generating) capacity of the power generation plants amounted to 34 208 MW, that has fully covered the domestic power demand. In relation to 1995, the increase in generating capacity was 3%, that was obtained in result of technical investments and modernisation to enhance the turbine capacities. Also, modernisation works were carried out with the aim to reduce coal use indicator, and to adapt the boilers to firing with another fuel type.

In heat supply sub-sector, activity is conducted in the field of heat energy generation, distribution and sales. This sub-sector includes so called professional sources (i.e. commercial heat generation plants), industrial sources and municipal sources. In 1999, heat energy generated amounted to 181 958 TJ, including heat generated in combined cycle accounting for 44.8% of the total heat generated.

The main activity objectives of gaseous fuel supply subsector are gaining gaseous fuels, their transport, storage and sales. In 1999, 10.9 billion m^3 natural gas was used in Poland. The largest gas engineering enterprise in Poland is the Polish Oil Mining and Gas Engineering Inc. (PGNiG), who deals with prospecting and exploration of crude oil and natural gas deposits, imports of natural gas, transport and distribution of gaseous fuels and their sales, and operation of subterranean gas storage sites. In 2000 organisational structure of this multi-division enterprise consisted of 23 gas distribution companies, 6 gas transfer regional divisions, oil mining division (supervising 6 mining divisions), 2 logistic divisions and the Main Division. On 21 December 2001, the following distribution companies have been separated from the Polish Oil Mining and Gas Engineering Inc.: Mazowiecka Gas Engineering Company Ltd. with headquarters in Warsaw, Karpacka Gas Engineering Company Ltd. with headquarters in Tarnów, Śląska Gas Engineering Company Ltd. with headquarters in Zabrze, Pomorsko-Wielkopolska Gas Engineering Company Ltd. with headquarters in Poznań and Oil Gas Engineering Company Ltd. with headquarters in Warsaw. This enterprise services more than 6.7 million household end-users and more than 2.5 thousand industrial plants, while managing supplies to them through gas engineering networks for the four basic gas types: high-methane natural gas, nitrogenous natural gas, propane-butane-air mix, and decompressed propane-butane. The provision rate of gas installation equipment in households accounts for about 80%, in urban areas and about 11% in rural areas.

Structural changes within the sector are managed in accordance with integrated time-schedule for privatisation of heat and power sector and the implementation of electric energy market, as adopted in May 2000 by the Council of Ministers. In 2001, an update was made of the issues pertaining to electric energy market, those were included in the Programme for Implementation of Electric Energy Market in Poland, that was approved on 10 April 2001 by the Council of Ministers. Also, the time-schedule was detailed for privatisation of the sector, as envisaged in document approved on 19 June 2001, titled The update of integrated time-schedule for privatisation of heat and power sector and implementation of electric energy market. The basic power plants, heat and power plants, electric energy distribution companies and the Polish Electric Energy Networks Inc. have became self-sustaining enterprises, being the companies of the State Treasury. In 2000, privatisation processes of the power plants and heat and power plants were continued, as were the pre-privatisation works in power plants and heat and power plants. Privatisation contracts were signed for one company in electric energy distribution sub-sector as well as for the first group of electric energy distribution companies. Privatisation of gas engineering sub-sector will be continued pursuant to the principles laid down by the Government in 2001. Privatisation of prospecting-extracting company in the course of public offer is planned according to the document Assumptions for Privatisation of Gas Sector in Poland. Distribution companies will be privatised two-stage: sale of stockholdings to the strategic investors (first stage) and introducing the stocks into the Warsaw Stock Exchange (second stage). The transfer-storage company (restructured PGNiG) will not be privatised in the nearest 5 years.

From March 1999, new tariffs are being successively introduced for electric energy, heat and gaseous fuels, those will be now determined by the electric energy distribution companies pursuant to the principles laid down in the Act on Energy Law and in executive regulations made by Minister of Economy, to be then approved by the President of Energy Regulation Agency. The method for clearance of electricity expenses have been basically changed, while the costs relating to electric energy have been separated from the service costs, i.e. transmission and distribution costs.

Energy demand and consumption balance. During recent period, the balance of energy demand and consumption in Poland shows an equilibrium tendency. No serious change was introduced into the structure of gaining primary energy, and a heavy predomination of domestically extracted hard coal still continues. Hard coal extraction in 1996–1997 retained on similar level. i.e. about 138 million tonnes, but it was apparently reduced in the subsequent years amounting to 112 million tonnes in 1999, that is the level reduced by about 18% in relation to 1995. Trade liberalisation favours coal imports, mainly from Russia, in Northern regions of the country at prices competitive to those of domestic coal. Annual brown coal output and use amounted to the level of 60–63 million tonnes.

Domestic extraction of crude oil satisfies only 2% of domestic demand, but it grew almost 1.5 times in the recent 5-year period. Newly discovered oil deposits in the Polish Lowland and sea bed extraction on the Baltic Sea give a chance to enhance domestic extraction. Domestic production of petroleum derivative products does not satisfy continuously growing needs of the economy. Almost 30% of engine petrol and about 80% of liquid gas originate from imports.

Extraction and production of natural gas in the recent 5-year period retained almost at the same level amounting to 4800 million m^3, including natural gas resulting from methane removal from mines, amounting to 330 million m^3. Works aimed at gaining natural gas from methane removal from coal deposits have been practically ceased due to excessive costs and given its insignificant effects. Extraction of natural gas satisfied only a part of domestic needs which have been satisfied with gas imports from Russia (57% of supplies), Ukraine, Norway and Germany.

Since 1988, significant change has effected in domestic balance of primary energy use. The use of primary energy in 1990–1997 retained on similar annual level. In 1998 it dropped to 4069.6 PJ, and in 1999 dropped to 3770.1 PJ. In 1999, the amount of primary energy use decreased by 30% in relation to 1988, whilst a decline in solid fuel use, mainly hard coal was yet deeper, and it amounted to over 40%. During that period, the use of hydrocarbon fuels increased by almost 5%.

The structure of primary energy carriers use changed gradually, and although hard coal still predominates, its share has diminished in favour of both hydrocarbon fuels and renewable energy sources. In 1999, the share of hard coal in domestic use of primary energy accounted for 52%, whereas that of brown coal accounted for almost 14%. The share of hydrocarbon fuels grew up-to almost 30% of the balance. Tendencies have emerged to using natural gas as fuel in professional power sector. The share of the other primary energy carriers use, although slightly growing, has still not exceeded 5% of domestic use of primary energy.

Renewable energy sources account for 4.6% in the balance of the domestic consumption of primary energy. They include primarily biomass, hydropower, and marginally such sources like wind power, and geothermal and solar energy. Considerable increase in wood and wood waste use in the nineties, as well as that in crops for energy purpose (i.e. willow, poplar or Miscanthus), setting up geothermal heating plants and several local heating plants fired with straw, commissioning several wind power plants and numerous small hydropower plants, setting up several biogas installation for agricultural and municipal purposes (for methane fermentation of liquid and solid manure, and energy recovery for waste landfills), as well as commissioning a dozen solar power plants (used generally to drying crops and warming water), and experimental rape bio-refinery, several spirits dewatering and ethanol providing installations, has been reflected by gradual growth in the share of renewable energy sources in the structure of primary energy consumption. At present, there are in operation: 29 professional wind power plants, total installed capacity 10 MW; 463 small hydropower plants, total installed capacity 228 MW;

Table 2.9. Structure of primary energy gains in Poland

Energy carriers	Percentage share of energy carries in energy gained in particular years					
	1990	1995	1996	1997	1998	1999
Hard coal	82.4	79.3	79.0	79.4	76.3	75.0
Brown coal	13.7	13.8	12.8	13.0	14.7	15.5
Petroleum	0.2	0.3	0.3	0.3	0.4	0.5
Natural gas	2.4	3.2	3.1	3.2	3.7	3.8
Other*	1.3	3.4	4.8	4.1	4.9	5.2
Total [PJ]	4114.5	4125.7	4309.1	4171.7	3662.2	3374.1

* Fuel wood, peat, waste fuels, water energy and other renewable energy carriers. Source: GUS.

Table 2.10. Structure of primary energy use in Poland

Energy carriers	Percentage share of energy carries in energy use in particular years						
	1988	1990	1995	1996	1997	1998	1999
Hard coal	67.6	63.9	60.2	60.2	59.0	55.7	52.4
Brown coal	11.1	13.3	13.0	12.4	12.8	13.3	13.8
Petroleum	11.5	12.6	13.5	13.9	14.8	16.7	18.9
Natural gas	8.1	8.9	9.1	8.8	9.3	9.8	10.3
Other*	1.7	1.3	4.2	4.7	4.1	4.5	4.6
Total [PJ]	5376.2	4217.0	4148.4	4468.1	4258.1	4069.6	3770.1

* Fuel wood, peat, waste fuels, water energy and other renewable energy carriers. Source: GUS.

Table 2.11. Electric energy consumption per capita

Years	1980	1988	1990	1995	1996	1997	1998	1999
Electric energy consumption [GJ]	12.24	14.04	12.60	12.60	12.97	13.29	13.31	13.26

Source: GUS.

13 thousand square metres water solar collectors; and several thousand installations of the air solar collectors, several square metres photovoltaic systems, 100 smaller boilers and 40 larger heating plants fired with straw, capacity 0.5–5 MW, 16 installations for use of landfill-gas, 20 biogas plants in municipal wastewater treatment plants, several agricultural biogas plants, and three geothermal heating plants. Geothermal waters are also used in eight localities for balneological and healing purposes.

The structure of direct energy use during the recent years has not changed too much. Consumption of solid fuels has diminished in favour of the share of liquid and gaseous fuels. Since 1996, consumption of electric energy has risen.

Transport. In the recent decade, in circumstances of developing economy, the tendencies appeared in Poland to reduced demand for transport. The changes tend towards rationalisation of haulage in terms of quantity and assortment of transported cargo and in selection of transportation mode. Decline of freight mass transported is estimated at 19%. Given the service time and quality, prevailing majority of haulage has been overtaken by road transport, servicing 80% of freight mass in 1999.

Public transport behaviour has essentially changed. Intensification of and growth in number of travels resulting in 250 travels per capita in 1998 have followed initial decline of communication mobility. The current change in mobility structure is characterised by high dynamics. In the nineties, traffic intensity on the national roads grew twice as much, on average, resulting in up-to 33% growth in car share in communication mobility of the public in 1998. A negative phenomenon is a decline of passenger rail travels by about 49%, with parallel slight increase in long-distance passenger travels.

In the group of road vehicles, cars predominate, with their share amounting up-to 78%. Vans are numerous group, about 10%, followed by motorbikes (7%), and trucks and buses (5%).

In the nineties, the number of cars grew dynamically, by about 700 thousand annually, on average, which was 70% increase in the number of cars. However, a decline in this growing tendency can be noted in the recent period. Despite significant growth in the number of cars, only 245 cars per 1000 population are noted in Poland that is much less than in European countries characterising by

Table 2.12. Freight transport size and structure

Transport mode	Years											
	1990		1995		1996		1997		1998		1999	
	billion t/km	%	billion t/km	%	billion t/km	%	billion t/km	%	billion t/km	%	billion t/km	%
Railway transport	83.528	24.1	69.116	23.0	68.332	22.1	68.651	20.8	61.760	19.5	55.471	17.9
Automobile transport	40.293	11.7	51.200	17.0	56.513	18.3	63.688	19.3	69.542	22.0	70.452	22.7
Marine transport	207.430	59.9	166.048	55.2	168.161	54.4	181.381	55.0	166.095	52.4	164.236	52.9
Pipeline transport	13.890	4.0	13.493	4.5	15.326	4.9	14.971	4.6	18.448	5.8	19.417	6.2
Inland water transport	1.034	0.3	0.876	0.3	0.851	0.3	0.930	0.3	1.100	0.3	1.028	0.3
Aircraft transport	0.057	0.0	0.074	0.0	0.089	0.0	0.116	0.0	0.107	0.0	0.094	0.0
Total	346.232	100.0	300.807	100.0	309.272	100.0	329.737	100.0	317.052	100.0	310.698	100.0

Source: MTiGM.

Table 2.13. Passenger transport size and structure

Transport mode	Years											
	1990		1995		1996		1997		1998		1999	
	billion pass.*/km	%	billion pass./km	%	billion pass./km	%	billion pass./km	%	billion pass./km	%	billion pass./km	%
Railway transport	50.373	49.6	26.635	40.7	26.569	40.8	25.806	40.3	25.664	39.3	26.198	40.2
Automobile transport	46.599	45.8	34.024	51.9	33.984	52.2	33.128	51.7	34.035	52.1	33.25	51.0
Marine transport	0.193	0.2	0.166	0.3	0.156	0.2	0.143	0.2	0.172	0.3	0.131	0.2
Inland water transport	0.028	0.0	0.025	0.0	0.012	0.0	0.03	0.1	0.018	0.0	0.018	0.0
Aircraft transport	4.43	4.4	4.633	7.1	4.407	6.8	4.93	7.7	5.401	8.3	5.629	8.6
Total	101.623	100.0	65.483	100.0	65.128	100.0	64.037	100.0	65.290	100.0	65.226	100.0

* – pass. = passenger. Source: MTiGM.

an average number amounting to more than 400. In Poland, total mean annual car mileage is estimated at about 9400 km, that is on the level by as much as 3100 km lower than that in European countries.

Despite progressing decline of unit fuel use by new cars in Poland, the vehicle stock replacement rate and the quality of periodical inspection of vehicles, as well as their technical maintenance, are of great importance for factual fuel use.

Industry. It is still the industry, who is the basic source for economic growth, despite its share in generation of GDP declined to 24%. After considerable decline in 1990, industrial production sold increased year after year to reach the highest growth rate in 1994 – 12.2% in relation to previous year. In 1995–1999, average increase in industrial production sold was 7.6%.

Private sector begins to play more and more important role, which generates 70% of total production sold, whereas yet in 1995 it contributed only in 47%. Continuation of privatisation processes is planned in metallurgical, chemical and machine sectors. The further progress is expected according to the adopted privatisation strategy in the basic domains of economic infrastructure, such like: energy sector, gas engineering, and mining industry.

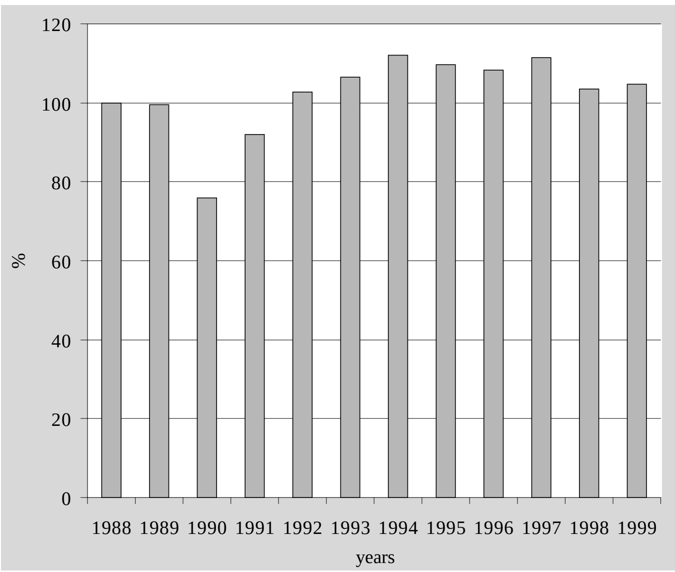

Fig. 2.1. The rate of changes in industrial production sold [previous year = 100%], source: GUS

Transition to market economy enforced the transformation of and changes in the Polish industry. Sectoral and branch structure of industry, which was so far predominated by heavy industry, had begun to change slowly. In the structure of industrial production, participation of mining and extraction sector declined in favour of processing industry. In regional aspect, structural changes appeared as partial reduction of disproportion between industrialisation level of particular regions, however they still remain large. Production growth, that is faster (by 16.7%) in sectors and branches recognised as the carriers of technical progress, than in the others, is a positive symptom, that resulted in their increased share of total production sold up-to 13.2%. High growth rate was achieved in the following sectors: manufacture of business machines and computers, manufacture of motor vehicles, also radio, TV and telecommunication equipment, as well as in editing and typographic activities. A symptom of positive qualitative and structural changes in industry is a high growth in labour efficiency (by 16%) accompanied by lower average employment (by 6.3%).

Waste management. Industrial and municipal sectors are the largest waste producers. In result of business activity managed in 1999, the quantity of 126.3 million tonnes waste was generated, whilst waste quantity was reduced by almost 5% in relation to the previous year. Almost a half of waste quantity was generated by fuel and power industry sector, that jointly with non-ferrous metal industries are responsible for 70.8% of overall waste quantity. Municipal waste is primarily waste originating from households, public service objects and open areas, such like roads and parks. Average waste quantity generated annually per capita amounts to 319 kg, and it has still risen. In relation to 1995 waste quantity increased by 8.5%.

In waste management policy for waste generated in result of business activity waste utilisation is preferred for industrial purpose, including energy or construction purpose, and for non-industrial ones, in particular for terrain surface reconfiguration. In 1999, as much as 72.9% of

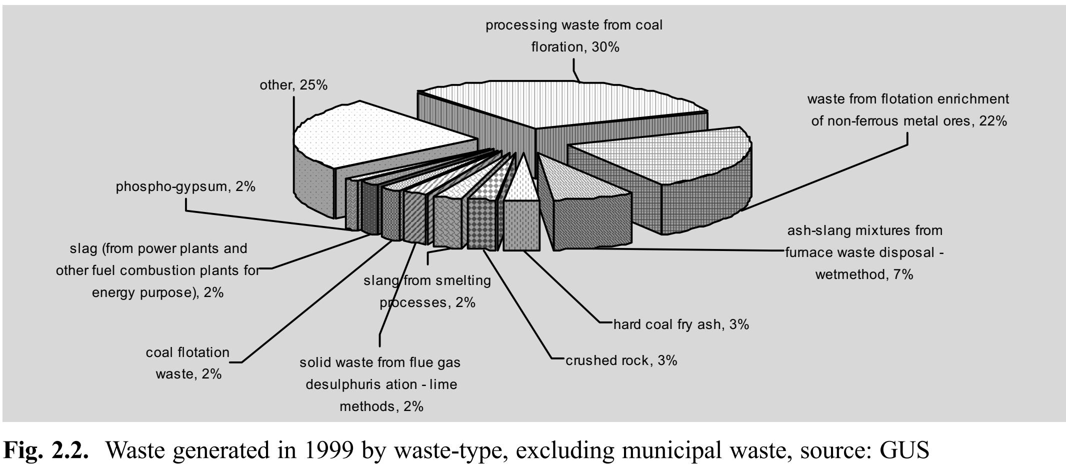

Fig. 2.2. Waste generated in 1999 by waste-type, excluding municipal waste, source: GUS

Table 2.14. Municipal waste generated and disposed annually

Years	1998	1999
Waste generated [million tonnes]	12.276	12.317
Waste sorted [%]	2.5	3.3
Waste treated in composting plants [%]	1.8	1.8

Source: GUS.

waste quantity was utilised for these purposes. 24.2% of waste was subject to waste disposal processes, including 22% deposited on waste landfills. Remaining 2.9% of waste was temporarily stored in the areas of the plants.

The most common method for municipal waste disposal is waste deposition on waste landfills, where almost 95% of waste is deposited. In 1999, the amount of 12.317 million tones municipal waste containing medium content of organic fermentable components, efficiency up-to 38%, was deposited on waste landfills. Only 3% of waste is recovered as reusable raw materials in 180 Municipalities, in form of waste paper, glass, plastics and metals, and about 2% of waste is subject to its composting.

Various type degassing installations are installed on 82 of total 998 domestic municipal waste landfills managed. 190 such installations are in operation, of which from 170 installations biogas is emitted into atmosphere without any treatment. Only on 17 waste landfills installation is installed for controlled biogas combustion in flares or electric generating sets. 37 Gg biogas is captured annually, that corresponds to about 10 Gg CH_4. Biogas is utilised as bio-fuel in electric generating sets, in electric generating sets coupled with heat-generation module, in flares and boilers.

Construction. In 1999, the number of flats in Poland reached 11 922 thousand, including 67% flat resources in urban areas. Average flat area surface is 61.3 m^2, that is 19 m^2 usable floor area per inhabitant. Most flats are provided with the basic water and sewage, gas and heating installations. Living conditions are worse in rural areas, since gas networks are available only in few (15%) residential buildings, and not all of them are provided with district heating (53%) or sewerage installation (65%).

Since 1996, the number of flats commissioned has constantly risen. In 1999, 81 979 flats were commissioned. Individual (40.6%) and co-operative (33.6%) type housing predominates in structure of flats commissioned. The present construction level which is similar to that of the fifties, does not satisfy the current housing demand, that is

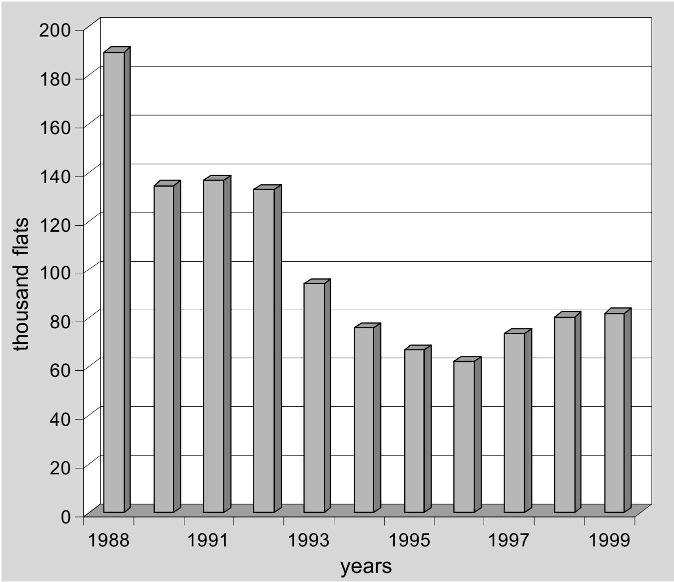

Fig. 2.3. Flats commissioned in the period of 1988–1999, source: GUS

estimated at 1.5–2 million flats, whilst the condition of existing housing resources, those average age is 40 years, has rapidly deteriorated. High energy consumption of such structures requires increased heat supplies for heating purposed and for warming water. In households, as much as 77% of energy is used for heating the flats, whereas 11% is utilised for warm water production. Unfavourable structure of energy carriers underpins the need to common use of solid fuels for heating the flats. The share of district heating is rather considerable, since it reaches 20% of total heat energy in construction sector.

Agriculture. Agriculture in Poland has mostly retained its traditional character featured by both multi-directional production and application of extensive cultivation methods. Mixed production, that has no clearly defined specialisation, is managed by more than 40% of individual farms; in 33% of farms predominating production direction are agricultural crops, and animal breeding and housing in 20% of farms. Agricultural models applied differentiate between particular country regions.

Agriculture is characterised by high partition degree of agricultural farms. In 2000, average acreage of arable land in an individual farm amounted to 7.2 hectare, while farm acreage amounting to 1–5 hectare still prevailed (56.1%), whereas the rate of large farms, those acreage was more than 50 hectares, accounted only for 0.7%. During

Table 2.15. Livestock population in thousands in 1988–2000

Years	1988	1990	1995	1996	1997	1998	1999	2000
Cattle:								
❑ total	10 322	10 049	7 306	7 136	7 307	6 955	6 555	6 083
❑ including: cows	4 799	4 919	3 579	3 461	3 490	3 542	3 418	3 098
Sheep	4 377	4 159	713	552	491	453	392	362

Source: GUS.

Table 2.16. Use of mineral fertilisers in kg per 1 hectare of agricultural land in the period of 1988–1999

Years	1988/ 1989	1989/ 1990	1990/ 1991	1991/ 1992	1992/ 1993	1993/ 1994	1994/ 1995	1995/ 1996	1996/ 1997	1997/ 1998	1998/ 1999
Mineral fertilisers (NPK)	196.0	163.9	95.1	62.1	65.8	71.1	79.7	84.5	88.3	89.6	87.4
Nitrogen fertilisers	82.0	68.9	39.9	33.9	37.7	42.0	46.6	47.6	49.9	49.8	48.4
Calcium fertilisers	202.0	182.4	139.0	117.2	115.2	104.7	131.9	124.4	139.0	130.6	104.2

Source: GUS.

the recent decade, the ownership structure of arable land changed essentially towards enhancement of the share of already dominating individual farms, which in 2000 managed 83.9% of arable land. Individual agricultural farms generate 86% of total commercial production output. In overall commercial production, animal production predominates, that is focused on breeding pigs, cattle and poultry. The basic agricultural crops are grain, potatoes and industrial crops. In 2000, these croplands accounted for 86.6% of overall cropland acreage.

After 1988, decline of livestock population was noted. In the period between 1990 and 1995, cattle population diminished by 2743 thousand, and sheep population by 3446 thousand. From 1995, the decline in livestock population slowed down. In the period of 1995–2000 livestock population diminished by 1223 thousand (drop by 16.7%), including cows by 481 thousand (drop by 13.4%), whereas sheep population diminished by 351 thousand (drop by 49.2%). Milk production is mostly dispersed. Milking capacity has regularly risen (by 12% during recent 5 years), and it amounted to 3510 litres in 2000.

Extensive production predominates in animal breeding. That relates to as much as 51.2% of cattle population and 38% of pig population. Only 2% of cattle and 16% of pigs are bred in the conditions of intensive production. Feeding the animals in Poland is based mainly on bulky feed produced in farms, and on nutritive fodder produced with own farms' grain mix. Given the circumstances of high partition degree of farms and their difficult economic situation, the implementation of modern principles for feeding the animals, aimed at achievement of production progress, has been made difficult.

In Poland litter rearing of animals and grazing them on pastures is widely applied.

The use of mineral fertilisers has been significantly reduced. In the years of the deepest recession (1991/1992), only 32% of mineral component dose applied in 1988/1989 was provided per 1 hectare with fertilisers, including only 41% of nitrogen fertilisers. After recession period, the level of mineral fertilisation grew up-to 87.4 kg NPK per 1 hectare of agricultural land (including 48.4 kg N/ha), however the fertilisation level is still twofold lower than in 1988. At present, the use of mineral fertilisers strays from reasonable needs of the Polish agriculture being managed on farmland, where light soil prevails, that is scarce of nutrients and heavily acidified. These natural conditions unfavourable for agricultural production constrain the necessity to increasing mineral fertilisation level up-to 140 kg NPK per hectare of agricultural land. In the Polish soil and climate conditions, the process of nitrous oxide generation and volatilisation runs less intensively, that favours reduction of nitrogen losses from mineral fertilisers. Soil acidification process, that lasts in Poland (strongly acid and acid reaction occurs in 55% of farmland area surface) requires application of calcium fertilisers in much larger quantities, since the current level of calcium fertiliser application does not balance the progressing acidification that results from soil-forming processes and the adverse industrial impact in form of emissions of nitrogen and sulphur compounds.

Forestry. In 1999, forest covered the area of 8850 thousand hectares, that accounts for 28.3% of the national territory. In the past-war period the ratio of forest cover increased by 36.9% and it has still risen (in 1988 amounted to 27.7%, in 1995 – 28.0%). Spatial differentiation of forest cover ratio ranges from 20.4% in Łódzkie Voivodship (Central Poland) up-to 48% in Lubuskie Voivodship (Western Poland). The share of forest cover per capita in Poland amounts to 0.23 hectare and it is one of the lowest in Central European Region. Productivity of forest habitats has increased, however cumulating air pollutants and not complete conformity of treestand species composition to the habitat has not allowed for their entire use. Coniferous forests predominate in the habitat structure, that cover about 60% of the forest area, whilst the others are deciduous forest habitats.

Table 2.17. Changes in forest resources [%]

Composition of treestand species	1945	1988	1997	1999
Coniferous trees:	87.0	78.4	77.3	77.2
❑ pine and larch	75.5	69.5	69.0	69.1
❑ spruce	8.8	6.3	5.8	5.6
❑ fir and Douglas fir	2.7	2.6	2.5	2.5
Deciduous trees:	13.0	21.6	22.7	22.8
❑ oak, ash, maple, sycamore and elm	4.1	5.7	6.2	6.2
❑ beech	3.3	4.1	4.2	4.3
❑ hornbeam	0.3	0.3	0.4	0.4
❑ birch and black locust	2.2	5.6	6.0	6.1
❑ alder	2.8	5.3	5.3	5.2
❑ aspen, lime, willow and poplar	0.3	0.6	0.6	0.6

Source: GUS and IBL.

Forests are characterised by only slight differentiation of treestand species composition. Coniferous species are prevailing, accounting for 77% of the overall forest area surface, with pine as predominating species (69%). However, tree species structure in forests undergoes essential change. For the recent 50 years, the share of deciduous species increased from 13% in 1945, up-to 23% at present when oak, ash, maple, sycamore and elm account for 6.2%, birch and black locust – 6.1%, alder – 5.2%, and beech – 4.3%. Average treestand age in forests increases and it reached 50 years, amounting to 57 years in forests being the State Treasury property and 40 years in private forests.

Public forests predominate (83%) in forest structure, those are managed by the State Forests Enterprise. Private forests cover 17% of the total forest acreage. Forest structure is characterised by considerable partition degree. Forest Districts manage 28 thousand forest complexes of which more than 6 thousand occupy acreage less than 5 hectares each.

In result of consequent expansion of forest acreage as well as restrained logging, overall forest reserves increased significantly during two recent decades. Timber resources in forests amount to 1637 million m^3 (i.e. by 93.2 mln m^3 more than in 1995). Mean annual timber recovery from forests amounts to the level of 1.5% of its total amount standing, and this has never exceeded the current level of treestand log volume.

Since many years, forests in Poland have been badly affected by permanent hazard to their health, resulting from insects, fungi, unfavourable climate phenomena, fires and air pollutants. Locally, these factors caused forest decay, and even ecological disasters (e.g. in the Sudety Mountains). Regular observations carried out since 1989, in the framework of the international forest biological monitoring, have shown, that forest health condition improved, but treestands have been still considerably endangered. The share of damaged trees (suffering from more than 25% depletion of assimilatory organs) has regularly declined from its highest level of 55% in 1994 to 31% in 1999, however only 11% of trees have been appraised as healthy. Insect pests and pathogenic fungi have massively appeared in forests. Almost 8% of forest acreage is endangered by infectious fungal diseases. Forest tree insect pests attack minor forest areas, although pine treestand folivores endanger almost 4.1% of forest acreage, including nun moth in as much as 1.6% of the acreage.

Treestand age composition, predominant share of coniferous habitats and coniferous species trigger high fire hazard, particularly in early spring and during long-lasting drought periods in the summertime. These circumstances favour rapid propagation of fires. In 1990–1999, 76 977 forest fires broke in Poland, overwhelming the acreage of 109 474 hectares.

Besides productive forests, considerable forest areas (40.1%) constitute protective forests, which are subject to protection due to functions they fulfil. They are soil- and water-protective forests (share amounting to 15%), within the zones of industrial impact (almost 13%), mass recreation of the public, healing and climate, landscape, and animal shelters. Forest management in protective zones is subordinated to special ecological and social functions, which these forests fulfil in the area in question. The acreage of legally protected nature increases, from 19.4% in 1990, up-to 32.5% at the end of 1999. Forest areas account for almost a half of the area of the national parks, landscape parks and protected landscape areas, including as much as 62% of the area subject to the supreme form of nature protection in the national parks.

Table 2.18. Treestand damaged by gaseous and particulate impacts

Years	Treestand acreage in thousand hectares			
	Total	Zone I (low damage)	Zone II (medium damage)	Zone III (high damage)
1985	588	389	166	33
1988	867	611	219	37
1990	1089	825	233	31
1995	2224	1626	573	25
1998	3418	2768	625	25
1999	3753	3056	670	27

Source: GUS.

Table 2.19. Forest acreage affected by fires

Years	1988	1989	1990	1995	1996	1997	1998	1999
Acreage [ha]	3801	4997	7341	5306	14120	6598	4019	8307

Source: GUS.

2.3. State and the protection of the environment

2.3.1. The most important legal and economic provisions aimed at environmental protection

Environmental protection is one of the State obligations that are included in the Constitution of the Republic of Poland, as well as it is the right and the obligation of its citizens. The Constitution adopted in 1997 states, that “The Republic (...) assures the protection of the environment, while guided by the principle of sustainable development”, and that “Public Authorities implement their policies aimed at ecological security for the sake of contemporary and future generations”.

The issues pertaining to comprehensive legal protection of the environment were addressed primarily in the Act on Environmental Protection and Management, that was adopted on 31 January 1980, and which was amended many times in consequent years, and continued in the Act on 27 April 2001 on Environmental Protection Law that came into force on 1 October 2001 jointly with the Act on Waste on 27 April 2001. The Act on Environmental Protection Law includes general principles which shall apply to all environmental Acts, as well as general principles, pursuant to which, specific regulations will be issued in relation to the protection of particular environmental components, such like air, nature and water. New Act guarantees the compliance of the Polish legal system with, inter alia, a number of Directives, which the European Union considers as strategic ones. As far as water management is concerned, following the principle of sustainable development, and particularly in relation to water use, water protection and water resource management, detailed issues are regulated in the Act of 24 October 1974 on Water Law (further amended). The new Act on Water Law on 18 July 2001 comes into force on 1 January 2002.

Legal system in the field of environmental protection has undergone its permanent updating by means of adjustment of existing Acts to changing social, economic and ecological conditions. The following Acts or amendments in exiting ones were adopted by the end of 2000:

- the Act on Environmental Protection and Management,
- the Act on Spatial Management,
- the Act on the State Inspectorate for Environmental Protection,
- the Act on Forests,
- the Act on Nature Conservation,
- the Act on the Protection of Arable and Forest Lands,
- the Act on Sanitation and Order Keeping in Municipalities,
- the Act on Waste,
- the Act on Fertilisers and Fertilisation,
- the Act on Hunting Law,
- the Act on Geological and Mining Law,
- the Act on Water Law.

Legislative works are under way on harmonisation of the Polish law to that of the European Union. The following Acts were adopted in 2001:

- the Act on the Conduct of Substances that Deplete Ozone Layer,
- the Act on Waste,
- the Act on Environmental Law,
- the Act on Packaging and Packaging Wastes,
- the Act on Economic Operators' Obligations in the Scope of Managing Certain Wastes and on the Product and Deposit Charges,
- the Act on Chemical Substances and Preparations,
- the Act on Amendments in the Act on the Crop Plants,
- the Act on Collective Water Supply and Collective Sewage Discharge,
- the Act on Water Law.

Pursuant to provisions included in the Second State Ecological Policy concerning environmental protection law and its harmonisation with requirements of the European Union up to 2002, the following Governmental Draft Acts will be considered by the Parliament:

- the Act on Spatial Planning and Management,
- the Act on the Protection of Animals,
- the Act on the Increase in Energy Use from Renewable Sources,
- the Act on Forest Reproductive Material.

Existing legal regulations impose criminal liability for offences and transgressions against the environment. Since 1 January 1998, all penal provisions, including those relating to offences against the environment, have been included in a single Penal Code. One of essential sanctions that may be imposed for transgression to environment protection principles is the possibility to cessation of the manufacturing activity of a given business.

Financial resources collected from fees and fines imposed for the use of the environment have fed the Municipal, County and Voivodship ecological funds, as well as the National Fund for Environmental Protection and Water Management, who acts in country-wide scale. These resources are the basic source for financing ecologically sound investments being the national or regional priorities.

2.3.2. Organisation structure of environmental management authorities

The supreme authority of the State Administration to co-ordinate and supervise overall activity in the field of environmental protection is Minister of Environment, who fulfils his functions by means of his executive structure – the Ministry. The basic responsibility and competence of the Ministry of Environment include preparation of draft proposals for the State policy in the field of environmental protection, introducing legislative initiatives, and implementation of the policies and Acts adopted. The control upon decisions being made is carried out by the State Inspectorate for Environmental Protection through the Chief Inspectorate for Environmental Protection and the Voivodship Inspectorates for Environmental Protection, who, in the framework of territorial integrated Governmental Administration, are subordinated to the Voivodes.

Responsibility scope of the State Inspectorate for Environmental Protection includes first of all the control over compliance with law and administrative decisions concerning the use of the environment, monitoring the state-of-the-environment and its assessment, as well as the improvement of the procedures and methods in this regard. Financial support to ecological activities is secured by the National Fund for Environmental Protection and Water Management and respective Municipal, County and Voivodship funds. Research backup constitutes the scientific/research institutes

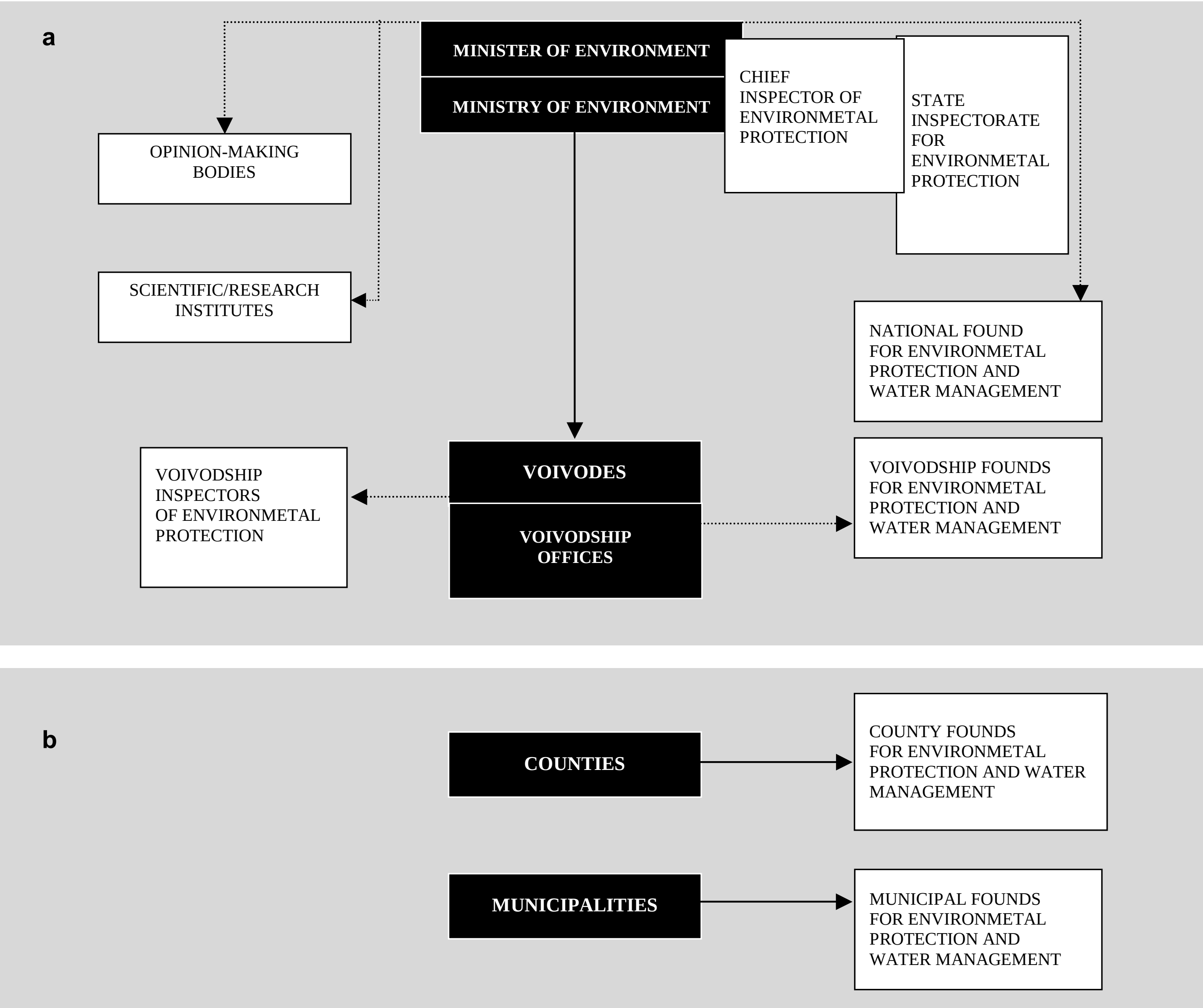

Fig. 2.4. Organisation structure of the authorities managing environmental protection in Poland: a – governmental level, b – self-governmental level, source: MŚ

supervised by the Minister, whereas opinion-making and consultative function is fulfilled by the State Council for Environmental Protection, whose responsibility scope includes making comments on environmental matters and putting forward proposals and conclusions aimed at establishment of environmental protection conditions, as well as preservation or improvement of the state-of-the-environment. In 1999–2000 opinion-making function on cases relating to climate change was fulfilled by Steering Committee for Climate Change.

They are the Voivodes, who manage the function of local State Administration Authority in the field of environmental protection, and who act by mediation of the Voivodship Divisions for Environmental Protection, whose basic responsibility and competence include taking administrative decisions which permit for using the environment, and setting out the conditions for such use, laying down any additional requirements in a definite area, managing database on type and scale of taking use of the environment, managing inspection activities and counteracting environmental hazards in emergency situations. Similar responsibility and competence scope in the field of environmental protection has been conferred to self-governmental authorities. The basic responsibility and choice of concrete actions aimed at environmental protection lay within individual business entities and local self-governments, who have a decisive capacity in respect to the matters in question, and who have financial resources ready as well from their own funds and those passed-on by ecological funds.

The obligation to provide for favourable conditions needed to the enforcement of environmental legal regulations rests on respective Ministers, who are responsible for particular sectors.

2.3.3. Legal mechanisms stimulating the limitation of greenhouse gases

Amended Act on Environmental Protection and Management imposes legal authorisation to issuing a set of Orders in the sphere of air protection defining, inter alia, the maximum permissible amounts of pollutant emissions. Another legal act indirectly aimed at climate protection is the Act on Forests, adopted on 28 September 1991 (consolidated text: O.J. of 2000, No. 56, Item 679) laying down the principles for forest resource preservation, protection and enhancement, and the principles for forest management in relation to other components of the environment and national economy.

Direct reference to greenhouse gas emission is included also in legal provisions laying down the principles for energy management and energy resource saving, as well as those supporting the increase in the use of renewable energy sources. Act of 10 April 1997 on the Energy Law (O.J. of 1997, No. 54, Item 348, further amended) authorises the Minister of Economy to issue the Order on the obligation to purchase electric energy and heat generated from unconventional sources and renewable sources, as well as electric energy generated in combination with heat generation. In this Order, the minimum percentage share is set out of electric energy originated from renewable and unconventional sources in energy sales managed by electric energy distribution companies. Order of the Minister of Economy of 15 December 2000, obliges the electric energy distribution companies to rise gradually the rate of energy originated from renewable energy sources in energy balance from 2.4% in 2001 up-to 7.5% in 2010. Resolution adopted by the Parliament of the Republic of Poland on 8 August 1999 on the Rise in Energy Use from Renewable Sources calls for assuming the obligation to achieve a definite share of renewable sources in the national energy balance in medium- and long-term time-horizon, and to prepare strategy for development of renewable energy sector. On 5 September 2000, Council of Ministers and on 23 September 2001, Parliament, adopted document titled Strategy for Development of Renewable Energy Sector, that defines quantitative objective for the development of renewable energy sector in form of rise of its share in the structure of primary energy carriers in Poland up-to 7.5% in 2010 and up-to 14% in 2020. In order to attain the objectives established, development programmes for particular renewable energy types are to be prepared and implemented. Currently, the first model programme for wind energy is under preparation, that will indicate the framework for development of wind energy in the forthcoming four years, including legal and economic mechanisms supporting the projects in the field of renewable energy sources. The principles to be elaborated during development of this programme will refer to all of the renewable energy sectors.

Another legal act stimulating limitation of greenhouse gases is the Act of 18 December 1998 on the Support to Thermo-modernisation Projects, that aim is to reduce energy use for the purpose of building heating and water warming for utility purpose, and to reduce energy losses in local district heating networks and local heat sources, as well as to replace conventional energy sources with unconventional ones.

2.3.4. Economic mechanisms stimulating the limitation of greenhouse gases

Economic mechanisms, which are presently mandatory in Poland, that are favourable for the limitation of greenhouse gases cover the following activities:

1. Introducing the fees for the emissions of greenhouse gases. Such fees are imposed on industrial and municipal enterprises for their emissions of carbon monoxide and nitrogen oxides, and since 1993, also for the basic greenhouse gases. The amount of fee rates for atmospheric emission of gaseous substances and particulate matter, including also CO_2, are updated on annual basis by way of subsequent Orders made by the Council of Ministers.
2. Provision of financial support to projects aimed at the reduction of greenhouse gases, in the form of:
   - low-interest loans from the National Fund for Environmental Protection and Water Management and from the Voivodship Funds;
   - donations from the National Fund for Environmental Protection and Water Management and from respective Voivodship, County and Municipal Funds;
   - preferential credits provided by Bank Ochrony Środowiska – BOŚ (the Environmental Protection Bank);
   - donations from the ECOFUND (see below for the explanation);
   - donations from Global Environmental Fund and the PHARE Programme.

2.3.5. Financial principles of environment protection

During recent years, favourable conditions appeared and consolidated in environmental protection, manifesting the improvement of the state-of-the-environment. So, the share of environmental investment expenditures rose in GDP, from 1.1% in 1995 up-to 1.6% in the period of 1996–1998, although in 1999 it slightly declined to 1.4% GDP.

Ecologically sound investments are financed mainly from both own company resources and environmental funds: National, Voivodship, Municipal and County (71%). Such projects are co-financed also by banks, e.g. BOŚ, as well as by the ECOFUND, that is the Foundation established by Central Government. The aim of the Foundation is effective management of financial resources resulting from the foreign debt for nature swap i.e. partial change of Poland's foreign debt into projects pertaining to environmental protection.

Table 2.20. Environmental investment expenditures in the period of 1988–1999 (excluding expenditures for water management) in current prices

Years	1988	1990	1995	1996*	1997	1998	1999
million PLN	20.0	415.2	3170.9	6137.9	7354.2	9018.7	8584.9
% GDP	0.6	0.7	1.1	1.6	1.6	1.6	1.4

* Given the enhanced classification scope of the investment modes, data since 1996 are incomparable to that pertaining to the previous years.
Source: GUS.

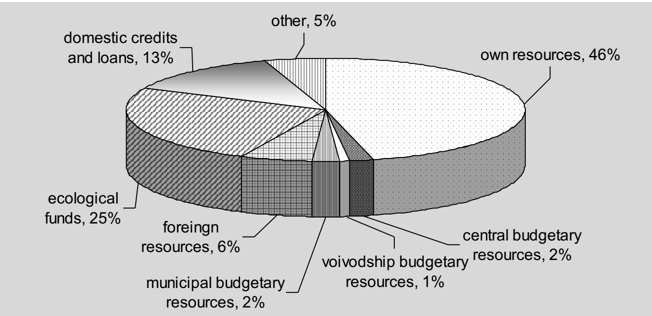

Fig. 2.5. Investment expenditures for environmental protection by financing sources in 1999, source: GUS

A list of project types being supported by ecological funds is presented in Table 2.21. Investment expenditures for environmental protection, coming from the ecological funds, including the breakdown of these resources into particular activity types, are shown in Figure 2.6. Moreover, positive effects for environmental protection have resulted from: firm policy of more stringent requirements for businesses polluting the environment, the use of better quality fuels, industrial restructuring, industrial modernisation and privatisation processes, and production limitation in the sectors being the sources of the utmost pollution.

2.3.6. State and trends of nature conservation

The positive tendency to enhance the areas of legally protected nature has been still retained, ranging from 3.5% of the total national territory in 1980 up-to 32.5% in 1999. Until 1999, in Poland 22 National Parks (covering almost 1% of total national territory and 3% of the protected areas) were established. Seven protected areas were put on the

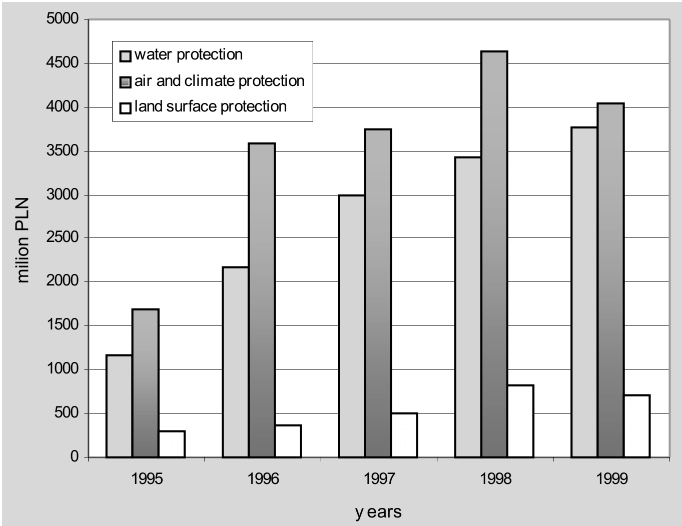

Fig. 2.6. Investment expenditures on environmental protection, source: GUS

Table 2.21. List of projects leading to limitation of GHGs emission financed by National Fund for Environmental Protection and Water Management and ECOFUND in 1997–2000

Financing Institution / Project Type	Amount of co-financing (thousand PLN)	Number of projects	CO_2 emission reduction (tonnes)
National Fund for Environmental Protection and Water Management	**1 054 783**	**264**	**1 743 341**
• Modernisation of heating systems	119 194	94	968 021
• Coal to gas conversion	78 946	129	180 332
• Utilisation of waste heat	1 200	1	–
• Use of renewable energy sources	107 785	13	130 372
• Enhancement of energy efficiency	117 323	6	452 961
• Other	630 335	21	11 655
ECOFUND	**180 209**	**73**	**1 591 068**
• Modernisation of heating systems	115 468	34	791 584
• Coal to gas conversion	37 285	10	507 532
• Utilisation of waste heat	5 204	8	196 520
• Use of renewable energy sources	22 252	21	95 432
Total	1 234 992	337	3 334 409

Source: ECOFUND and NFOŚiGW.

UNESCO list of global biosphere reserves. Moreover, the number of the other legally protected areas has still risen. At present, there are: 1269 nature reserves (covering 0.5% of the national territory and 1.4% of legally protected areas), 120 landscape parks (covering 7.8% of the national territory and 1.4% of legally protected areas), and 403 protected landscape areas (covering 22.9% of the national territory and 70.4% of legally protected areas). A new form of nature conservation are ecological usable lands of high importance for the preservation of biological diversity. They include marshes, peat swamps and natural water reservoirs. In 1999, an inventory of 5.3 thousand such sites has been completed covering the acreage of 38.1 thousand hectares.

Despite the favourable changes that ensued for the sake of nature conservation, there are still existing the areas of significantly damaged environment, including firstly the heavily industrialised and urbanised areas.

In 2000, the Council of Ministers adopted the Second State Ecological Policy, that formulates the basic principles, objectives and directions for the State policies in the field of environmental protection. The basic goal of this new ecological policy is to provide for the national ecological security (including the public, social infrastructure and natural resources) by means of the implementation of such national development model which would not pose any hazard to quality and sustainability of natural resources. As far as the air protection is concerned, this new policy assumes:

- enhancement of the list of pollutants subject to activities aimed at reduction or limitation of their emission and its adverse effects, including the substances which have effects on climate change;
- gradual elimination of pollutants at source by means of replacement of energy carriers with particular regard to renewable energy sources, application of cleaner raw materials and technologies, and minimising the use of energy and raw materials;
- enhancement of emission standardisation in industry, energy and transport sectors;
- broader implementation of product standards limiting air pollutant emission with regard to full life-cycle of the products.

2.4. Special circumstances of fulfilling the commitments by Poland

Following Article 4.6 of the Convention, and paragraphs 4a and 7 of Decision of the Second Conference of the Parties to the Convention, Poland recognises the purposefulness of flexible approach to fulfilling its commitments resulting from the Convention as regards the following matters:

- Poland has assumed 1988 as the base year for the assessment of its commitments; 1990 emission could be only used for the assessment of the state of global emission, but it should not constitute any basis to square up Poland of fulfilling its obligations resulting from the Convention;
- this Report was drawn up in accordance to reporting principles as adopted by the Fifth Conference of the Parties, and the required information scope and presentation form have complied with to far extent possible;
- given the long period needed to elaborate on official national statistics, statistical data presented in this Report cover the period by the end of 1999 inclusively, and where available – by the end of 2000 inclusively;
- it could be a case, that sectorial policies for greenhouse gas emission reduction and enhancement of its sink, as well as projections of greenhouse gas emission by sectors and gases might be presented here incompletely.

The reason, that Poland adopted the assumption concerning the change in the base year from 1990 to 1988 is the fact, that 1990 was the first year in Poland after essential political and economic transformation, that apparently demonstrated in staggering its economical stability[1]. It was just 1990, when the Polish economy temporarily collapsed. Therefore, the quantity of greenhouse gas emission in 1990 correspond neither to normal emission level, as it results from the national development needs, nor to factual Poland's economic potential. That is the reason why 1990 as the base year would not be conclusive for the Polish economy.

[1] Detailed explanation of the reasons which caused Poland to adopt 1988 as the base year was presented in the First Governmental Report for the Conference of the Parties to the Convention (1994).

3. INVENTORY OF GREENHOUSE GAS EMISSIONS AND REMOVALS

3.1. Emission inventory

Inventories of anthropogenic emissions by sources and removals by sinks provide the basis for an appraisal of the Parties, as listed in Annex I to UNFCCC, including Poland, in fulfilling their commitments imposed by them under Convention. This Chapter presents inventories of emissions and removals of the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), and the emissions of industrial gases: HFCs, PFCs and SF_6.

In the period between the base year (1988) and 1999, considerable change in greenhouse gas emissions was noted in Poland. In Figure 3.1, aggregate emission of greenhouse gases is presented, i.e. the sum of the three basic gases expressed as carbon dioxide equivalent (see also Annex A to this Report). Greenhouse gas emissions dropped mostly in the beginning of the nineties, whereas in 1990, the emission was as much as by 19% lower than in the base year. During subsequent 4 years, emission stabilised on similar level that accounted for 78–76% of 1988 emission. After 1994, the emission further declined, whilst interlarded with single insignificant rises. The mostly considerable drop was noted in 1998 and 1999, when the emission reached the level of 71% of the base year emission. The changes in greenhouse gas emissions were accompanied by a decline in energy use in the national economy, as well as by the change in fuel consumption structure in favour of hydrocarbon fuels containing lower carbon content.

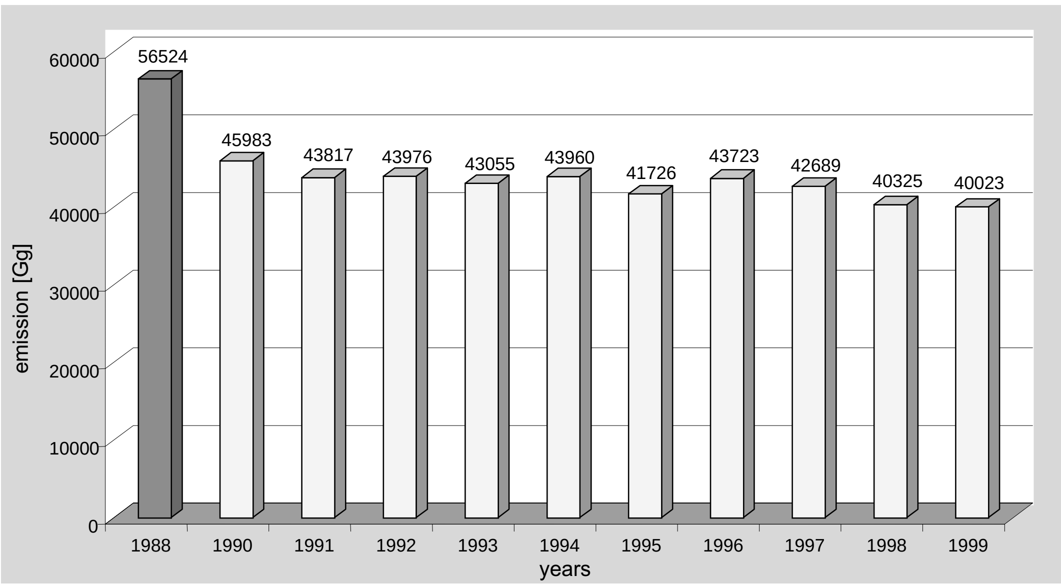

Fig. 3.1. Aggregate emission of greenhouse gases (CO_2 – excluding removals, CH_4, N_2O) in Poland in 1988–1999, source: MŚ

Table 3.1. Changes in emission of carbon dioxide, methane and nitrous oxide (CH_4 and N_2O expressed as CO_2 equivalent) in 1988–1999 [Gg]

Years	1988	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	477 584	381 482	367 689	372 311	363 980	372 293	348 926	373 202	362 300	338 095	329 739
CH_4	65 961	58 821	54 369	51 954	51 072	51 807	51 597	47 292	47 838	49 035	47 250
N_2O	21 700	19 530	16 120	15 500	15 500	15 500	16 740	16 740	16 740	16 120	23 250

Source: MŚ.

It is carbon dioxide, which contributes mostly to greenhouse gas emission, accounting for 84% of the total greenhouse gas emission, on average. Methane accounts for 12% of aggregate emission of greenhouse gases, and nitrous oxide for 4% of the emission. The proportions of the composition of aggregate emissions of greenhouse gas changed in 1999 in relation to 1988 towards reduction of carbon dioxide share to 82%, with parallel shift in nitrous oxide up-to 6%. That was accompanied by apparent rise in nitrous oxide emission which level exceeded the base year emission by 7%. In 1999 inventory, a modification was introduced, on the basis of results of domestic studies, into emission calculation methodology of this gas from its major emission source category, i.e. Agriculture, Sub-Categories 4.B: Manure Management and 4.D: Agricultural Soils.

It is the – Energy – IPCC Category, which contributes mostly to aggregate emissions of greenhouse gases, and which includes emission from fuel combustion and fugitive emission from fuels (Figures 3.5. and 3.6). That Category accounts for more than 84% of total emissions. Its share in 1988 accounted for 87.1%, and it fell in 1999 to 84.6%. The importance of the other sources is rather insignificant, while Agriculture remains the most important one, that in 1988 accounted for almost 5.5%, but shot up in 1999 to 7% of total emissions.

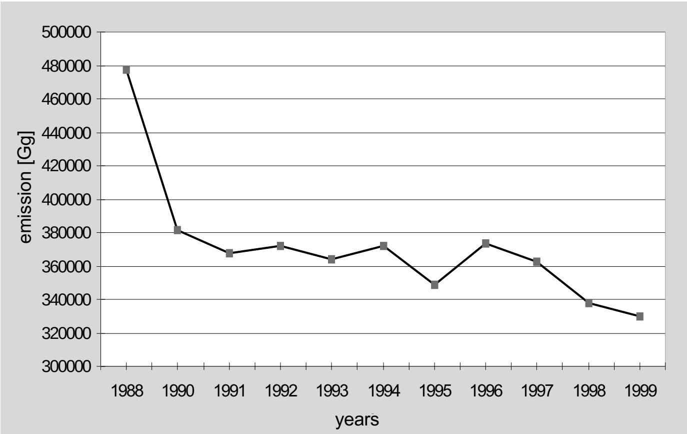

Fig. 3.2. Carbon dioxide emission (excluding removals) in 1988–1999, source: MŚ

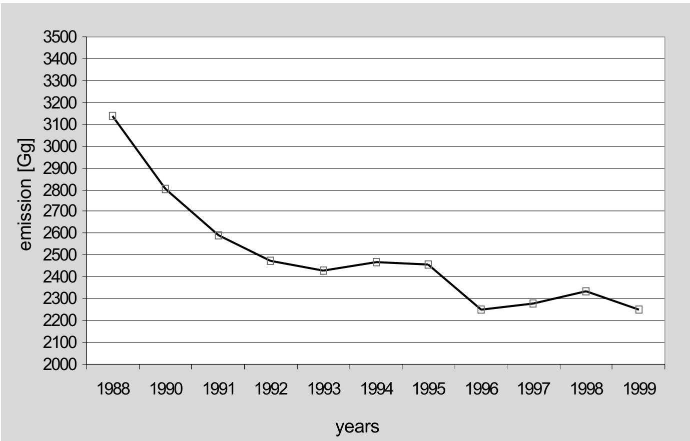

Fig. 3.3. Methane emission in 1988–1999, source: MŚ

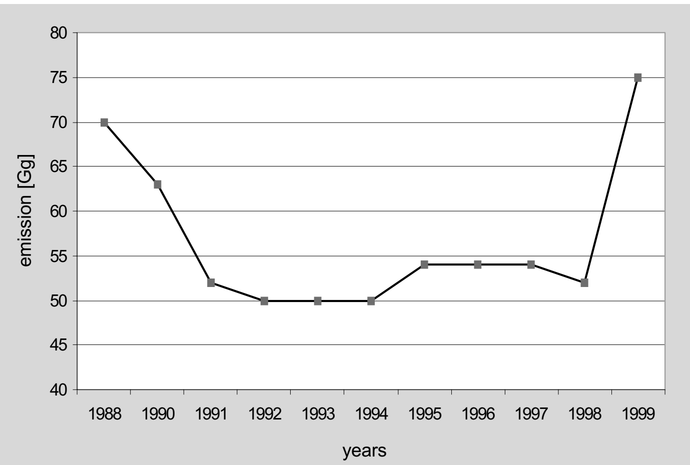

Fig. 3.4. Nitrous oxide emission in 1988–1999, source: MŚ

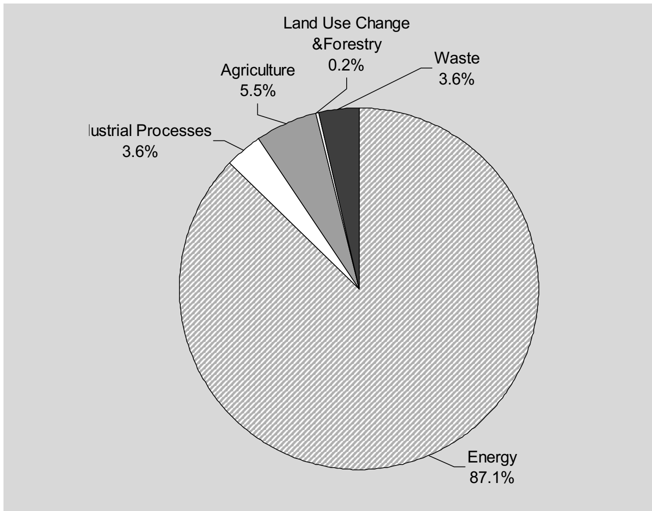

Fig. 3.5. The share of greenhouse gas emissions by source category in 1988, source: MŚ

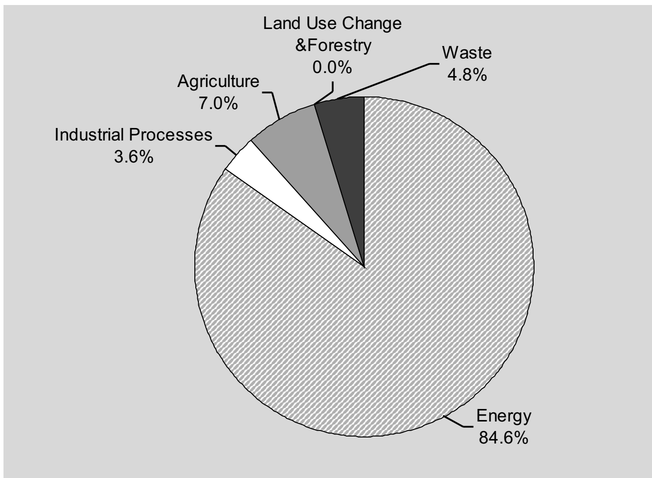

Fig. 3.6. The share of greenhouse gas emissions by source category in 1999, source: MŚ

3.2. Methodology

The inventories of emission by sources and removals by sinks in Poland were prepared following the methodology recommended by the Conference of the Parties, with adaptation of domestic performance to changes proposed in the IPCC methodology as improved since 1995. The inventories of greenhouse gas emissions and removals for 1988, 1990 and 1994 were prepared following the previous version of IPCC methodology Draft Guidelines for National Greenhouse Gas Inventory [1995], whereas the first originally prepared in Poland the 1992 inventory followed the OECD/IPCC methodology recommended by the Conference of the Parties to the Convention, that was published in 1994 in The Greenhouse Inventory Workbook. Draft Guidelines for National Greenhouse Gas Inventories. The results of these inventories were presented in the Second National Report to the Conference of the Parties to the Convention. The inventories of greenhouse gas emissions and removals for 1991, 1993, 1995, 1996, 1997, 1998 and 1999 were prepared following the basic principles included in mandatory version of IPCC methodology Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, i.e. with application of specific methods (Tier 2/3), but in few cases otherwise, with application of simplified methods, since the aforementioned were not applicable due to the availability of official statistical data. The structure of emission source and removal categories included in that methodology was fully complied with, except for the category of methane fugitive emissions from fuels, into which a new emission source was introduced in 1999, i.e. methane emission from closed down mines. In 1999 inventory, methodological modification was introduced regarding estimation of CO_2 emission and removal consisting in activity transfer from Sub-Category 5.C: Abandonment of Managed Lands into two other Sub-Categories of Category 5., i.e. Land Use Change & Forestry. No abandoned areas occur in Poland, i.e. there are no areas which would be left without any anthropogenic activity, since the areas, where agricultural use was ceased have been managed in favour of either forestry or municipal management.

The basic information sources on activities performed by particular emission sources are official publications by Central Statistical Office, i.e. Statistical Yearbook, Energy Statistics, and others such as: Industrial Statistical Yearbook, Forestry, Environmental Protection, Livestock, Application of Mineral and Calcium Fertilisers, as well as data published officially by Directorate General of the State Forests Enterprise. However, the structure of statistical data published by Central Statistical Office needs to adjust fuel use amounts to particular Sub-Categories of 1996 version of IPCC methodology.

For estimates, also non-published data is taken into account concerning engine fuels, that is elaborated by the Institute for Automobile Transport, and data obtained from the State Forests Enterprise on the amount of biomass increment, as estimated with application of regression method. As supplementary data, also statistical data from national agricultural census are used.

In order to reduce uncertainty in estimation of the quantities of greenhouse gas emission and removal, studies are performed successively on particular emission sources within the source-structure determined by IPCC methodology. All the emission and removal categories were comprised within such a study, when greenhouse gas inventory for 1992 was under preparation. These primary studies formed methodological basis for preparation of national inventory of greenhouse gases and for elaboration of input data files, including emission factors file (see Annexes B–L). These files were subject to continuous supplementing with data included in subsequent versions of IPCC methodology (Standard, Revised) and in other methodologies (EMEP/CORINAIR), and also in documents from institutions, who co-operate with UNFCCC. In subsequent years, the following source categories were subject to detailed studies in the framework of preparatory works on the inventories:

- Land Use Change & Forestry (Category 5) (1988, 1990 and 1994),
- Transport (Sub-Category 1.A.3) (1996),
- emissions of HFCs, PFCs and SF_6 (1995–1999).

Land Use Change & Forestry Category was subject to additional studies in 1997 because of essential change introduced in methodology of this category made in 1995 IPCC methodology version (Standard), and then slightly modified in the Revised 1996 IPCC version.

The recent detailed studies performed for the purpose of 1999 inventory regarded the following emission sources and removal categories:

- Enteric Fermentation (4.A),
- Manure Management (4.B),
- Agricultural Soils (4.D),
- Land Use Change & Forestry (5),
- Landfills (6.A)
- Transport (1.A.2.g, 1.A.3, 1.A.4.c.ii, 1.A.4.c.iii and 1.A.5.b),
- Fugitive Emissions from Fuels – Coal Mining (1.B.1).

Further detailed studies to verify information on source activity and to update the values of emission factors will be carried out in the framework of annual inventories of greenhouse gases.

Following the recommendations of Article 5.1 of the Kyoto Protocol, steps are made towards establishment of the national inventory and reporting system in Poland, that aim is to make greenhouse gas emission and removal assessment possible in the context of the national commitments assumed. The first step to create such as system in Poland was the establishment of the National Centre for Emission Inventory and the Polish UNFCCC Executive Bureau, both managing their close co-operation with the Ministry of Environment.

4. POLICIES AND MEASURES TO MITIGATE GREENHOUSE GAS EMISSION

4.1. General context of the mitigation policy

The process of restructuring of the national economy which has originated since the beginning of the nineties has resulted in significant reduction of greenhouse gas emission, in particular of carbon dioxide which is the prevailing greenhouse gas emitted by Polish economy. The process of emission reduction tends to continue and according to some predictions it will long for a few more years. By the reduction, Poland fulfils its obligations imposed by the Climate Convention and built up an emission reserve, which makes it easier to fulfil the obligations of the Kyoto Protocol. Thus, no need to undertake any specific actions aimed at emission reduction is expected in the period by 2008. The policy is still to be effective to continue the actions which are favourable from the point of view of improvement in energy efficiency of economy, while leading to parallel emission reduction.

The tasks of the policy aiming at the improvement in energy efficiency and minimising the impact of the power engineering sector on the environment were included in the following governmental documents prepared in 2000 titled Assumptions for Energy Policy for Poland until 2020 (within the framework of the Act on Energy Law), Strategy for Use of Renewable Energy Sources, The Second State Ecological Policy and Poland 2025 – Long-Term Strategy for Sustainable Development.

In both in the Assumptions for Energy Policy for Poland until 2020 and The Second State Ecological Policy provisions are included relating to the Climate Convention and the Kyoto Protocol. Thus the obligation of Poland to mitigate the emission of CO_2 in the period between 2008–2012 is reflected in the Assumptions for Energy Policy for Poland until 2020 according to which it is expected that CO_2 emission as predicted for the period between 2010–2020 will be significantly lower than in the base year 1988 in result of coal to gas conversion as well as of the improvement in energy efficiency in the entire transformation chain (from the moment of its extraction, to the end user). Further international co-operation with respect to the actions taken within the framework of the UN Framework Convention on Climate Change and ratification of the Kyoto Protocol have been accounted as the priority goals in The Second State Ecological Policy.

In accordance with the above mentioned governmental documents, the reduction of energy intensity is to be achieved by means of reduction of the hard coal and lignite share in the demand for primary energy to the level of 60% in 2025 and increase in renewable energy share in the national balance of primary energy at least up-to 14% by 2020 and up-to 1% of the energy recovered from waste. Also, limitation of thermal and electric energy losses in the transmission systems to the level not exceeding 20% is expected.

The dynamics of changes of carbon dioxide emission in the basic production branches between 1991–1995 has been presented in the Second National Report. Table 4.1 below, such changes are given for the period of 1995–1997.

Table 4.1. Emission changes in the years 1995–1997 [Mg]

Industry Branches	CO_2	CH_4
Petroleum refining	–4 245	0
Coke products	–375 494	–5 119
Hard coal mining and flotation	–370 052	–55
Brow coal mining and flotation	–39 348	0
Extraction of petroleum	3 078	0
Iron ore mining, cast iron	–547 273	1 141
Production of non–ferrous metals	–11 952	190
Manufacturing metal finished product	25 182	4
Manufacturing machines and facilities	–1 021 944	–8
Manufacturing fine mechanical equipment	–28 198	0
Manufacturing transport equipment	–145 587	21
Manufacturing electronic equipment	–150 216	0
Mining of mineral raw mat. salts and chemicals	–3 286 653	–12 689
Production of building materials	–404 333	1
Production of glass and glassware	–252 158	–3
Manufacturing whiteware	–42 428	2
Prod. of timber and its products (excl. furniture)	78 428	9
Production of cellulose, paper and articles	87 993	11
Woven fabric production	–437 675	–2
Manufacture of clothing	–58 005	0
Manufacturing leather products	–39 281	0
Production of foodstuffs and beverage	36 553	16
Production of animal fodder	6 965	0
Typographic and publishing activities	–10 320	0
Other industrial branches	–6 705	0
Total	**– 6 993 668**	**– 16 481**

"–" means reduction of gas emission
Source: IOŚ.

Environmental funds, who finance investment projects related to environmental protection, including climate protection, play substantial role in the process of mitigation of greenhouse gas emission in industrial sectors of the economy. For more detailed description of the above mentioned role of environmental funds – see Section 2. Table 4.2, below, shows a selection of such actions taken in the period of 1996–1999.

With respect to transportation, the long-term strategy provides for actions aiming at, inter alia, mitigation of greenhouse gas emission through development and modernisation of the road system, modernisation of the railway infrastructure, utilisation and development of water transport or bicycle transport in urban areas.

Table 4.2. Selected instances of upgrading and new investment projects financed by the National Fund for Environmental Protection and Water Management and ECOFUND in 1996 – 1999

Investment Project	CO_2 Reduction [Mg/year]
Liquidation of low emission and optimisation of heating system in Wrocław	640 254
Modernisation and conversion of the 2nd Power Station into Urban Combined Heat and Power Station	411 156
Construction of heating system main 2x 800 connecting the 1st CHP and 2nd CHP	85 000
Reconstruction and modernisation of the Solina Hydro-Power Plant	61 259
Construction of heating system in the Sochaczew Municipality – Phase One	50 860
Construction of geothermal system in the Podhale Region including installation of heat exchangers on the sites	32 760
Modernisation of heating system in Melioration and Grassland Institute, in Falenty	32 522
Modernisation of heating system in residential buildings (conversion of coal-fired boiler houses into those gas-fired)	31 759
Modernisation of main drainage system in the Olkusz–Pomorzany Mine	29 508
Modernisation of the Piaskówka Heating Plant – liquidation of Lwowska Boiler Plant in Tarnów	17 050
Modernisation and converting of a coal-fired boiler house into a gas- and oil-fired boiler house at F.A.M. S.A., in Chełmno	12 980
Modernisation of urban heating system in Biskupiec	10 943
Modernisation of heating system in the “Northern” region in Starachowice	10 327
Construction of the Barzowice Wind Power Station with 4.998 MW rated power	10 072
Modernisation of heating system in the “Świt” Housing Co-operative	18 715
Comprehensive Modernisation of heating system in Dzierżoniów	27 723
Reduction of atmospheric pollutant emissions in Katowice CHP	163 322
Modernisation of heating system in Ustka	25 220
Modernisation of heating system in Sopot	33 104
Modernisation of heating system in Wrocław	106 672
Liquidation of low emission in Kudowa Zdrój	10 491
Modernisation of technology process in Paper-Mill, in Bardo	12 507
Installation of gas turbine in Wizów CHP	34 428
Installation of gas turbine in Rzeszów CHP	461 002
Methane utilisation in Borynia Mine to generate utility heat	24 684
Utilisation of waste natural gas for heating purpose in the Municipality of Krokowa	101 437
Utilisation of biomass in heating systems in Wejherowo	17 780
5 MW wind power station in Barzowice	12 670
Utilisation of straw for energy generation in CHP in Lubań	10 573
Total	**2 496 778**

Source: ECOFOUND and NFOŚiGW.

4.2. Measures implemented and their effects in some selected economy sectors

4.2.1. Power engineering sector

As a result of significant decrease in demand for energy in the period between 1988–1999, demand for primary energy diminished, that is presented in Table 4.3, below.

As it appears from Table 4.3 the use of energy carriers decreased, as compared with that in the base year 1988, primarily coal consumption (by about 40%), whilst hydrocarbon fuel consumption increased slightly (by 5–6%) at the same time. The increase in gas consumption and decrease of coal consumption is especially marked in the public power plant sector. Due to the decrease of the primary energy consumption and the change in fuel combustion structure in the public power plant sector, the carbon dioxide emission level has gone down by around 29%.

Table 4.3. Dynamics of changes in use of primary energy carriers in Poland

Annual consumption (1988=100)		
Years	1998	1999
Primary energy	77.1	71.4
Solid fuels	66.8	59.4
Gaseous fuels	109.0	106.1
Liquid fuels	100.6	105.0

Source: IOŚ.

Production activity of the public power plants and cogeneration plants decreased by 1–1.5% in relation to the base year. Domestic consumption of electricity fell by much more; in 1998, it was lower by about 6.5% and by nearly 8% in 1999 when compared with the base year 1988.

The actions performed in the public power engineering are based on the National Programme for Integration with the European Union, the Assumptions for Energy Policy for Poland until 2020, as well as the Agreement signed in 1996 between Minister of Environment and Minister of Economy concerning the program of SO_2 emission reduction by 2010. As a result of the implementation of the aforementioned policies, a programme has been implemented aiming at the improvement in hard coal quality and the operational efficiency of power plants and cogeneration plants through the modernisation of turbines and combined generation of heat and power. The following are the most important actions aimed at mitigation of greenhouse gas emission, which have been introduced under provisions of the Act on Energy Law:

- imposing an obligation to purchase electricity generated in combination with heat generation;
- the obligation to purchase heat and electricity from renewable and non-conventional sources;
- statutory determination of the maximum level of fixed transmission charges amounting to 40% in case of gaseous fuels and electricity, and 30% for heat.

The actions taken in the public power plant sector have resulted in structure of fuel combustion being changed. It is reflected in a decrease of the consumption of hard coal, brown coal and fuel oil in favour of an increase in natural gas consumption. The list of actions implemented or planned to implement in the future is presented in Table 4.4.

4.2.2. Hard coal mining

In 1998, the Council of Ministers adapted governmental programme: Reform of the Hard Coal Mining in Poland in 1998–2002. Implementation of the Reform is supported by the Act of 26 November 1998 on the Harmonisation of Hard Coal Mining with the Performance in Free Market Economy and on Special Rights and Challenges for Mining Municipalities. In December 1999, the Council of Ministers approved a corrigendum to the governmental programme, the result of which was an amendment to the Act of 1998. The Act on the Harmonisation of Hard Coal Mining with the Performance in Free Market Economy and on Special Rights and Challenges for Mining Municipalities was passed by the Parliament of the Republic of Poland on 15 December 2000.

The results of the implementation of the governmental programme in the period between 1998–2000 were following:

- reduction of the production capacity of the mining sector by 26 million tonnes per annum;
- liquidation of twenty-one coal mines (twelve of which number were totally liquidated and nine of them partially); and
- employment level declined by more than 88 thousand people (36.3%).

The reduction of the employment in mining sector was effectively backed up by the so called Mining Social Package, of which more than 61 thousand persons benefited. Such effective fulfilment of the governmental programme aimed at restructuring of mining sector was possible due to the support from the Sate budget, which amounted to PLN 4.4 billion. In 1999, financial results in mining sector were below the prediction included in the Programme that resulted from a decrease in sales of coal and its prices. However, as early as in 2000, mining sector achieved positive unit result on sales of coal.

Table 4.4. Examples of policies and measures aimed at mitigation of greenhouse gas emission in energy sector

Name of policy or measure	Instrument Type[1]	Objective and/or activity affected[2]	Status of the Action Progress[3]	Implementing entity or entities	Estimate of mitigation impact by gas [thousand tonnes/year]	
					2000	2005
1. National Programme for Integration with EU: ❑ Establishing of free market principles in power gas engineering sectors	Law adaptation / organisation and ownership reform, policy of privatisation of the power engineering sector	Improvement of economy and energy efficiency of power engineering companies	Decision in accordance with the negotiation schedule	RM/MG, MSP		
2. Assumptions for Energy Policy for Poland until 2020 (ZPE20) (Document of the Council of Ministers of 22/02/2000)	Obligatory for public administration; for reference only for the other entities	Objectives: safety, competitiveness, environmental protection. Impact on all the components of environment	Effective from 22 February 2000 upon a Decision of RM (the Council of Ministers)	The Council of Ministers and entire central administration and Voivodes RM	About 480 (about 0.7% increase of combined methods from 12.1% to some 12.8%)	About 6517 (an increase of combined methods from 12.1% to 22%)
a) strategy for transitional period: ❑ restructuring of hard coal mining	Special Act on Restructuring of Hard Coal Mining	Economical level of coal production. Improvement of coal quality and CH_4 reduction	Valid from 15/12/2000[4]	RM, MG		
❑ Long-term contracts	Of civil law and regulatory character, of legal character – MŚ Ordinance	Modernisation of public power engineering. Reduction of atmosphere pollution. Emission standards and charges	System of Compensation Charges included in the Second Environmental Policy; Ordinance of MŚ[5]	President of URE and Power Stations and CHP's		
❑ Restructuring of PGNiG	Of legal character	Basis to create a market structure	Governmental Strategy of Privatisation of PGNiG adopted in 2000	MSP, MG, RM and PGNiG		
❑ Self-governmental offices and power engineering companies (PEN)	Of legal character	Development of local markets including OZE	Decided in 1997 upon the Act on Energy Law, in the course of implementation	President of URE, Self-governmental offices, PEN		
❑ Monitoring system	Recommendation of RM	Supervision over ZPE20 effectiveness	Being considered	MG, URE		
❑ New sources of gas supplies	Of legal character	Safety of deliveries, reduction of GHGs emission	Act of 26/05/2001 on Amendments to the Act on Energy Law (PE) is still effective	MG, PGNiG		
b) strategy of integrated management of energy and environment: ❑ pinch technology analysis ❑ promotion of OZE ❑ emission trading (SO_2 and CO_2)	Legal, economical and regulatory instruments are expected to be used	Improvement of energy efficiency of companies, and increase of competitiveness with significant reduction of emission and at the cost as low as possible for companies and the whole country	Recommended upon ZPE20 and Resolutions of the Parliament of the Republic of Poland. There are projects of amendments to some Acts and Ordinances of MG. It has been implemented since 1998	MG, MŚ, President of URE		

Table 4.4. Continuated

<table>
<tr><th rowspan="2">Name of policy or measure</th><th rowspan="2">Instrument Type[1]</th><th rowspan="2">Objective and/or activity affected[2]</th><th rowspan="2">Status of the Action Progress[3]</th><th rowspan="2">Implementing entity or entities</th><th colspan="2">Estimate of mitigation impact by gas [thousand tonnes/year]</th></tr>
<tr><th>2000</th><th>2005</th></tr>
<tr><td>c) strategy of organisational and technological decentralisation of power engineering systems:
❑ investment policy
❑ development of small CHP's
❑ development of local markets – local resources (OZE and others)
❑ assumptions and plans of communes and plans of companies</td><td>Of legal, regulatory, information and education and research character</td><td>Development of local energy markets, increase of OZE share, development of small CHP sources, stimulation of activities in communes – as a result, significant growth of energy use efficiency is expected.
Strong rationalisation of the energy use and decrease of emission level.</td><td>Decided upon the Energy Law:
OZE + commune plans – heat, from 1997,
commune plans – energy from 1998,
CHP from 2000,
MG Ordinance of December 2000</td><td>MG, territorial self-governments and power engineering companies</td><td></td><td></td></tr>
<tr><td>d) strategy of liberalisation of energy efficiency:
❑ privatisation policy
❑ regulation policy
❑ price policy</td><td>Market reform in power engineering sector, of legal and regulatory character as well as implementation of competitiveness, including TPA</td><td>More severe competitiveness in the sector, acquisition of investment capital for development and budget and improved customer service</td><td>Decided and implemented since 1990 and 1997 (PE); revised in 2000 (PE) and ZPE20. Price regulation since 1999 (electricity) and 2000 (gas)</td><td>MSP, MG, President of URE</td><td></td><td></td></tr>
<tr><td>e) strategy of improvement of energy efficiency:
❑ policy of rationalisation of the utilisation of fuel and energy
❑ policy of promotion
❑ educational and research and information policy</td><td>ZPE20 recommends legal, regulatory and supporting instruments (of information and education and research character). PE promotes CHP</td><td>Lower energy intensity and energetic costs. Improved competitiveness, rational resource management, environmental protection, meting international obligations and those of integration with EU</td><td>Decided in 2000 and implemented upon PE since June 2000; no amendment to MG Ordinance, the work on a draft of the Act is not continued</td><td>MG, MŚ, President of URE, MSWiA, UKIE, KBN</td><td></td><td></td></tr>
</table>

1 The instruments are: of economical, fiscal, voluntary, information and educational character, education, research programme (EU) and other.
2 Types of gas which are affected by business activities, emission factors, and/or accompanying interactions.
3 Action progress status can be: sensible, distinct (year), implemented (year), definite financial expenditures (years, amounts), financing sources planed (years, amounts), expected date of completion (year).
4 Act of 15 December 2000 on Amendments to Act on the Harmonisation of Hard Coal Mining with the Performance in Free Market Economy and on Special Rights and Challanges for Mining Municipalities.
5 Ordinance of the Council of Ministers of 30 December 1997 concerning charges for Emitting Pollutants to the Atmosphere and Cutting Trees and Shrubs, as recently amended by Ordinance of 28 December 2000 and Ordinance of MOŚZNiL of 8 September 1998 concerning Emitting to the Air Pollutants from Technological Processes and Technical Operations.

Source: IOŚ.

Moreover, the Governmental Programme for the reform of the mining sector envisages also, that:

- the production capacity of the mining sector will decrease by around 36 million tons annually, by 2002;
- the employment level will be lower by about 48 thousand people between 2000–2002; and
- the impact of coal mines on the environment will be less intensive and damages to the environment will be reduced, that should result in the environmental protection requirements being complied with within entire hard coal mining sector (by 2005, at the latest).

4.2.3. Cement industry

The production of clinker has been systematically falling down in relation to the base year, in line with a decrease in the unit heat consumption. Those changes are illustrated in Table 4.5, below.

Table 4.5. Changes in clinker production and heat consumption

Years	Cement Clinker Production [thousand tonnes]	Heat Consumption [kJ/kg]
1988	13 387	6 158
1995	12 602	5 316
1999	11 678	4 487

Source: GUS.

The above mentioned production decline and improved energy efficiency of the production process have resulted in carbon dioxide emission in the sector being decreased by 25%, in comparison with 1988 base year. That was possible due to modernisation of production process in the existing cement plants and, first of all, elimination of the wet method of burning clinker and adopting a dry technology. In the period between 1997–2000, seven of the major cement plants were modernised with the use of such method by means of making twenty-seven kilns using wet technology non-operational. At present, dry technology is used in seventeen kilns in the sector accounting for 70% of the clinker output (60% of clinker was produced using the method in 1999). Wet technology is still used in nineteen kilns.

According to the assumptions of industrial policy for Poland, it is planned to eliminate wet technology totally by 2010. Also, it is expected that the clinker output will increase by about 13 000 thousand tons and the average heat consumption will amount to 3350 kJ/kg then. It means, that the level of carbon dioxide (11 330 thousand tons) will be maintained somewhat below the value of 1999 (11 550 thousand tons).

4.2.4. Metallurgical industry

Modernisation and restructuring of the Polish metallurgical industry, that have been carried out since the beginning of the nineties, including the Programme of Restructuring of Iron and Steel Industry in Poland adopted in 1998 and updated on 21 June 2001, have led to:

- reduction of employment by around 85 thousand people in the period of 1991–1999;
- reduction of nearly 35% of the pig iron production potential;
- significant decrease of the open-hearth technology in steel production process down to 4%;
- adopting low energy and material consumption technologies of steel continuous casting, which has resulted in the increase of the share of this method in the total production output from 8% to 70%,
- elimination from the production process of outdated and inefficient production lines.

Due the liquidation of the exhausted potential in the production of coke, sinter, pig iron, the energy efficiency of metallurgical industry has been improved.

4.2.5. Refrigerating engineering

Some measures are adopted in the refrigerating engineering sector to replace, in the refrigerating systems, the cooling gases which are subject to the obligations of the Montreal Protocol, with their substitutes R134a and R141b, as well as to diminish the production energy intensity consisting, inter alia, in improved operating efficiency of industrial systems, and in waste energy recovery.

In the period of 2000–2005, it is planned to develop new insulating materials and technologies for household refrigerators, commercial furniture, cooling chambers foamed with the use of CO_2, HFC and pentanes, eliminate successively R141b and reduce the utilisation of R22. In addition, it is expected that high-performance, up-to-date refrigerating machines will be developed, as well as technologies enabling further recovery of waste energy and use of renewable energy sources. As a result of these actions, it is intended to achieve further greenhouse gas emission reduction by 20%, in relation to refrigerating and foaming media, and by 6% in relation to energy consumption.

An example of the measures adopted to mitigate emission in one of the largest manufacturing plant of refrigerating systems is presented in Table 4.6.

Table 4.6. The scope of implemented or planned to implement measures to reduce greenhouse gas emission at Zamex Żagań Works, who manufactures refrigerating systems

Activity area	Type of Measures Implemented	Time-limit/ Implementation Progress	Assessment of Impact on Greenhouse Effect
Replacement of refrigerating agent	1. Substitution of R134a refrigerating agent instead R12 freon	1995: project implemented	Elimination of R12 consumption amounting to about 20 tonnes/year
	2. Utilisation of R600a agent in manufactured refrigerating systems	Project implementation envisaged for 2000–2005, in 2002 it is still in its research and development phase	
Replacement of polyurethane foam formation process	1. Adoption of a stiff polyurethane foam formation system using R 141b	Project already implemented in 1994/1995	100% elimination of R11, amounting to about 40 tons per year
	2. Adoption of a polyurethane foam formation system with the use of cyclopentane (C5)	Project already implemented in 1999	Foaming system based upon C5, completely environmentally friendly; use of R141b eliminated in the production process by in about 36 tons in 2000
Reduction of energy intensity	1. Alteration of insulation layer thickness in manufactured products	1997/1998: insulation layer thickness increased up to 80 mm in five types of products TZ/PM 450 and TZI30/170/270	Decrease of electric energy consumption by about 15% (0.17 kWh/24h per product on average)
	2. Modification of evaporator structure and technology with the view to improvement in efficiency of the refrigerating system	1999: a new type of evaporator was developed, that is constructed of aluminium pipe arranged spirally and adhering tightly to the walls of cooling chamber	Improvement in efficiency of refrigerating system, that results in reduced energy intensity by 5% (0.055 kWh/24h per product on average)
	3. Application of energy-saving compressor technology	2000–2005: once research and development works are completed on selected compressors, less energy-consuming compressors made by DANFOSS and ELEKTROLUX will implemented	Decrease in electric energy consumption by about 30% (on the average 0.45 kWh/24h/product)

Source: ICP.

4.2.6. Transport

In the period of 1990–1995, several actions were undertaken which resulted in keeping the emission increase within the limits. Those actions are presented in the First and the Second National Reports. The fundamental problem faced by the sector is a constant increase in the number of vehicles.

The increase in the number of vehicles amounts to above 700 thousand per annum, but the increasing trend seems to slow down. Nevertheless, the number of passenger cars per 1000 population amounts only to 245 and is lower than the average in OECD (400).

Predicted changes in the cargo and passenger transport for various transport modes are shown in Tables 4.7 and 4.8. The prognostic values for 2020 included in the Tables represent averaged values derived form two variants of the dynamics of transport use, as developed for different growth levels in GDP, whilst the difference between these two variants does not exceed 20%.

Further increase in N_2O emission from road transport is expected, due to the increase in the number of cars provided with three-way catalytic converters, and a significant reduction of velocity because of impediments in urban traffic.

General target of transport policy for the period of 2000–2015 is to achieve sustainable transport system in respect to its technical, spatial, economic, social and environmental aspects in conditions of intensively growing free market economy and improvement of life quality. The accomplishment of this goal is possible by:

- ❒ gradual changes of present transport operational system;
- ❒ adaptation of new technical, organisational and legal solutions taking into consideration internal and external conditions;
- ❒ implementation of international agreements on transport and fulfilment of international requirements concerning market of transport services.

The Draft State Transport Policy for the period of 2000–2015 provides, inter alia, for:

- ❒ Development of transport needs (rationalisation of demand for cargo transport and individual mobility of the public) as well as promotion of passenger collective transport, and bicycle and pedestrian transport;
- ❒ Establishment of mechanisms in favour of the performance of passenger and cargo transport, including promotion of transportation means using reduced pollutant emission and energy consumption;

Table 4.7. Prediction of the size and structure of cargo transport

Specification	Years			
	1998		2020	
	billion tonnes per km	%	billion tonnes per km	%
Railway transport	61.8	19.5	45.0	11.5
Road transport	69.5	21.9	157.5	40.1
Maritime transport	166.1	52.4	162.5	41.4
Other transport	19.6	6.2	27.5	7.0
Total	317.0	100.0	392.5	100.0

Source: IOŚ.

Table 4.8. Prediction of the size and structure of passenger transport

Specification	Years			
	1998		2020	
	billion passengers per km	%	billion passengers per km	%
Intra-housing estate public transport	65.3	34.9	60.0	23.4
Municipal transport	25.7	13.7	27.5	10.5
Individual transportation means	96.0	51.4	170.5	66.1
Total	187.0	100.0	258.0	100.0

Source: IOŚ.

- Introduction of economical and fiscal instruments focused on sustainable development of transport (road charges, differentiated fuel prices and other fees proportionally to the level of pollutant emission and fuel consumption, etc.);
- Elimination of the transportation means which do not conform to environmental standards;
- Establishment of the conditions for alternative fuels to be introduced;
- Establishment of mechanisms supporting the use of 'cleaner' transport (railway, shipping);
- Promotion of combined transport;

4.2.7. Construction and housing sector

Among the factors negatively affecting atmospheric pollutant emission in cities, as result from this sector, they are low energetic standard of the existing building resources, that requires increased heat amount supplies for heating purposes and for water warming, as well as the unfavourable structure of the energy carriers which contribute to so called "low emissions". The role of the Government in the sector resolves itself into creation of formal and legal instruments contributing, inter alia, to reduction greenhouse gases. These measures include:

- reduction of the "low emissions" in the areas of urban agglomerations by means of modernisation of existing heat sources and by fuel conversion;
- improvement of energy standard of existing buildings by means of their thermal modernisation;
- application of the more stringent energy standards in the newly built houses.

In the period of 1995–2000, the actions related to the existing building resources, in the first period (until 1997), included granting subsidies from the state budget to thermal modernisation projects. By 1997, in the framework of this system, in above 10% of the housing resources were insulated, thermostatic valves and heat water meters were installed, as well as faulty heating systems were replaced in more than 6% of all apartments in towns. Heat meters were installed in heat distribution stations in 40 700 buildings.

Since 1999, once the Thermal Modernisation Act became effective, such actions have been performed under this Act. The Act has provided the provisions for State financial assistance for investors undertaking investments resulting in thermal modernisation by means of bank credits contracted in commercial banks. The assistance in form of thermal insulation premium is conferred in amount of 25% of credit utilised for investment project and is paid back directly to the bank as the part of contracted credit. In order to improve the effectiveness of the programme and to increase the number of the investment projects supported by the State, the Act laying down the legal basis for this programme was amended. Adopted on 21 June 2001 The Act on the Amendments to the Act on Supporting Thermal Modernisation Undertakings introduced certain changes which made the credits more accessible for investors. The premium will be now paid directly on the completion of the thermal modernisation project, and not as it used to be earlier, when the investor has paid back his utilised credit, as diminished by the premium granted, as well as the maximum time-period for credit repayment has been extended from seven to ten years. By the end of May 2001, 353 premiums were granted to the applicants for thermal modernisation of buildings, those amounted to 5.5 million PLN.

In relation to newly erected buildings, their thermal protection standards were modified and adapted to meet the European Union requirements. Since 1995, ISO and EN standards have been introduced. It is expected that in 2001 the work on the guidelines for energy audits will be completed and amendments will be introduced to the building regulations with details concerning technical conditions to be complied with by buildings and their location. Among numerous changes planned, there are, inter alia, new requirements which concern making the standards more the stringent with respect to energy efficiency of hot water supply heating installations, and ventilation and air conditioning systems. Table 4.9 presents aggregated effects of such actions co-financed with the resources from environmental funds.

Table 4.9. Reduction of carbon dioxide emission in the municipal sector as results from implementation of projects financed by the National and the Voivodship Funds for Environmental Protection and Water Management and the ECOFUND in 1996–2000 [Mg]

Project type	CO_2 reduction	
	ECOFUND	The National and Voivodship Funds
Modernisation of heating systems	925 688	989 236
Fuel conversion	589 393	249 462
Utilisation of waste heat	1 331 230	–
Renewable energy sources	162 314	132 859
Improvement in energy efficiency	–	452 961
Other	–	11 655
Total	3 008 625	1 836 173

Source: ECOFUND and NFOŚiGW.

4.2.8. Waste and sewage management

The emission of carbon dioxide and methane related to waste management declined by about 50% in 2000 in comparison with the base year 1988. That resulted, inter alia, from the implementation of the programme for setting up the installation of degassing systems, the numbers of which has risen at the annual rate of 2.5%.

So far, the systems with controlled biogas burning in torches, or in power units, have been installed at 17 waste landfills. The total of 37 Gg biogas is burned annually, which equals to about 10 Gg methane. The structure of biogas utilisation is as follows:

- in power generation units – 6076 kW_{el}
- in power generation units with heating element – 2476 kW_{th}
- in torches – 7750 kW_{th}
- in boilers – 100 kW_{th}

In accordance with the European Union requirements, Poland will adopt three basic measures with respect to waste management, namely:

- segration of waste materials before they are deposited;
- collecting and neutralisation of biogas from very beginning of waste deposition;
- covering with compost layer the parts of landfills which are not subject to exploitation.

Furthermore, in order to satisfy the requirements of the European Union, small municipal landfills are to be successively suppressed and waste recovery plants built instead, those will serve at least 50 thousand inhabitants.

In the period between 2000–2005, the methane emission from waste landfills should be maintained on the level registered in 2000, i.e. 475 Gg/year. Maintaining this level will be possible thanks to implementation of the following tasks:

- maintaining the present rate of erecting the degassing installations;
- gradual application of degassing methods with heat recovery at medium size landfills;
- enhancement of emission monitoring at landfills;
- testing the landfill gas resource rate;
- provision of training for investors and landfill personnel.

Prognosis of greenhouse gas emission from landfills in the period between 2000–2005 is shown in Table 4.10.

Limitation of greenhouse gas emission in waste-water treatment plants is to be imposed through the following measures:

- applying technologies of biogas collection and its utilisation;
- adopting biological processes of treatment using the most up-to-date technologies available;
- lowering the energy intensity level of the treatment process;
- making waste-water treatment plants self-sufficient in terms of energy through utilisation of biogas with the use of combined methods of heat and power generation.

The aforementioned actions should, first of all, result in reduction of methane emission. In the period between 2000–2005, waste-water treatment plants are to be successively modernised in order to adapt their parameters to meet the requirements of the European Union. With new systems installed, it should be possible to manage about 2.6 million m^3 biogas. However, on the other hand, the increase in the number of new waste-water treatment plants and the growth sewage volume may result

Table 4.10. Quantitative evaluation of possible greenhouse gas emission reduction from landfills in the period of 2000–2005

Action Type	Effects on Individual Gases [Gg/year]	
	CH_4	CO_2
Construction of 400 kW/year biogas energy systems	– 2	+ 3
Processing of 2% of waste annually to produce compost for the purpose of the landfill to coverage and relevant land reclamation	– 8	+ 11
Modernisation of medium-size landfills together with their degassing (1 installation constructed each year, capacity of 300 m^3/h gas)	– 2	+ 3
Natural increase in waste production	+ 12	+ 60
Final effect – increase in comparison with 2000	0	+ 77

Source: IOŚ.

in an increase of carbon dioxide emission up to 300–350 Gg/year with methane emission being maintained at the level of 95 Gg/year. A collective list of measures taken in order to mitigate the greenhouse gas emission from landfills and waste-water treatment plants is shown in Tables 4.11 and 4.12.

4.2.9. Agriculture

The objectives of the policy of development of rural areas and agriculture in Poland relate, inter alia, to: redevelopment of the agriculture sector structures in order to improve the area structure of farms, modernisation of farms

Table 4.11. Actions leading to reduction of greenhouse gas emission (CO_2 and CH_4) from municipal waste landfills and waste-water treatment plants up to 2000

Tasks	Instruments	Progress Status as at the end of 2000
Starting up the landfill degassing and heat and power generation systems or burning the gas in torches or oxidation in biofilters	Landfill gas monitoring instruction. Recommendations to construct and operate systems of landfill gas extraction and utilisation. Ordinance of the Minister of Economy of 2 February 1999 concerning the obligation to purchase electric energy and heat from renewable energy sources.	Total of 22 biogas utilisation systems were started in which 22.58 Gg of biogas were burned and 34,025 MWh of electric energy as well as 12,128 MWh of thermal energy generated. Monitoring of biogas from municipal landfills in Poland (since 1991, work in progress).
Limitation of biodegradable waste depositing	New technologies of utilisation and rendering selected groups of waste harmless (among others biodegradable waste).	Starting of the production of equipment which supports the process of composting: ❑ mobile rotary sieve; ❑ compost mass spreaders; ❑ biological-kitchen waste disintegrator. Composting of 211.7 thousand tons, which represents 1.8% of the total municipal wastes.
Collection and utilisation of biogas in waste-water treatment plants	Greenhouse gas monitoring from waste-water treatment plants (2001 Plan). Recommendations to construct and operate systems of energetic utilisation of biogas in waste-water treatment plants (2001 Plan).	As at the end of 2000, thirty-nine systems of the total burning output of 58.3 Gg of biogas.
Management of sludge using natural methods	Development of a technology and guidelines for technical and economical assumptions for the equipment to utilise sludge with the use of natural methods. Ordinance of MOŚZNiL of 11 August 1999 concerning conditions to be fulfilled while utilising sludge for non-industrial purposes.	A concept of equipment for natural application of sludge.

Source: IOŚ.

Table 4.12. Actions leading to reduction of greenhouse gas emission (CO_2 and CH_4) from municipal waste landfills and waste-water treatment plants between 2001 and 2005

Years				
2001	2002	2003	2004	2005
Monitoring of landfills [OBREM]. Updating the recommendations to construct and operate biogas systems. Recommendations to construct and operate compost biofilters to neutralise biogas at small-size landfills.	Monitoring of landfills [OBREM].	Monitoring of landfills [OBREM].	Monitoring of landfills [OBREM].	Monitoring of landfills [OBREM].
	Preparation of guidelines for construction of waste recovery plants with minimal gas emission.			
Data base and monitoring of waste-water treatment plants.	Data base and monitoring. Preparation of guidelines for minimisation of greenhouse gas emission from waste-water treatment plants.	Monitoring of waste-water treatment plants.	Monitoring of waste-water treatment plants.	Monitoring of waste-water treatment plants.

Source: IOŚ.

and establishment of the conditions for sustainable development towards limitation of adverse agricultural impact on the environment.

In 1997, the Programme for Development of Environmental Agriculture was accepted, which includes the following partial programmes directly affecting the greenhouse gas emission:

- Programme for soil protection in 1996–2015;
- Programme for improvement of agricultural economy on the hydrogenic soil areas;
- Programme for soil protection against water and wind erosion;
- Programme for adaptation of mineral and organic fertilisation techniques and technologies to meet environmental protection requirements;
- Programme for adaptation of plant protection to meet environmental protection requirements and the needs of agricultural production;
- Production technologies on grassland, and a programme of adapting them to meet environmental protection requirements;
- Programme for adjustment of animal production techniques and technologies to improve environmental quality of foodstuffs;
- Programme for promoting good practice in farming;
- Programme for enhancement of environmental education in rural communities.

Emission of greenhouse gases generated in the process of agricultural production is difficult to determine and, at the same time, it is impossible to be entirely eliminated. However, certain correlated actions to optimise the emission and productive efficiency of agriculture can be taken. Therefore, it seems that the following production technologies should be adopted, those will contribute to the reduction of:

- carbon dioxide emission by means of reduction of fuel demand, including, first of all, solid fuels (such as coal and coke), modification of the structure of fuels used towards hydrocarbons fuels and by reduction of diesel oil consumption;
- methane emission by means of applying methane capturing techniques from litter rearing of ruminants and by adjustment of livestock volume to the market needs;
- nitrous oxide emission by means of optimisation of fertilising combined with crops production efficiency.

It is assumed that the number of cow population will increase up to about 4 million by 2005. However, it will be still by 1 million below the 1989 figures. Also, the minimal growth in cattle population noted every year does not indicate that the level of cattle population amounting to above 10 million will be attained soon. As for sheep breeding, the decrease of population can be seen as well from 4.4 million to 0.5 million in the period of 1989–1996. The main reason of such a dramatic decrease of sheep breeding was its poor profitability (especially with respect to wool) in the first years of the economy transformation process. The main objective of the policy with regard to sheep breeding is to reverse the downward trend. It is assumed that the livestock will be reconstructed up to the level of 1.0–1.2 million.

The policy to reduce methane emission from manure is focused, inter alia, on the following:

- leaving manure on the pasture where it can dry in the aerobic conditions thus methane emission is minimum;
- removing solid manure onto manure boards – the manure is collected in a solid form and stored until it can be taken to be deposited on a field. Methane emission is insignificant due to the access by oxygen;
- collecting manure in so called deep cow-sheds, this method for manure collection is used in small-size stock farms having the cow-sheds of an old type, where single animals are kept. In such cow-sheds, only the deep layers of manure are deprived of oxygen. Considering, that the surface layer is constantly moistened with urine and prevents the nitrifying bacteria from their proliferation, methane emission is rather insignificant in such cow-sheds.

Only in case of collecting manure in a litter-free rearing system where liquid manure is collected in deep containers, methane production will be maximised with oxygen-free conditions getting harder.

With the actions already taken, the current and planned increase of cattle and sheep population is not going to result in a higher methane emission with respect to the base year 1988.

Reduction of nitrous oxide in agricultural sector in Poland can be achieved by means of the following measures:

- improved efficiency of nitrogen fertilisers use;
- improved techniques of feeding animals;
- improved systems of breeding livestock.

The emission of nitrous oxide from organic fertilisers used in fields is not well recognised. It is estimated that the volume of nitrous oxide amounts to about 0.5% of the total nitrogen contained in the fertiliser. Higher emission of nitrous oxide results from using mineral nitrogen fertilisers.

In the period between 1997/1998, consumption of mineral fertilisers in Poland amounted to 89.6 kg NPK per 1 hectare of agricultural lands, including 49.8 kg N per 1 hectare of agricultural lands and was two times lower than in 1989. In the Assumptions of Social and Economical Policy for Rural Areas, Agriculture and Food Economy by 2000 the necessity to increase the level of mineral fertilising was determined to amount up to 112–115 kg NPK per 1 hectare of agricultural lands. However, this level is going to be much lower than the mineral fertiliser consumption figures in the base year 1988.

Taking into consideration the above mentioned, it must be said that the decrease of consumption of fertilisers in Poland aimed at limitation of nitrous oxide emission seems not to be justified. However, the main actions will be focused on rationalisation of the fertiliser utilisation, including nitrogen fertilisers. Legal document to determine the types of fertilisers, methods of their storage and utilisation as well as services related to fertilisers and fertilisation is the Act on Fertilisers and Fertilisation of 26 July 2000.

After 1990, a decrease of solid fuel and an increase in liquid fuel consumption has been noted in agriculture. At the same time, the consumption of light furnace oil has grown, and the consumption of heat, coke and semi-coke increased as well. The consumption of natural gas has also shown an upward tendency, but significant drop of the consumption was observed in 1999, due to the price increase. It appears from the above mentioned figures that a slow trend to shift from coal fuel to hydrocarbon fuel can be noted. This results from modernised heating methods for buildings, and from replacement of coal fired boilers by heavy-duty boilers of gas or oil type. Unfortunately, the data from 1999 indicate that the tendency was somewhat slowed down due to high prices of crude oil and changes in the excise duty rates.

With the prices of fuel going up, some farmers become more interested in bio-fuels particularly using straw for heating purposes. However, the scale of the phenomenon was mostly insignificant in 2000 and practically it does not affect the total fuel and energy consumption.

4.2.10. Forestry

The forestry policy has been formulated in both the State Forestry Policy and the National Programme of Increasing Forest Cover, which assumes enhancement of forest cover in Poland up to 30% by 2020 and up to 33% by 2050. This means that 700 thousand hectares have to be afforested by 2020 and further 1.5 million hectares within next 30 years. In the period between 1995–2000, a total of 110 thousand hectares was afforested. The time-distribution of total afforestation and reforestation activities has been shown in Table 4.13.

Table 4.13. The afforestation and reforestation volume between 1995–2000

Years	Afforestation and Reforestation Area [thousand hectares]
1995	77.8
1996	68.4
1997	59.1
1998	60.3
1999	63.3
2000	68.9
Total	397.8

Source: GUS.

The increase of the national forest cover arising from the implementation of the State Forestry Policy has resulted in more intense absorption of atmospheric carbon by the biomass of the forest ecosystems. However, forests perform many other important functions as well, therefore the scope of the State Forestry Policy is much wider and it also covers: limitation of the wind and water erosion phenomena, surface and underground water protection, increasing retention capacity of the country, improvement in ecological and landscape system as well as improvement in climate conditions (including improvement of the air purity).

5. EMISSION SCENARIO AND OVERALL EFFECT OF THE MEASURES IMPLEMENTED

5.1. Introduction

In this Section, potential future trends of greenhouse gas emissions and removals by 2020, up-to-dated with respect to the Second National Report, resulted from the national measures and policy adopted have been shown. Also possible emissions and removals paths without taking into consideration such a policy and measures, developed by a multidisciplinary panel of experts in 1999, have been presented.

Scenarios of emission changes have been presented only with respect to six sectors of economy, i.e. electrical power engineering, manufacturing industry, transport, agriculture, forestry, services and households. Additionally, greenhouse gas emission projections for the entire power engineering system and macroeconomic scenarios of greenhouse gas emission reduction on a national level have been shown.

It should be pointed out here that particular scenarios were developed by groups of experts working independently (but co-ordinated) and by means of various modelling instruments. Thus results of projection estimates presented below may not be fully compatible. It especially relates to the macroeconomic assumptions (CGE-PL model) for energy sector modelling (EFOM-PL model) as well as to the results of modelling of aggregated effects of measures undertaken in entire economy (LRDM-NE model). Projections of macroeconomic development as cited in the Assumptions for Energy Policy for Poland until 2020 do not present full consistency with earlier mentioned analysis. This differentiation should be treated here as the uncertainty measure for the methods applied.

5.2. Greenhouse gas emission in the basic sectors of the economy

5.2.1. Electrical power engineering

On the basis of the electricity demand estimates for this country, the efficiency of energetic conversion process in the electricity generation and the assumptions of the carrier structure of primary energy used in the power engineering sector, the CO_2 emission levels in the sector have been determined. Unit emissions for coals burned amounting to 101 kg CO_2/GJ and for hydrocarbon fuel burning of 56 kg CO_2/GJ energy contained in the fuel have been assumed.

A high degree of energy determination of emission related to the implementation of the passive scenario seems to be characteristic (see Section 5.3) in which abandonment of economical reforms, low economic growth rate and heavy demand for electricity have been assumed. The emission estimate, in case of the base-line scenario, which provides for a deeper restructuring of the economy and its further privatisation, is subject to uncertainty to a higher degree (Tab. 5.1). This is due to the fact that the above mentioned scenario depends on the transformation rate of the economy in which there is a high degree of indeterminacy of partial phenomena, in particular of such effects as demand for electrical energy and the fuel structure of its generation.

Table 5.1. Expected changes of CO_2 emission in the electrical power engineering sector according to different development scenarios (in million tons of CO_2)

Scenarios	Predictions in the year		
	2005	2010	2020
Base-line	127–129	121–125	96–107
Passive	159	173	187

Source: [Gaj *et al* 1999].

5.2.2. Manufacturing industries

The base-line scenario forms the basis used in calculation of the demand for direct consumption of energy in industry by 2020. The industrial energy intensity, structure of production and fuel structure as at 1996 has been assumed. With respect to direct consumption of individual energy carriers, motor spirits, aviation petrol, jet engine fuels and diesel oils have not been taken into consideration as they belong to the sector of transport. Neither was the section Provision with Electrical Energy, Gas and Water taken into consideration, which section belongs to the electrical power engineering sector.

Table 5.2. Expected changes of greenhouse gas emission in manufacturing industry according to different development scenarios (in million tons of CO_2 equivalent)

Scenarios	Predictions in the year				
	2000	2005	2010	2015	2020
Base-line	215	224	283	364	469
Reduction	215	203	259	339	442

Source: [Gaj *et al* 1999].

The determined demand for energy by 2020 formed a basis to calculate greenhouse gas emission from the industrial sector expressed in equivalent of CO_2. The evaluation of emission was prepared for two scenarios: the base-line scenario and reduction scenario (Tab. 5.2.). In the base-line scenario (“with measures”), improvement of the industrial production efficiency is envisaged through embarking on economically effective undertakings resulting from the economical policy of the state. The reduction scenario (“with additional measures”) presents emission with allowance made for additional measures arising from the introduction of the climatic policy instruments.

5.2.3. Transport

Since 1989, except for a slight decrease of transport intensity of the economy, no favourable changes, from the point of view of GHGs emission, have been encountered. On the contrary, changes leading to unfavourable effects occurred in the most factors of decisive influence over the emission. The rapid growth of motorization and the role of road transport resulted in an increase of petrol consumption by 40% and diesel oil by 28%, in the years 1990–1997.

In all the scenarios being examined (Tab. 5.3.), the total emission from the transport sector is going to grow quite fast at the beginning and then at a slower rate. This is due to the technological progress and rationalisation of performance, irrespective of the efforts aiming at reduction. According to the reference base-line scenario, based on the assumption of the occurrence of trends that are most likely to happen, without an intervention aiming at reduction of GHGs (“without measures”), the emission in 2020 will amount to around 150% of the figure of 1995. According to the reduction base-line scenario (“with measures”), the emission level will be lower than in 2020 amounting to 137% of 1995 value.

Table 5.3. Expected changes of greenhouse gas emission for the optional scenarios (in million tons of CO_2 equivalent)

Scenarios	Predictions in the year				
	2000	2005	2010	2015	2020
Reference base-line	30 456	34 203	37 776	39 153	39 611
Reduction base-line	29 881	32 188	34 527	35 182	35 755

Source: [Gaj *et al* 1999].

The following measures aiming at mitigation of emission are envisaged in the reduction base-line scenario:

- decreasing the motorization growth rate;
- decreasing the mobility;
- decreasing the transport intensity of the economy;
- decreasing the unit emission of cargo transport.

5.2.4. Agriculture

No separate emission reduction model simulations have been carried out for the agricultural sector. The evaluation of emission was based on the current assumptions of the agriculture policy in the context of the accession of Poland to the European Union. According to estimates, the emission of the sector will be decreased by 0–25% for CO_2 and by 8–12% for CH_4 and by 6–12% for N_2O in the years 2010–2020.

The main factor to reduce carbon dioxide emission from this sector, apart from the technical upgrading, will be creating large-size farms by integration of small-size ones. Methane reduction will be achieved by improvement of fodder quality, introduction of new breeds of cattle, using metagenesis inhibitors in the livestock feed as well as energy generation from biomass wastes, liquid manure and manure.

Nitrous oxide emission is expected to decrease, first of all, due to the rational use of nitrogen fertilisers. Detailed description of the schedule of actions is to be seen in Section 4.

5.2.5. Forestry

Two scenarios of CO_2 removals were elaborated: the base-line (“with measures”), in which a complete implementation of the National Programme of Increasing Forest Cover (KPZL) is assumed and the passive scenario (“without measures”), in which the Programme is assumed not to be put into effect. Changes in CO_2 sinks by forest ecosystems are shown in Table 5.4.

The progress of implementation of the afforestation programme so far does not cause any grounds for the passive scenario to be adopted and, as it appears from the analysis of the base-line scenario in the years 1990–2020, an increase of CO_2 absorption up to 10 million tons can be expected. The increase is due the biomass growth and the increase of carbon absorption in the forest ecosystem soils established on the post-agriculture land.

It has been estimated that the greenhouse gas emission from the biomass burning will be constant in the period of question.

Table 5.4. Expected changes in CO_2 absorption by forest ecosystems in accordance with various development scenarios [million tons]

Scenarios	Predictions in the year		
	2000	2010	2020
Complete implementation of the National Programme of Increasing Forest Cover (KPZL)	29.8	32.9	37.1
Without implementation of the National Programme of Increasing Forest Cover (KPZL)	29.5	32.2	34.8

Source: [Gaj *et al* 1999].

5.2.6. Sector of public utility, services and households

The base-line scenario of GHGs emission ("with measures") in the sector of public utility, services and households was estimated while taking into consideration, inter alia, improvement of the efficiency of generation and transmission of heat and electric energy as well as increase of utilisation of natural gas for energy generation up to about 20% (Tab. 5.5).

The increase of greenhouse gas emissions with respect to the base year 1988 can be expected by nearly 20% for CO_2 and above 50% for N_2O, unless a special climatic policy is adopted in this sector.

Implementation of such measures as thermal modernisation of blocks of flats, replacement and additional sealing of the windows, changes of the current building thermal protection standards or expanding the renewable energy sources aimed at additional GHGs emission reduction would result in mitigation of the greenhouse gas emission ("with additional measures" scenario). The estimated levels of emission after implementation of such measures have been shown in Table 5.6.

With such measures adopted, the emission of carbon dioxide would increase by 13% in relation to 1988, the emission of methane would remain unchanged or decrease by 2–3%, while that of nitrous oxide increase by 50%.

Table 5.5. Expected greenhouse gas emissions in the public utility sector and households – "with measures" scenario

Greenhouse Gases	Predictions in the year		
	2000	2010	2020
CO_2 [million tons]	136	149	165
CH_4 [thousand tons]	3	3	3
N_2O [thousand tons]	7	7	8

Source: (Gaj *et al* 1999).

Table 5.6. Expected emission of greenhouse gases in the public utility sector and households – "with additional measures" scenario

Greenhouse Gases	Prediction in the year 2020
CO_2 [million tons]	157
CH_4 [thousand tons]	3
N_2O [thousand tons]	8

Source: [Gaj *et al* 1999].

5.2.7. Power engineering sector

The expected levels of CO_2 emissions related to energy utilisation in the whole country, i.e. connected with the whole power engineering processes in general, are presented below. The present Section should be treated separately with respect to the previous six sectors, since in the power engineering sector also includes the emissions already classified to the other sectors (e.g. industry and transport).

In the base-line scenario the increase of consumption of the primary energy on the average by 1% per year, i.e. several times lower than the GDP growth rate is assumed, with three times lower primary fuel unit consumption at the same time. The gradual change of the fuel structure, in accordance with the assumptions, means an increased share of liquid fuels (from 16.4% in 1996 to 24% in 2020) and natural gas (from 8.9% to 22.4%, respectively) and a decrease of the share of solid fuels from about 70% to around 51%. Moreover, the base-line scenario provides for the accession of Poland to the European Union before 2005 and a high rate of the economic growth by 2010 (6.2% per annum) to decrease gradually by 2020 (4.8%).

The second, so called, passive scenario provides for lower rate of the economic development (up to the annual

Table 5.7. The values of some selected macroeconomic variables for the base-line and passive scenarios in power engineering sector

Specyfication	Unit of Measure	Years			
		1996	2000	2010	2020
		Base-line Scenario			
Employees	million	15.8	15.9	16.7	17.2
Unemployment rate	%	13.1	9.9	8.4	6.7
GDP level	PLN billion	385	507	958	1,571
GDP dynamics (1996=100)	%	100	132	249	408
Exports	PLN billion	66	79	195	367
Imports	PLN billion	100	115	190	316
		Passive Scenario			
Employees	million	15.8	15.9	16.6	16.9
Unemployment rate	%	13.1	9.9	8.9	8.1
GDP level	PLN billion	385	473	684	1,037
GDP dynamics (1996=100)	%	100	123	178	269
Exports	PLN billion	66	79	110	186
Imports	PLN billion	100	115	157	240

Source: [Gaj *et al* 1999].

level of 3.5% between 2005–2010), negative balance of trade in the whole period, low rate of unemployment reduction. The basic macroeconomic assumptions for both scenarios are shown in Table 5.7, where archive data for 1996 according to GUS (Central Office of Statistics) and predictions for the years 2000, 2010 and 2020 performed by means of CGE model are presented.

In the base-line scenario, the emission level of CO_2 in the period until 2000 is maintained at a more or less constant level, then rises up to 394 million tons in 2010 and about 439 million tons in 2020. The biggest increase is expected in the public electrical power engineering sector due to the growing demand for electricity. In 2020, the total CO_2 emission from power stations and public CHP's may amount to above 200 million tons, which significantly exceeds the emission of the sector in 1988 (estimated at 160 million tons). The growth of emission from the other sectors is much slower, which makes it possible for a generally low CO_2 emission growth rate below the annual average of 0.7% to be maintained in the whole period of time. It is a lower growth rate as compared with the corresponding index of primary fuel consumption, which results from a shift of the fuel consumption structure towards hydrocarbon fuels. Emission of CO_2, as calculated for the passive scenario, is lower than that in the base-line scenario (Tab. 5.8).

Table 5.8. Expected changes of CO_2 emission in the power sector according to different scenarios of develop-ment [million tons of CO_2]

Scenarios	Predictions in the year				
	2000	2005	2010	2015	2020
Base-line	370	382	394	428	439
Passive	368	372	372	379	383

Source: [Gaj *et al* 1999].

5.3. Evaluation of the effects of aggregated measures

In the Second National Report, the macroeconomic reference and reduction scenarios of greenhouse gas emission developed between 1994–1996 within the framework of the National Study on Climate Changes were presented. There were three macroeconomic scenarios of the reduction of greenhouse gas emission based on the Macroeconomic Reference Scenarios, which are hypothetical scenarios of the country development in a macro scale. Those scenarios represent some reference for the macroeconomic costs and the reduction of greenhouse gas emission for reduction development scenarios defining long-term strategies of greenhouse gas emission reduction:

- the base-line scenario – based on the political assumptions declared by the state authority in the period when the scenarios were developed (1993–1995);
- the chance scenario – based on the assumption that structural changes faster and deeper than in case of the base–line scenario may be possible with respect to the economy and social life;
- the stagnation scenario – based on the assumption that structural changes in the economy would be not accepted by the society which would result in some costs involved; the scenario is characterised of slower rate of changes than those assumed in the base-line scenario.

As it appears from the experience gained in the period of the last five years, the changes of emission occur, as a matter of fact, in accordance with the most optimistic scenario, so called scenario of chance, due to the accelerated process of changes of the economic structures towards more energy and material saving, of higher degree of processing and more open approach with respect to international co-operation and increased consumption of hydrocarbon fuels as well.

In 1999, the macroeconomic scenarios of emission reduction and sinks ennancement of greenhouse gases by 2020 were up-dated. New macroeconomic reference scenarios include: the verified base-line scenario and the passive scenario (of passive economic development).

It should be mentioned that the new scenario simulations are coherent with the newly adopted (1999) governmental policy towards the power engineering sector with respect the economic growth rate and the nature of the basic macroeconomic structural variables in time.

The characteristics of the base variables of the base-line and passive scenarios is shown in Table 5.9, while the potential changes of the future CO_2 emission have been presented in Figure 5.1.

As it appears from the analysis of the current economical and social situation of the country between 1999–2000, the condition of the economy deteriorated and the indexes achieved are lower that those assumed in the passive scenario. It might mean that the greenhouse gas emission will be lower than expected.

5.4. Methodology

In the above mentioned scenarios, two hierarchical levels can be identified in the system being examined: the level of the economy sectors and the level of the national economy.

Different methodology and different research instruments are applied with respect to these two levels in the system analysis. While analysing the economy sectors, in particular the power engineering economy, a bottom-up[1]

[1] Bottom up modelling arrives at economic conclusions from an analysis of the efect of changes in specific parameters on narrow parts of the total system.

Table 5.9. Values of selected macroeconomic variables for the base-line and passive scenarios

Specification	1996	Reference Scenarios in the year					
		Base–line			Passive		
		2000	2010	2020	2000	2010	2020
Population of the country	38.5	38.8	39.4	39.9	38.8	39.4	39.9
Macroeconomic Variables:							
GDP [PLN billion ’96]	385	498	936	1561	492	804	1073
GDP rate per year [%]	6.0	7.0	5.9	4.8	5.9	4.2	1.9
GDP per capita [PLN thous. ‘96]	10	12.8	23.8	39.0	12.7	20.4	26.8
Savings rate* [%]	22	25	21	20	25	21	21
Structural Parameters:							
Share of the service sector in the global production [%]	36	37	48	58	37	46	51
GDP energy intensity [’96 = 100]	100	83	49	31	84	61	53
Service expenditure on a global production unit [’96 = 100]	100	110	143	175	109	124	125

* The macroeconomic savings rate represents the share of depreciation in GDP.
Source: [Gaj *et al* 1999].

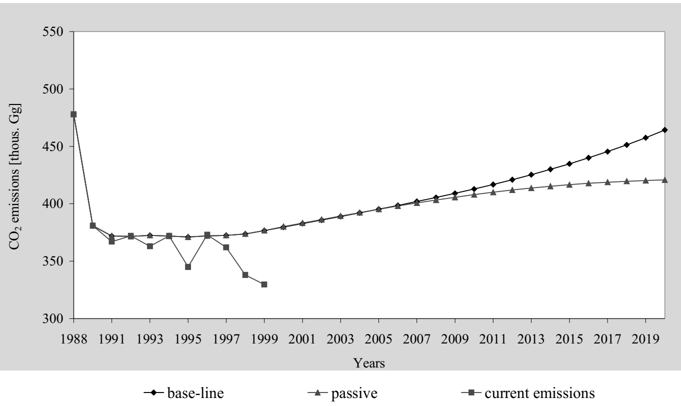

Fig. 5.1. Potential changes of CO_2 emission in Poland according to the two scenarios: the base-line scenario and the passive scenario and the current emission estimated [Gaj *et al* 1999]

modelling methodology was adopted. In case of the macroeconomic analyses of the entire national economy, a top-down[2] methodology was applied. The following are the input data for the analysis:

- statistical data concerning important variables characteristic of the national economy, with a focus on utilisation of energy;
- assumptions of the current and foreseen economic and social policy of the country which assumptions make allowance for external commitments resulting from international agreements concluded, in particular the UNFCCC and
- climatic changes expected.

Political assumptions are based on existing documents issued by the state administration organs, legal status determined by adequate acts and administrative regulations as well as provisions of proper international conventions. Assumptions of the predicted changes of the climate were based on the calculations made with the use of COSMIC[3]. Expected changes of climate, only with respect to the agriculture and forestry, the sectors which are especially vulnerable to the natural conditions have been taken into consideration.

On the basis of the above mentioned assumptions, three so called macroeconomic reference scenarios, which provide the paper with a certain context with respect to the general economical development of the country, have been defined. LRDM-NE macroeconomic model has been used for that purpose. Projections of development trends for individual economic sectors have been made while taking into consideration the above mentioned context of the general economy. Therefore, both model approaches and statistical estimations have been employed in order to estimate sectoral emissions, the description of which is shown below.

National economy. Before the assessment of emission changes was made, two scenarios of national economy development had been prepared: one including measures aimed at climate protection (“with additional measures”) and the other excluding such measures (“with measures”). The Long-Run Dynamic Model for National Economy (LRDM-NE) was used for elaboration of these scenarios. The following economy branches were included into the LRDM-NE model: heavy and light industries, coal mine, fuel and power engineering industries, construction, transport,

[2] Top-down modelling approach proceeds from broad, highly aggregated generalizations to regionally and/or functional disaggregated details.

[3] Schlesinger M.E., Williams L.J. – COSMIC – Country Specific Model for Intertemporal Climate – Electric Power Research Institute EPRI, USA, Palo Alto, 1997.

agriculture and services. Then the scenarios of greenhouse gas emissions were developed based on scenarios mentioned above.

Power Engineering Sector. Taking into consideration the fact that the emission of carbon dioxide from production, processing and energy utilisation represents above 92% of the total emission in the country, the highest priority has been given to the aggregated scenarios which cover all the problems faced by the power engineering sector.

The scenarios of national emission were prepared using three models in which the following macroeconomic conditions were taken into account: a macroeconomic model of general equilibrium (CGE-PL), simulation demand model (PROSK-E) and optimising supply model (EFOM-PL).

The CGE-PL model adopted is energy oriented and used for a complex analysis in a macro scale of long term changes of the economy structure (the structure of production, the change of resources allocation and prices). Model EFOM-PL is used in order to determine resources of energy. As a result of calculations made with the use of this model, the supply of the basic energy carriers, expenditures and costs of production, processing and distribution of those carriers, marginal costs of emission reduction and optimum technological structure, primary and final energy balances or emission release to the atmosphere can be determined.

Model PROSK-E combines the results of the analyses of macroeconomic and demographic categories (e.g. added value dynamics, population, etc.) together with the predictions of products or services of a high level of energy intensity. The results achieved by the model include the demand for final and useful energy and emissions of pollutants.

The methodology of calculation applied in the scenarios is based on connections among all the models where the results of one model are used as input for another. Additionally, the results of the models are compared with the results of detailed analyses concerning, inter alia, economical efficiency evaluation of various power technologies and verified on that basis.

Industrial Sector. A model developed by S. Pasierb in the years 1989–1997 has been used to analyse the energy intensity changes and greenhouse gas emission in the manufacturing industry. With this model it is possible to evaluate the impact of the changes of production value, production structure and energy use efficiency and fuel structure on the energy intensity and greenhouse gas emission. The model was used in the National Study on Climate Changes, "Strategies of Greenhouse Gas Emissions and Adjustment of the Polish Economy to Climatic Changes " and published in the Structural and Technological Changes of Greenhouse Gas Emissions During the Transition Period in Polish Industry. Environmental Management, Vol. 20. Supplement 1, pp. S37–S45, February 1996.

Reduction of greenhouse gas emission potential assessed in 1994 in the above mentioned Study was updated for twenty-four undertakings divided into power technologies (universal, to be found in each branch of industry, e.g. heating, pumping, ventilation, drying, compressing, lighting, steam generation, etc.), autonomic technologies (mainly related to industries of high level of energy intensity, such as metallurgy, cement and lime production, chemical and petroleum chemistry industries) and environmental protection technologies (change of fuel, e.g. from coal to gas). The utilisation of the above mentioned potential of reduction between 1994–1998 was determined by consulting branch experts. The reduction of greenhouse gas emission for twenty-four undertakings was calculated using spread sheets for greenhouse gas emission reduction cost calculation at a branch level for the updated prediction of fuel and energy prices.

The base-line reference scenario ("with measures") is based on the assumption that the improvement of power efficiency will be limited to the market interactions, without an intervention of the state through special programmes. The dynamics of the production output changes for the industrial sector adopted in each scenario is based on Alternative Scenarios of Macroeconomic Development of the National Economy (1998) developed by the Polish Foundation for Energy Efficiency (FEWE). The reduction scenario ("with additional measures") results from the mitigation of greenhouse gas emission by the industrial sector, by 2020, in the base-line scenario due to the reduction of emission related to the implementation of twenty-four undertakings at the rate which was assumed by FEWE.

Transport. A model with the following parameters taken into consideration: efficiency of the existing means of transport, the rate of transport modes utilisation, motorization development prediction, transport intensity (number of passengers and tons per kilometre) as well as power consumption and emission has been applied.

Agriculture. The results of GISS and GFDL General Circulation Models (see Section 6.1) provided a basis for evaluation of changes in the agricultural production (also including biomass used for energy purposes) and animal production, while making allowance for the assumptions of the state agricultural policy adopted. The production output determined on that basis formed a base for evaluation of emission for different options of the production.

Forestry. The key problem in the evaluation of greenhouse gas balance strategy in this sector was how to define a forest. The legal definition, still valid in Poland, which is formulated in the Act on Forests was adopted, within the meaning of which forest is a compact area of land of at least 0.1 hectare covered with, or temporarily deprived of, forest flora, designed forest production. The assessment of the future changes was based on the National Programme of Increasing Forest Cover. While preparing the scenarios, the following three categories of processes related the use of arable land and biomass changes were included: changes in the forest resources, changes of the forest ground purpose, abandonment of land used in the agricultural sector.

The model developed makes allowance for three types of emission: from biomass burning, from biomass decomposition, from forest soils and size of afforestation of postagricultural lands and biomass annual changes in forests. As a result, CO_2, CH_4, CO, N_2O and NO_x emission and CO_2 absorption can be observed.

Public Sector. While developing scenarios for the sector, the formalised power engineering model was not employed. The emission estimation was based on identification of the current and predicted energy needs in the public sector, services and households, determination of utility energy carriers supplied to the customer and methods of their final conversion and aggregated averaged greenhouse gas emission coefficients. The adopted method of emission evaluation is based on the bottom-up method. The identification of the energy needs was based on an analysis of the resources and the condition of equipment in the objects and predictions related to their changes.

5.5. Strategy of nitrous oxide emission reduction

A strategy of nitrous oxide emission reduction in the Polish economy was worked out under the auspices of the Ministry of Environment in 2001. It appears from an analysis of N_2O emission sources, arranged according to the structure of Revised 1996 IPCC categories for 1999, that the agriculture accounts for the largest share of 74% in N_2O emission in Poland, then goes the chemical industry with 16% and fuel combustion –10%.

An important methodological principle of the project was to combine the reduction of N_2O emission with the macroeconomic development of the country. The basis of the nitrous oxide emission reduction is a projection of N_2O emission in a certain time horizon which projection is subject to a specific policy of the country. The Assumptions of the Energy Policy for Poland until 2020, prepared by the Ministry of Economy in accordance with the principle of sustainable development have been adapted as an obligatory document of the country, as they contain, inter alia, the following:

Table 5.10. Structure of generating the Gross Domestic Product (GDP)

Structure of generating the GDP	Years			
	1997	2020		
		Reference Scenario	Survival Scenario	Progress Scenario
GDP [PLN billion '99]	562.4	1 362.1	954.7	1 995.6
GDP including [%]:				
❑ Processing industry and construction	25.8	25.1	35.5	29.2
❑ Power engineering sector	6.2	5.2	6.4	4.0
❑ Agriculture	5.7	4.2	4.9	2.2
❑ Services	44.3	44.6	38.6	46.5

Source: [Assumptions... 2000]

- a prediction of domestic demand for fuels and energy, while making allowance for the growth of the Gross Domestic Product;
- investment policy;
- measures related to the environmental protection.

The scenarios proposed in the Assumptions... (2000) are characterised by the following:

- the reference scenario takes place under conditions of political stability and international environment development without any upheavals or rapid changes; the Gross Domestic Product amounting to 4.0%;
- the survival scenario, to be implemented under conditions of slight global development hampered by political upheavals; economical policy of the country without a firm foundation for future development with an increase of the Gross Domestic Product of 2.3% and the scenario is of warning character;
- the progress scenario to be implemented under favourable conditions of the international environment and active domestic policy, with the Gross Domestic Product amounting to 5.5%.

The structure of generating the Gross Domestic Product, with the sectors responsible for N_2O emission selected, is shown in Table 5.10.

On the basis of the sectoral papers, calculations of N_2O emission projections for each macroeconomic scenario by 2000–2020 have been made (Tab. 5.11.).

However, the estimates of N_2O emission have been made only for the chemical industry and agriculture. The share of N_2O emission from fuel combustion is relatively small (about 10%) and moreover, the share of N_2O in total direct emission of all greenhouse gas (CO_2, CH_4 and N_2O) emission in the fuel combustion category amounts only to 0.002%.

Table 5.11. Emission of N_2O in the years 2000–2020 in Poland [Gg]

Category	Years				
	2000	2005	2010	2015	2020
REFERENCE Scenario					
1.A. Combustion	7.620	7.808	7.794	7.980	8.168
2.B. Chemical Industry	13.990	13.890	14.190	14.090	13.990
4. Agriculture	55.415	57.063	59.852	61.539	62.714
Total Country	77.025	78.761	81.836	83.609	84.872
SURVIVAL Scenario					
1.A. Combustion	–	7.897	7.803	7.879	7.938
2.B. Chemical Industry	–	11.962	12.142	12.057	11.972
4. Agriculture	–	56.203	58.071	58.973	59.629
Total Country	–	76.062	78.016	78.909	79.539
PROGRESS Scenario					
1.A. Combustion	–	7.880	8.093	8.406	8.725
2.B. Chemical Industry	–	13.890	14.190	7.890	7.890
4. Agriculture	–	61.094	63.717	65.006	66.334
Total Country	–	82.864	86.000	81.302	82.949

Source: [Radwański *et al* 2001]

Table 5.12. Comparison of N_2O emission in the chemical industry according to the reference and reduction scenarios [Gg/year]

Scenario	Years				
	2000	2005	2010	2015	2020
Reference	13.99	13.89	14.19	14.09	13.99
Reduction-Chance	12.87	12.77	13.79	4.84	4.82
Reduction-Progress	13.99	13.89	14.19	7.89	7.89
Reduction-Moderate	13.99	13.89	14.19	8.70	8.70

Source: [Radwański *et al* 2001].

In Table 5.12, possible reduction of N_2O emission in the chemical industry, where the emission refers to the production of nitric acid and caprolactam, are presented. Three types of N_2O emission reduction scenarios were proposed here, where the progres one is recognized as the most realistic.

In Table 5.13, possible reduction of N_2O emission in the agricultural practice has been presented.

To implement the option of N_2O emission reduction both in the chemical industry and agriculture will require preparation and implementation of programmes of detailed measures under the supervision of competent ministries.

Table 5.13. Potential annual reduction of nitrous oxide (N_2O) in the agricultural sector

Reduction Source	Estimated Reduction [Gg]
Increasing the efficiency of nitrogen fertilisers utilisation:	
❑ reduction of the nitrogen fertilisers consumption (by applying a modernised technology of nitrogen use, adaptation of the nitrogen supply to the crop demand, crop plant cultivation, leaving crop residues containing nitrogen in the field, optimisation of land cultivation, irrigation and drainage).	1.769–2.002
Improving the animal feeding techniques:	
❑ better balance of food rations to ensure better utilisation of fodder, including elimination of redundant amino acids from the animal food rations;	1.357–1.502
❑ adding some formulations to the fodder to absorb nitrogen compounds which represent sources of N_2O emission.	0.111–0.125
Improving the systems of livestock rearing:	
❑ adding to the manure and litter biotechnological formulations which can limit N_2O emission;	0.339–0.375
❑ reducing the area of evaporation of the manure from lair and litter;	1.658–1.877
❑ lowering the temperature of the manure components by recovery and cumulation of thermal energy;	0.663–0.751
❑ methane fermentation of liquid manure;	0.113–0.125
Manure boards and liquid manure tanks being commonly used.	0.309–0.375

Source: [Radwański *et al* 2001].

6. ASSESSMENT OF VULNERABILITY, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

6.1. Agriculture

Two scenarios of the future climate in Poland were applied with the aim to determine likely direction of changes in agricultural production. The scenarios build on atmospheric General Circulation Models assume an increase in the air temperature and a change in precipitation, and those relate to double concentration of carbon dioxide in the atmosphere. They are GISS and GFDL models developed in the USA.

GISS scenario envisages growth in mean annual temperature in Poland by 3.5 °C to the end of the 21st Century, and this growth will amount up-to 4.5 °C in winter, 2 °C in the summertime, and the growth in precipitation total by about 23% in the period from autumn to spring, and by about 10% in the summertime with some decrease in September. Higher increase in precipitation will be expected in the North-Eastern part of the country, and lower in the Southern. According to GFDL scenario, an increase in mean annual temperature by 5 °C can be expected, whereas annual precipitation will retain on its present level, and it will increase by about 20% in spring and decrease by 15% in summer.

The rise expected in air temperature, as estimated with application of empirical material and statistical data, could result in extension of the climate vegetation period by 30–40%. The consequence would be an acceleration by about 3 weeks of the time-limit for sowing all of the plants and of the harvest period by about 3 weeks. Generally, the climate heat resources useful for agricultural production would grow in Poland, but their effective utilisation will depend upon the opportunity to satisfy water needs of the plants under cultivation. It could be water deficit, that will appear as the factor reducing the future agricultural production (according to scenarios of the future climate change), and that will force to seek for new solutions.

According to GISS scenario, the future agro-climate conditions, given the more favourable water conditions, would result in favourable conditions for agricultural plant production in Poland. Potential winter crop yields would stay at the current level while sugar beet production would grow by about 3–10%. Thermophilous plants (maize, soybean, oilseed sunflower) would react with their highest crop growth rate (likely even about 30%). Productivity of grasslands may grow by at least 25–30%. The period, when animals are kept on pastures would be considerably extended. As far as the common crops are concerned, that of potato would react with a drop (by 20–30%) in its yield. However, it would be necessary to introduce appropriate changes into plant production structure and technology in order to make the production growth a reality. If no adaptation actions are undertaken, the total plant production might even drop by 5–10%.

Less favourable for agricultural production will be the direct consequences of the "warmer" and more "dry" GFDL scenario. It would result in a drop of winter crops by about 10%, sugar beet by 15%, and potato as much as 70%. Only thermophilous plant could yield in these conditions higher by 30–40%. The productivity of grasslands would decrease, and the continuity of animals grazing on pastures during grass vegetation period would be only possible in irrigated areas. It is estimated that due to unfavourable water conditions, and without any adaptation efforts, agricultural production of the major field crops could drop by 25%.

Moreover, it should be expected that the poorest soils where anticipated crops are inasmuch low, that they do not cover the current production costs, would be exempted from their agricultural use. Reduction of these areas could be fully compensated by growth in crop yields on better soils.

The share of cereals in overall crop structure will likely rise from the current 67–74%, depending on the region, up-to 70–85% of the field crops area in the future. The acreage of winter barley could grow. Generally the contribution of the winter crops, which yield by 10–15% higher than spring crops, would apparently grow. Almost 50% of the acreage currently occupied by the spring crops might be sown with maize, which produces higher yield, than small-grain crops and that will reach higher yield in changed climate conditions. One should also expect a reduction in fodder crops, since under poor rainfall conditions the fodder yields will be likely lower and more variable on yearly basis. Two species, maize and lucerne, are likely to predominate the production of bulky feed.

Expansion of thermophilous crops will be possible. Maize, depending on the earliness of its varieties, could mature throughout the country territory (except from highland regions), or with exclusion of the Northern regions.

No climate restrictions are envisaged in cultivation of soybean and oilseed sunflower.

Tillage of potato may reduce just to its consumable and industrial varieties, and a reduction of potato cultivation for fodder could appear. The acreage of potato crops would be reduced to a relatively small area, though the crops could be at least doubled, that would satisfy the current needs, but it could be only the case, when sprinkling irrigation has been applied.

The following factors will be important for adaptation of agriculture in Poland to expected climate change: the choice of appropriate plants, the change in mode of land use and crop structure, the progressing production zoning, and the introduction of technologies which use water resources in a rational manner, as well as the extended vegetation period.

Adaptation of the Polish agriculture to predicted climate change will manifest as a multi-year, sluggish processes which could provide for the national food self-dependence. However, realisation of this challenge will require production efficiency to be improved, losses to be reduced, and considerable organisational changes to be implemented in agriculture, as well as a growth in capital outlays supported by external financing of agriculture, especially in relation to establishment of water management infrastructure (reservoirs, and water intake sources).

6.2. Coastal zone

The length of the Polish coastal line is 788 km, including the shore of the Helski Peninsula, and the Szczecin and Vistula Lagoons. The Polish coast is a diversified one: from low-situated beaches to high cliffs, and there is also a depression in the Eastern part of the coast in the area of the Vistula Marshland, with its the lowest point situated at 1.8 m below sea level. That is one of the sites situated in the Polish coastal zone of the Baltic Sea, those are mostly vulnerable to changes in sea level.

Research on the vulnerability assessment of the seashore and on the adaptation of the Polish coastal-zone to potential consequences of climate change, including the increase in sea level, is carried out by Ministry of Transport and Marine Management and its subordinate institutions, and that includes:

1. Regular research leading to operational observation of the effects of climate change:
   - ❒ Coastal zone data collection system (the “Coast” Database);
   - ❒ Implementation of the marine hydrological and meteorological observation and forecast system in the framework of the GOOS global observation network.
2. Analytical studies and synthesis leading to the assessment of the vulnerability of the Polish coastal system to the change in sea level:
   - ❒ Forecasting the impact from the groin system on riparian processes in the circumstances of sea level rise;
   - ❒ Determination of safety profiles for the coastal zone;
   - ❒ Estimation of the storm impact range alongside the Southern Baltic Coast;
   - ❒ Estimation of risk to hazard from climate change impact and establishment of procedures for littoral zone management;
   - ❒ Classifying the erosion and flood hazards along the coastal line.
3. Strategy for the protection of the Polish sea-shore against the change in sea level:
   - ❒ Elaboration of long-term seashore protection and beach preservation programmes;
   - ❒ Assessment of safety conditions for the Helski Peninsula and of the effects from its artificial replenishment in the period of 1997–2000, as well as the proposals for the protective works planned for the period of 2001–2005;
   - ❒ Preparation of seashore protection strategy;
   - ❒ Elaboration of guidelines for the adoption of the magnitude of hydrological and meteorological phenomena for the design of the seashore protective projects;
   - ❒ Elaboration of seashore protective methods and those for restoration of beaches in the area of the locality of Ustronie Morskie;
   - ❒ Participation to Integrated Management of Riparian Zones in the group of the Baltic States;
   - ❒ Elaboration of the concept to reinforce the cliff in the area of the locality of Jastrzębia Góra.

Moreover, the Marine Institute, who is a research and development unit of the Ministry of Transport and Marine Economy, has actively participated to the EURO GOOS works and to the international research team Coastal Ocean Observation Panel.

Based on the results of the atmospheric General Circulation Models, scenarios were elaborated by the Marine Branch of the Institute of Meteorology and Water Management for local climate and oceanographic conditions in the Polish coastal zone of the Baltic Sea in the circumstances of multiple CO_2 concentrations. They indicate the likelihood of the occurrence of changes limited in principle to the enhancement of variability ranges of particular parameters, without any essential or rapid changes in their mean values.

The scenarios developed for the variability of wind climate, wave field and sea levels in the circumstances of multiple CO_2 concentrations, do not form any basis to formulate a hypothesis that any rapid changes in mean values may occur (i.e. of the growth of mean wind velocity, wave height, sea level) as a result of change in atmospheric circulation only. However, they indicate quite apparently an essential rise of the variability range of the basic parameters describing meteorological and oceanographic conditions in the coastal zone. So there can be expected more frequent occurrence of heavier winds (including hurricanes), related increase in the wind waving height (including also swell), and an increase in sea level, and also extreme values of water stage raised by storms.

The results of the study could be used in development of adaptation strategies to expected global changes. However, there is the need to develop further methods and techniques allowing to describe the casual nexus between the multi-scale atmospheric processes and the local climate and oceanographic elements.

6.3. Water resources

Hydrological simulation carried out for three selected river-basin areas situated in various geographical conditions in Poland proved quantitatively differentiated changes in parameters, depending on scenario for future air temperature and precipitation changes, although a tendency of these changes remains unchanged: reduction of water outflow, soil moisture, water retention within the river-basin, and real evapo-transpiration, particularly in Western Poland, with higher temperature rise and heavier drop in precipitation. A shift is also expected in the occurrence of the spring high water stages from March–April to January–February, caused by earlier melting of accumulated snow. Moreover, it is estimated, that the area of irrigated areas in agriculture should enhance from the current level of 1.5% up-to about 4% in 2050. The latter value relates to irrigation level in certain West European countries, where mean annual air temperature is by about 2 °C higher than in Poland.

Expected rise in water temperature stimulated by the rise in the air temperature in the circumstances of doubled CO_2 concentration in the atmosphere will affect shortening the river icing period in Poland. According to GFDL model, an increase in mean annual air temperature by 4 °C could lead to the exceedance of threshold water temperature above 26 °C, that in turn would result in deterioration of water quality on lowland river sections, where considerable emission of water pollutants is already a reality. Higher water temperature means also a growth in nutrient level that leads to intensification of eutrophication processes in water reservoirs, particularly in shallow ones.

Potential efforts, which could be undertaken with the aim to counteract the unfavourable impact from climate change on water management, are following:

- New legal and economic efforts to be done by both the public and various economy sectors with the aim to protect water resources;
- Temporary restriction of water use by industries and for irrigation purposes during drought periods;
- Effective performance of existing water management infrastructure;
- Development of water management systems, e.g. construction of new water reservoirs, water transfer between catchment areas, etc.

7. FINANCIAL RESOURCES, TECHNOLOGY TRANSFER AND THE JOINT IMPLEMENTATION PROJECTS (AIJ/JI)

7.1. Financial resources and technology transfer

Pursuant to Articles 4.3, 4.4 and 4.5 of the UN Framework Convention on Climate Change, the countries listed in Annex II to this Convention are obliged to provide financial assistance, as well as to implement measures aimed at technology transfer to developing countries. These activities would enable developing countries to implement the provisions of Convention and to cover their costs of adaptation to climate change.

Poland is not an Annex II country, and so, it is not be obliged directly to provide any financial or technological assistance to developing countries, however it participates to many international projects which are co-financed by the Polish Government.

7.2. Joint Implementation Projects (AIJ/JI)

Poland actively joined the implementation of the Joint Implementation (JI) mechanism with the aim to undertake in collaboration with the other Annex I Countries the activities in the territory of Poland, those have resulted in greenhouse gas reduction. The willingness to implement jointly the objectives of the Convention was expressed by the Governments of Finland, The Netherlands and Canada (i.e. memorandums of understanding were signed) and by the Norwegian Government. Five Joint Implementation projects were set up, as well as were 3 other projects in the framework of the pilot phase of the Activities Implemented Jointly (AIJ).

The group of activities implemented in the framework of the pilot phase include the following two Polish-Dutch projects:

- modernisation of heating system in Byczyna – project concluded in December 1999,
- energy efficiency improvement with the use of combined generation of power and heat and fuel conversion from coal into gas in Szamotuły – project concluded in December 2000.

Moreover, the Polish-Norwegian project was set up consisting of two components:

- fuel conversion from coal into gas (29 investments in small- and medium-size boiler plants),
- energy efficiency improvement in new residential buildings (11 investment in the field of heating residential buildings and assembling energy saving equipment there).

This project includes investments throughout Poland, which are in various implementation phases. The project is planned to conclude in December 2002. Planed the total annual CO_2 reduction achieved from three AIJ projects is estimated at 309 200 tonnes.

Begun in 1998 the co-operation in the field of Joint Implementation resulted in the following projects implemented jointly with The Netherlands, Finland and Canada:

- utilisation of biomass from urban greenery for heating purpose in Jelenia Góra – Polish-Dutch project, concluded in October 2000;
- construction of hydropower plant on the Bóbr River in the locality of Leszno Górne – Polish-Canadian project which conclusion time-limit is planned in September 2001;
- conversion of coal-fired peak-hour boiler plant in Elbląg into gas fired combined heating and power plant – Polish-Finnish project which conclusion time-limit is planned in 2003;
- construction of small hydropower plants on the Odra River on its upper section – Polish-Canadian project which conclusion time-limit is planned in 2004;
- construction of wind power plant in the locality of Skrobotowo – Polish-Dutch project which conclusion is planned in December 2003.

The total annual CO_2 reduction to be achieved from JI projects is estimated at 274 285 tonnes.

The Polish procedure for development and approval of both AIJ and JI projects envisages the following steps:

- signing the memorandum of understanding with the country concerned about implementation of joint projects leading to greenhouse gas emission reduction;
- joint preparation of the project proposal which conforms to the project criteria of participating parties;
- approval of the project proposal, as accompanied by relevant opinion, by the Polish side represented by Minister of Environment;
- detailing the responsibility scope of the parties who implement the project.

On the Polish side, it is the Polish UNFCCC Executive Bureau in the Department of International Cooperation in the National Fund for Environmental Protection and Water Management, which is responsible for preparation of the project proposals for Joint Implementation.

8. RESEARCH AND REGULAR OBSERVATIONS

8.1. The national activities

8.1.1. Research

They are the budget funds, which are the major source for financing scientific studies in Poland, and those have been since 1991 managed by the State Committee for Scientific Studies. Financing the studies is managed mainly by means of co-financing:

- statutory activities managed by scientific, research and development entities and universities;
- investments for the purpose of scientific studies;
- research projects;
- target projects, including those implemented upon contracts.

Studies aimed at observing the climate change and variability, and climate processes are carried out in numerous scientific institutes, including first of all the Polish Academy of Sciences, universities, agricultural academies, technical colleges, and research and development institutes subordinate to Ministry of Environment, while the major function in this regard is fulfilled by the Institute of Meteorology and Water Management (IMGW). The most important scientific and application achievements of IMGW in the recent years in the field of climate change include:

- Assessment of multi-year variability of climate elements in Poland and its anticipated trends;
- Determination of characteristics of multi-year variability and trends of extreme thermal phenomena in Poland;
- Development of detailed characteristics of climate variability in regional scale for the Sudety Mountains, Western Carpathians and the Baltic Sea;
- Determination of trends for change in precipitation for 18 meteorological stations based on measurement series since 1881;
- Determination of the main features of spatial and time variability of sea level along the Polish coast of the Baltic Sea;
- Development, on the basis of the results of two global climate models, of scenarios for sea level change in the circumstances of multiple carbon dioxide concentration;
- Determination of variability characteristics and trends for extreme precipitation phenomena in Poland;
- Development of the characteristics of trends in extreme snowfall in Poland with regard to the multi-year variability and the probability of their occurrence;
- Thermal and humidity assessment of seasons of the year as the climate change indicator in the regional scale in Poland.

Moreover, the State Committee for Scientific Studies manages for co-financing the projects being under implementation in various scientific centres. Examples of recently implemented individual grants relating to the issues of climate change are following:

- Secular climate change in the Southern Poland on the basis of the Cracow meteorological series with special regard to the turn of the minor glacial period (i.e. the verge of 18th and 19th Centuries);
- Seasons of the year in Poland: seasonal environmental changes and multi-year climatic trends;
- Short term climate changes during the Ems glacial period on the basis of studies on magnetic vulnerability of sediments;
- Assessment of the effects from the future climate change on temperature and precipitation in Poland;
- Application of tree increment analysis for determination of climate change in the Szczecin Lowland.

Studies in the field of climate change scenarios for Poland, those relate to increasing greenhouse gas concentration in the atmosphere, are carried out in the Institute of Geophysics of the Polish Academy of Sciences. These scenarios are developed on the basis of the results of simulation performed with use of atmosphere and ocean General Circulation Models accessible by the Data Distribution Centre that was established by the Intergovernmental Panel on Climate Change. Setting up a website is planned for the scenarios of potential climate change for Poland, those could be used, inter alia, by the scientists, who deal with the climate change impacts on various environmental elements and processes in Poland.

Studies on climate change impacts and adaptation to this change are carried out in various scientific centres. The following projects are the examples of grants financed by the State Committee for Scientific Studies:

- Intra-species variability of Scotch pine and Norway spruce reaction to the impact from climatic factors and atmospheric concentration of carbon dioxide;
- Study on bird cherry and grain aphid – major cereal pest – in the presence of accelerated climate change;
- Adaptation of mathematical model for description of water circulation within the river-basin with the view to assess the climate change impacts;
- The example of coastal waters in the Gulf of Gdańsk as the basis for the biodiversity development model for the Baltic plankton in circumstances of anticipated global climate change.

The basic research directions concerning the climate impact on economic sectors and ecosystems and the adaptation activities include first of all coast, water resources and agriculture. Their results were presented in Chapter 6.

8.1.2. Regular observations

The first in the territory of Poland regular instrumental meteorological measurements were commenced in 1779 in the Royal Castle of Warsaw, however yet in July 1647, at the presence of King Vladislaus 4th Vasa himself, four years after barometer was constructed, the first measurements of atmospheric pressure had been carried out. In studies on climate variability in Poland, the use of 100-year measurement series of air temperature prevails, and to less extent have been used those of atmospheric precipitation, air pressure and wind. Uniform character have multi-year air temperature series for 6 meteorological stations in Poland, namely Cracow – Astronomical Observatory – since 1792, Puławy – Institute of Soil Science and Plant Cultivation – since 1851, Gdańsk-Wrzeszcz since 1851, Hel since 1851, Mount Śnieżka since 1881, and Warsaw – Astronomical Observatory – since 1779.

When considering climate observing system, it is noteworthy, that the Institute of Meteorology and Water Management was established just to this end, which represents Poland as the member to the World Meteorological Organisation.

The IMGW, as the only entity in Poland, implements the tasks of meteorological and hydrological services, those consist in continuous monitoring of atmospheric and hydrosphere conditions, that is carried out within a network of various level stations, as well as the hydrological and meteorological protection of the national economy; this protection is managed by means of dissemination of communiqués and drawing up the forecasts which are addressed to the State authorities on various levels, and to specialised users such like, inter alia, land, marine and air transport, and agricultural and power sectors. IMGW manages also an early warning system alerting against elemental impact from nature forces, such like flood, hurricanes, storms, hailstorms, catastrophic precipitation and water and atmospheric pollution.

Unfortunately, given the allocation of unsatisfactory financial resources in recent 3 years for the maintenance of the basic meteorological network, in 11 of total 61 meteorological stations managing 50-yearly measurement sequences the uniform observing series have been interrupted. Due to the same reason, also the activity of the Polish meteorological services has been confined which have been managed by the IMGW in the field of the international free exchange of data and information.

Meteorological and atmospheric observing systems. Information is presented below on climate observing systems in Poland, that was structured in accordance to the guidelines as included in document FCCC/CP/1999/L.4/Add.1.

The following sites in Poland are included into the global system of meteorological and climatic observing networks: 61 GSN ground synoptic stations and 3 GUAN aerological stations active within the network managed by the Institute of Meteorology and Water Management, and 987 meteorological and precipitation posts of which 980 are owned by IMGW and one by the Nicolaus Copernicus University (UMK), in Toruń, and 6 by the Adam Mickiewicz University (UAM), in Poznań (Tab. 8.1).

Table 8.1. Combined information on atmospheric observing system in Poland

Measurement stations	GSN	GUAN	GAW	Other*
How many stations is the Party responsible for?	61	3	3	987
How many of them are currently operated?	61	3	3	987
How many stations participate to international data interchange?	35	3	3	140
How many stations are to be operated in 2005?	**	**	**	**
Does the country operate any international archive centre?	NO	NO	NO	NO
Does the country operate any centre for archive/control quality?	NO	NO	NO	NO

* Meteorological and precipitation posts.
** Depending on funds available.
For symbols – see the List of Abbreviations.
Source: [Pawłowska 2000].

The IMGW-owned 35 synoptic and 2 aerological stations, and 140 meteorological and precipitation posts participate to the international data exchange, whereas UMK and UAM base stations do not participate to such an exchange.

The plans concerning the activity scope of the IMGW network for 2005 are dependent upon financial resources, which the Institute will acquire for maintenance of the observing network. It is envisaged that 7 base stations will be operated in 2005.

Oceanic observing systems. The Institute of Meteorology and Water Management, Institute of Oceanology (IO PAN) and Institute Hydroengineering (IBW PAN), both institutes are members of the Polish Academy of Sciences, participate to oceanographic observing system (Tab. 8.2).

The IMGW oceanographic network secures the GCOS needs in terms of the following observation types: water temperature, salinity, sea level on the stations along the Polish coastal line, water temperature and salinity profiles taken since the fifties during regular cruises throughout the Southern Baltic Sea. All the data is subject to verification and it is stored in the national and international databases.

IO PAN manages process-oriented studies on the Baltic Sea and on the European Arctic Seas (Norwegian Sea, Greenland Sea and Barents Sea). In relation to GCOS, its needs are being secured primarily by the Polish research studies carried out in the Arctic, those are guided by the exploration of variability of water, heat and salt exchange between the Arctic Ocean and the Northern Atlantic, as well as heat exchange with the atmosphere. Also, solar radiation parameters are measured there (direct diffused, reflected, absorbed, etc.) with the aim to determine energy balance. On the Baltic Sea, the research is carried out also on the matter and energy transfer inside this sea (between its particular basins), on the interchange processes through the boundary between the atmosphere and sea, on energy transfer from the sea surface in-depth direction, as well as the measurements of and modelling the solar energy balance.

Since 1996, in Hydroengineering Institute of the Polish Academy of Sciences, the undulation measurements on the Baltic Sea have been carried out, as well as the study on the effects form marine undulation on energy and heat exchange through the sea surface.

As it results from Table 8.2 which pertains to oceanographic observing network, in Poland, there are 101 type VOS platforms (i.e. ships for voluntary observing), 3 SOOP type (programme for occasional on-board measurements), including 2 owned by IMGW, 1 – by IO PAN, and 11 TIDE GAUGES type (sea level measurement stations) – all owned by IMGW, and 3 MOORED BUOYS type, i.e. autonomic measurement buoys, each one owned by IMGW, IO PAN and IBW PAN.

All IMGW stations and 1 measurement buoy of IO PAN participate to the international system of data interchange.

IMGW plans for 2005 are dependent upon financial resources to be granted, whereas IO PAN is intended to enlarge the number autonomic measurement buoys up-to 2, and IBW PAN will remain with the one currently under operation.

Earth surface observing systems. Geomorphologic Division of the UAM participates to the Earth surface observing system (Tab. 8.3).

Poland is a member of the International Permafrost Association (IPA), and it participates to the Circumpolar Active Layer Monitoring (CALM) Programme which is a part of the global climate observing programme GTN-P. CALM Programme was established in early nineties of the last century with the aim to assess the changes occurring within active layer of the multi-year permafrost, and to provide information to regional and global models. Measurement results collected by researchers on CALM sites are then transferred through electronic way to the CALM data centre in Cincinnati University, USA.

Satellite systems for climate observing. Since 1967, the Institute of Meteorology and Water Management has applied satellite data in its operating system. Currently, PDUS/METEOSAT and HRPT/NOAA satellite transmission station is operated in Cracow. In Table 8.4 information is presented on research satellite observations in Poland.

The Satellite Research Division, in Cracow, is responsible for satellite data and its distribution throughout the Institute of Meteorology and Water Management. Both, scientific research and servicing activities are conducted there. In December 1999, the Memorandum of Understanding was signed between Poland and EUMETSAT. It is planned to include into real time distribution such products like: surface temperature of the Baltic Sea, land surface temperature in the territory of Poland, snow and ice monitoring on the Baltic Sea in winter, atmospheric (tropospheric

Table 8.2. Combined information on oceanographic observing system in Poland
For symbols – see the List of Abbreviations

Measurement platforms	VOS	SOOP	TIDE GAUGES	SFC DRIFTERS	SUB-SFC FLOATS	MOORED BUOYS	ASAP
How many platforms is the Party responsible for?	101	3	11	–	–	3	–
How many of them participate to international data interchange?	101	3	11	–	–	2	–
How many stations are to be operated in 2005?	101	1	–	–	–	3	–
Does the country operate any international archive centre?	NO	NO	–	–	–	–	–
Does the country operate any centre for archive/control quality?	NO	NO	–	–	–	–	–

Source: [Pawłowska 2000].

Table 8.3. Information on the Earth surface observing system that Poland participates to

Measurement stations	GTN-P	GTN-G	FLUXNET
How many stations is the Party responsible for?	300	–	–
How many of them are currently operated?	300	–	–
How many stations participate to international data interchange?	23	–	–
How many stations are to be operated in 2005?	23	–	–
Does the country operate any international archive centre?	NO	–	–
Does the country operate any centre for archive/control quality?	NO	–	–

For symbols – see the List of Abbreviations.
Source: [Pawłowska 2000].

Table 8.4. Information on satellite observing system (for research and operating purposes) in Poland

Has the Party space research programme in place?	Series/missions: Input into EUMETSAT programme
Is there any commitment concerning the quality and continuity of the climate data obtained from satellite data?	NO
Is there any national programme for obtaining the climate data from satellite data?	NO
Are the data files disseminated on regular basis?	Currently still in scientific/experimental phase
Is the data accessible on free of charge basis?	In the IMGW network
Does the country operate any international archive centre?	NO
Does the country operate any centre for archive/control quality?	NO

Source: [Pawłowska 2000].

and stratospheric) monitoring with application of TOVS information in visible spectrum.

Greenhouse gas monitoring. A relatively dense measuring station network has been established world-wide with the aim to record current concentrations of CO_2, CH_4 and other greenhouse gases. The observing sites are located mostly on oceanic islands, continental coasts and other sites which location authorises the results obtained to be validated and interpreted as representative in global scale. The basic condition here is an insignificant impact from local emission (or sink) on the composition of samples under analysis. Such stations may be considered as "clean". It is a clear fact, that much more difficult would be to choose such "clean" site in the mainland of the continent, since the inversion layer, that occurs periodically in lower troposphere has mostly confined the number of representative measurements. Majority of continental stations is located on mountain peaks. In Western Europe, "clean" continental stations are located in Alps, Apennines and Schwarzwald. It appears, however, that for the greenhouse gas emission be estimated and modelled properly on the European scale, the measurement results taken deeply inside the continent are extremely useful.

The Mount Kasprowy Wierch station in Poland was established in 1994 by the personnel of the Chair of Environmental Physics of the University of Mining and Metallurgy, in Cracow. Location of the station on the peak of Mt. Kasprowy Wierch (1987 m asl) in Tatry Mountains was driven by the expectations, that this site will satisfy the requirements of "clean" station, and at the same time, as being situated in Central Europe it will provide information on distribution of the concentration in the mainland the continent.

Since September 1994, the measurements of carbon dioxide, methane and sulphur hexafluoride concentrations in the air have been carried out on Mt. Kasprowy Wierch. They include measurements of mean weekly content of trace gases in the atmosphere, those are performed with application of the lines for filling-in aluminium sacks. The results of these measurements do not provide any basis for any conclusions to be drawn on the short-term variations of atmospheric composition. In early June 1996, automatic gas chromatograph was installed in the building of the High-mountain Meteorological Observatory. Continuous measurements were begun from that moment. Apart from concentration measurement, also analyses are performed of isotopic composition of carbon dioxide (in a weekly cycle) and methane (in a monthly cycle). Since 1998, survey of $^{14}CO_2$ concentration is carried out.

Among the three gases tested, only carbon dioxide shows very regular, seasonal concentration changes. Content of the two other gases do not change periodically. From the point of view of surveying atmospheric composition change in the aspect of growing greenhouse effect, important is an accretion of concentrations of gases characterised by high greenhouse potential. It is convenient to use multi-year observation in order to assess both the periodical changes and the increase in gas content in the atmosphere. The measurements taken with the use of gas chromatograph cover 5-year period, whereas those using the sacks comprise the period longer than 6.5 years.

Carbon dioxide concentration reaches its highest values in spring, whereas the minimum falls in early autumn. The amplitude of seasonal cycle amounts to about 12 ppm. This cycle relates to biospheric activity and carbon dioxide assimilation by the plants. Decline of CO_2 concentration between April and September relates to decrement of carbon dioxide assimilated by biosphere (Figure 8.1). Mean annual concentration of carbon dioxide in 2000 on the Kasprowy Wierch Station amounted to 368 ppm, ranging between 355 in summer and 380 ppm in winter, and it has shown a tendency to increase by about 3 ppm/year. The increase in concentration of this gas has been perce-

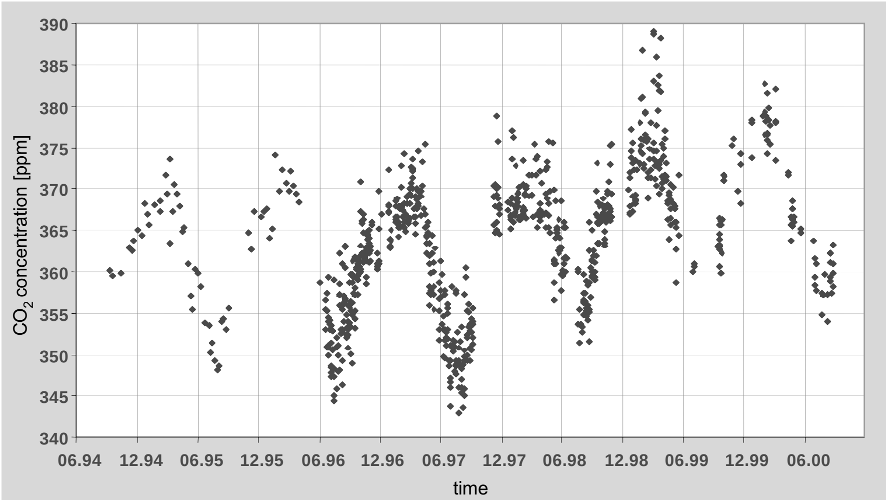

Fig. 8.1. Record of CO_2 concentration change on Mt. Kasprowy Wierch in the period of 1994–2000, source: AGH

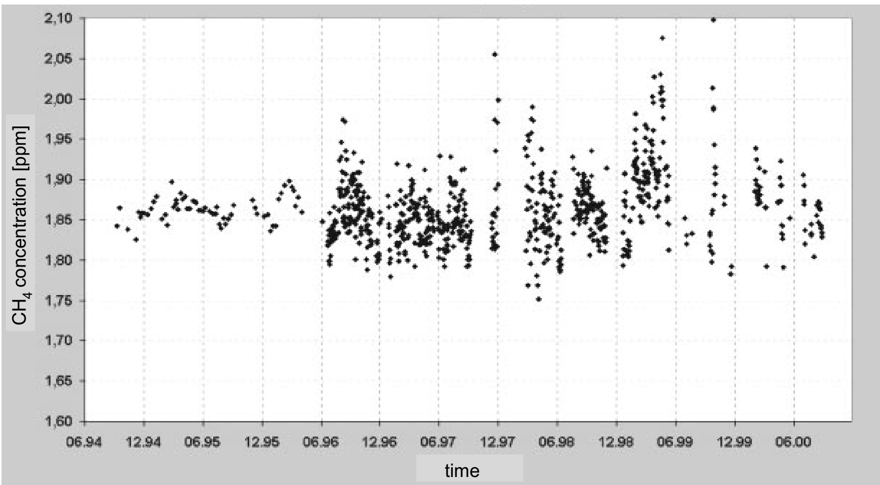

Fig. 8.2. Record of CH_4 concentration change on Mt. Kasprowy Wierch in the period of 1994–2000, source: AGH

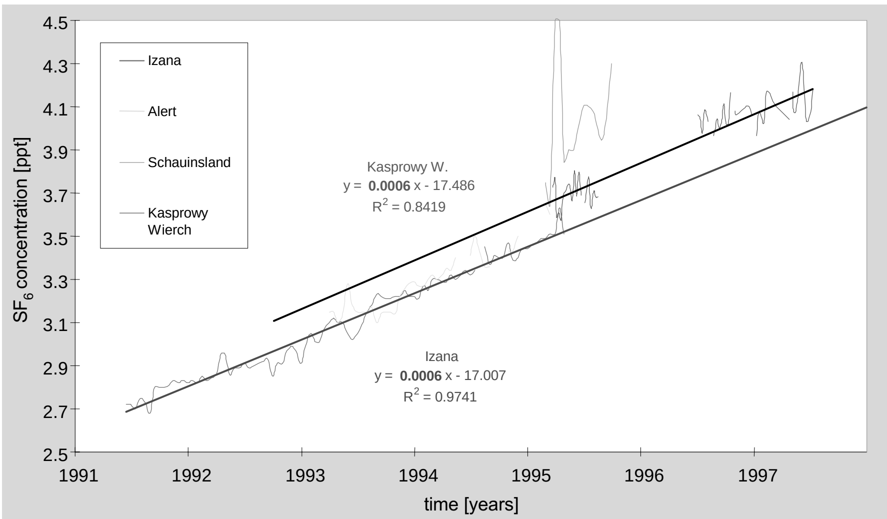

Fig. 8.3. SF_6 concentration changes measured on measuring stations in the period of 1991–1997. Regression straight lines are drawn-up for Kasprowy Wierch (Poland) and Izana (Canary Islands) stations, source: AGH

ivable as late as since 1998. The earlier data indicated steady mean level of carbon dioxide content in Central European region. It should be however emphasised, that in the period of 1995–1998, the observing carried out in other European stations indicated also considerable decline in the growth rate of CO_2 concentration in the atmosphere.

Methane concentration does not change regularly. Variation of CH_4 content in the atmosphere in 1994–2000 is shown in Figure 8.2. Considerable spread of CH_4 concentration values results due to the daily nature of this gas concentration, and also from variable weather conditions, that arrests (or does not arrest) the inflow of local air mass enriched with methane.

Mean methane concentration on Mt. Kasprowy Wierch is by 35 ppb higher, than that recorded in Schwarzwald, Germany (Schauinsland station), by 62 ppb higher, than that noted in Mace Head station, Ireland, and as much as by 100 ppb higher, than oceanic level determined on the basis of measurements taken on Canary Islands (Izana). Methane emission on the continent is hence meaningfully represented by the measurement results from stations situated in the European mainland. The increased concentration level noted on Mt. Kasprowy Wierch is reliable, and, in parallel with the results obtained in other measuring stations, it could be used for calculation of this gas emission, as well as to observing its efficiency on continental scale. However, given the heterogeneity of methane sources, it is especially important for the station not to be located in the vicinity of major methane emitters, since methane concentration measured in such case would be considerably higher.

Measurements of sulphur hexafluoride concentration on Mt. Kasprowy Wierch were carried out in 1995 on the basis of air samples captured into aluminium sacks. Continuous measurements performed since July 1996 with use of automatic gas chromatograph are the continuity of the previous measurements, since they have been calibrated in relation to the same standards. When analysing 1995–1997 data, mean annual accretion of SF_6 concentration can be determined as observed on Mt. Kasprowy Wierch (Fig. 8.3). It amounts to

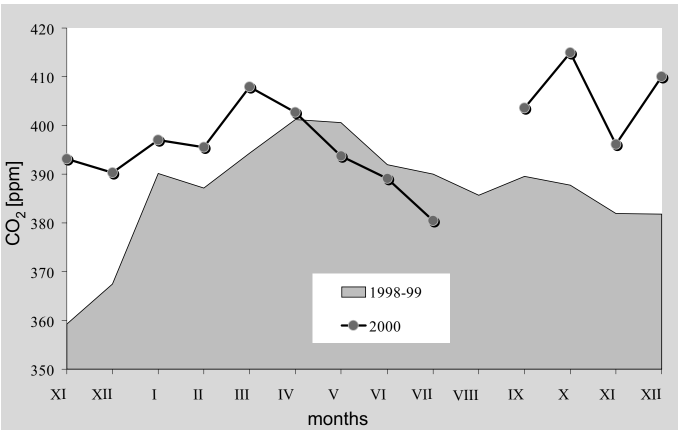

Fig. 8.4. Mean monthly values of the ground CO_2 concentration on the "Borecka Forest" Comprehensive Environmental Monitoring Station in 2000 on the background of mean values in 1998–1999, source: IOŚ

0.22 ± 0.01 ppt/year, that with mean concentration amounting to 3.94 ppt accounts for 5.7 ± 0.3% on annual basis. Growing trend of SF_6 concentration noted on Mt. Kasprowy Wierch conforms to observing carried out on Izana station (Fig. 8.3) and on the other "clean" stations situated far away from the sources of this gas (e.g. Alert, Georg von Neumayer). This is the result of low utilisation rate of this gas in Central Europe, and of the absence of impact from direct SF_6 emission on its concentration measurement taken at the station. The shift between Izana and Mt. Kasprowy Wierch amounts to 0.48 ± 0.1 ppt and it results form continental emission of sulphur hexafluoride, mainly in Western Europe. Measurement taken in Cracow do not show any meaningfully higher concentrations, than that on Mt. Kasprowy Wierch. Similarly, SF_6 measurements taken in the Southern Poland have shown increased concentration only on a single site. Linear accretion of SF_6 concentration noted on Mt. Kasprowy Wierch would have indicated a world-wide arrest of production growth of this gas and its retention on stable level.

Methane concentration retains on stable level amounting during recent five years to about 1850 ppb. Concentration of sulphur hexafluoride rises regularly with the rate of 0.2 ppt/year; its current value is 4.5 ppt.

The "Borecka Forest" Comprehensive Environmental Monitoring Station was established in 1992 by the Institute of Environmental Protection, Warsaw Branch. The station is located near the locality of Diabla Góra (i.e. Devil Mountain) in Borecka Forest, in North Eastern Poland. It fulfils the role of regional monitoring station for the background pollution of land environment. The aim of studies conducted in the station is a long-term assessment of changes in the state of natural environment affected by anthropogenic activity.

At the end of 1997, continuous measurement of carbon dioxide concentration was begun in the station. The ground level concentration of carbon dioxide in the "Borecka Forest" station depends first of all upon biospheric activity, i.e. photosynthesis and soil emission, and anthropogenic activity (i.e. fuel combustion for energy purposes).

CO_2 measurements performed in the period of 1998–2000 showed cyclical nature of CO_2 concentration in various scales. The average amplitude of annual cycle amounts to about 20 ppm, that accounts for less than 5% of mean annual value. CO_2 concentration reaches the highest values in spring and autumn, whereas its the lowest values fall in summer. This cycle relates to biospheric activity (from spring to autumn) and it is being intensified by fuel combustion for energy purposes in winter season.

In 2000, mean annual CO_2 concentration amounted to 397 ppm, and it was slightly lower than in the recent two-year period (401ppm), given the assumed measurement accuracy ±10%. Much higher amplitude of mean monthly values was noted (35 ppm) in relation to the past period (15 ppm). The highest mean monthly values were noted in October (415 ppm) and March (408 ppm), and the lowest ones in summer (380 ppm in July). The fact is noteworthy, that when compared to the average values noted in the period of 1998–1999, in 2000, the higher CO_2 concentrations occurred during chilly season, and the lower in summer (Fig. 8.4). Due to accidental break in CO_2 gauge operation in August and partly in September 2000, it is difficult to asses the period, when the minimum CO_2 concentration appeared. It is supposed that this occurred likely in the period of July–August.

8.2. International activities

8.2.1. The World Climate Programme

Since 1993, the Institute of Meteorology and Water Management has continued its efforts aimed at setting up the National Climate Programme, according to the guidance of the World Climate Programme. In 2000, proposal of targeted project was submitted to the State Committee for Scientific Studies in the framework of which the Institute could commence an implementation of six of total nine constituent tasks of this multi-disciplinary programme. These tasks included primarily: climate change in Poland during Holocene period, contemporary trends in climate change with regard to extreme climatic phenomena and the sea level of the Baltic Sea, projections for climate change in Poland, design for monitoring and periodical assessments of climate in Poland, and assessment of the changes and methods for adaptation of terrestrial and aquatic ecosystems, water management systems and plant and animal production affected by climate change. So far, the National Climate Programme has not been yet implemented.

Having in mind the WMO recommendations concerning establishment of the climate programmes, since 2000, IMGW has elaborated on study projects being partial tasks of the National Climate Programme which has been planned to implement, such as:

- Variability of selected climatic phenomena in Poland in 20th Century,
- Atlas of wind resources in Poland,
- Assessment of multi-year variability of selected climate elements in Poland and its anticipated trends,
- Ozone changes in the atmosphere and their impact on the ground UV-B radiation.

8.2.2. International Geosphere-Biosphere Programme

In 1989, the Polish National Committee for IGBP Global Change was established at the Presidium of the Polish Academy of Sciences. Personal composition of the Committee includes 30 members representing various scientific disciplines related to global climate change and its natural consequences. The work of the Committee concentrates on organisational, scientific, publishing and informative activities being the result of the international co-operation and initiatives implemented on the national level.

The National IGBP Committee actively supports the efforts to establish the National Climate Programme in Poland and to organise scientific conferences dedicated to the issues of climate change. The Committee's activity relates closely to major IGBP projects such like: BAHC, LOICZ, LUCC and IHDP, as well as the other world-wide and European programmes, e.g. WCRP/WMO, IHP UNESCO, START IGBP or ENRICH. The Committee publishes its annual information bulletin in the English language on its activity, and it supports publishing scientific series of the Geographia Polonica. Papers in IGBP Global Change, also in English, where the articles are published, those have been written by the Polish scientists in the field of climate change and its consequences.

8.2.3. Global Climate Observing System

Detailed information on the activity scope in Poland in the framework of GCOS is presented in paragraph 8.1.2.

It is noteworthy to add, that the project titled Inventory of Existing State of Research on Climate Change in Poland in the Aspect of the National Participation to Global Climate Observing System has been assumed to implement in the framework of planned National Climate Programme.

8.2.4. Intergovernmental Panel on Climate Change

The Polish IPCC Focal Point was established in 1990. Primarily, it was associated with Climatological Division of the IMGW, and in 1992 it was moved to Climate Protection Centre of the Institute of Environmental Protection. Since 1999, it has been located at the Polish UNFCCC Executive Bureau, in the National Fund for Environmental Protection and Water Management. The activity of the Polish IPCC Focal Point is subject to its supervision by the Ministry of Environment.

The IPCC Focal Point is concerned with the co-ordination of activities aimed at IPCC in Poland, pronouncing opinions on IPCC documents, nominating experts to participate in working groups and expert sessions. The Polish experts participate to preparation and reviewing IPCC documents and reports, including TAR.

Pursuant to efforts made by the Polish IPCC Focal Point, two following IPCC reports were published in the Polish language version:

- Climate Change, 1995: IPCC Second Assessment Report. Published by the Institute of Environmental Protection in 1997;
- Technologies, policies and measures for mitigating climate change – IPCC. Technical Paper 1. Published by the Institute of Environmental Protection in 1999.

It is also planned to translate and publish the Climate Change 2001. Synthesis Report and to disseminate it among scientific, governmental, self-governmental and non-governmental circles.

9. EDUCATION, TRAINING AND PUBLIC AWARENESS

9.1. Educational policy

A high priority is attributed in Poland to environmental protection issues, including those of climate change. According to Constitution of the Republic of Poland, Public Authorities shall pursue policies ensuring the ecological security of current and future generations (Article 74, paragraph 1 of the Constitution). When signing the UN Framework Convention on Climate Change, Poland committed itself to fulfil the obligations aimed at development and implementation of educational and public awareness programmes on climate change and its effects and at public access to information on climate change and its effects (Article 6 of the Convention).

Two Ministries take responsibility for educational policy in the field of environmental protection: Ministry of National Education and Ministry of Environment. In 1995, these Ministries signed Memorandum of Understanding on the co-operation in the field of ecological education, that resulted in preparation of the National Strategy for Ecological Education, which major objectives are:

- to disseminate the idea of sustainable development throughout all of the life-spheres including human labour and recreation, i.e. to comprise all population in Poland within permanent ecological education,
- to implement ecological education as inter-disciplinary education on all the levels of the formal and informal education,
- to establish the Voivodship, County and Municipal programmes for ecological education,
- to promote good practices in the field of ecological education.

This document constitutes the basis for the implementation of tasks relating to ecological education within formal education system (from kindergartens to universities), in major agencies, central administrative institutions, and in the institutions, which act in favour of environmental protection in the Voivodships and self-governments. Strengthening the self-governance relates, inter alia, to the responsibility of local Government for the matters of environmental protection and environmental education. The local governments bear also the obligation to determine the objectives and forms of this education with regard to specific regional features, local identity and cultural tradition.

Based on the aforementioned Strategy, in 2000, draft Executive Programme was elaborated regarding to the National Strategy for Ecological Education and its implementation conditions. This Programme aims at the attribution of adequate priority to ecological education considered as an indispensable prerequisite to achieve sustainable development. Intention of this Programme is to prepare the public in Poland to joining environmentally sound activities in accordance to environmental protection standards mandatory in European Union.

Public awareness in the field of environmental protection is being developed at schools and by means of various type actions undertaken by governmental and public organisations and by the media. Also training programmes dedicated to various professional and social groups are of special importance. The objective of the Executive Programme for the National Strategy for Ecological Education is to integrate those various spheres of ecological education, and hence to enhance the effectiveness of its social effects.

9.2. Formal education

The basic goal of ecological education is to create such type attitudes and behaviour of the public to ensure promotion of the idea of sustainable development. In the Acts outlined below which pertain to general education system the provisions have been included concerning the implementation of environmental education:

- The Act of 7 September 1991 on the Education System provides, that "Education system shall provide in particular for: dissemination of ecological knowledge among children and youth and developing appropriate attitudes towards environmental protection issues" (Article 1 paragraph 11).
- The Act of 27 April 2001 on Environmental Protection Law provides, that "The issues of environmental protection and sustainable development shall be dully taken into account in the programme basis for general education for all the school types (Chapter 8th, Article 77); Administrative authorities, co-ordinating institutions

and those managing scientific and research and development activities, as well as universities, scientific and research and development institutes, whose activity scope includes the domains of science or scientific branches relating to environmental protection, shall be obliged to make allowance in their fixed programmes and activities for studies concerning environmental protection issues, and to develop these studies" (Chapter 8th, Article 79).

Raising the public awareness as well as developing public education in field of environmental care begin in kindergartens, through a six-year grammar school, then three-year gymnasium and also in three-year high school. Such type of overall educational system was initiated in 1999.

Mandatory contents of education in kindergartens and general profile schools has been determined in the programme basis – issued by Minister of National Education – for the kindergarten and general profile education for all school types. Just on this basis all of the educational programmes and manuals are built.

In kindergarten education, the programme basis provides for delivery of knowledge on healthy life-style, assessment of behaviour which favours health or which threats health, creation and taking of the opportunities to familiarise with nature by means of observing, experimenting, and developing the pro-ecological habits and behaviour.

In grammar school, during initial phase of education, i.e. in standards from 1 to 3, the following has been placed among educational objectives ... to wake the need to contact nature, and among educational substance – observing natural phenomena and processes which are accessible to child's experience, and the essence of environmental protection forms within the closest neighbourhood have been put forward.

During the second educational period, i.e. in standards from 4 to 6, a broad spectrum of ecological substance is discussed. First of all, so called ecological path has been introduced. In the framework of these classes, the pupils get familiarise with the issues pertaining to man's relation with natural environment, and their sensitivity is being increased to hazards resulting from human environmental interference. These issues are also represented in the objectives and substance of teaching the subject "nature", in the framework of which the following issues are discussed: to understand relations existing in natural environment; to gain the skills of taking observations of natural phenomena and to describe them; to familiarise with interrelations between man and the environment, and to train the sense of responsibility for the environment.

In the same way, in the subsequent phases of education, i.e. in gymnasium and high school, ecological issues are represented in general educational programme. They assume the form of inter-disciplinary ecological path and they are present in the contents of such subjects like biology, geography, physics and chemistry. The difference in relation to the previous basic educational phases consists in higher complexity of the issues under consideration. For instance, the following issues have been included into the ecological path in so called profiled high-school:

- Economic and social aspects of relations between the environment and man, including its activity. The value of the environment. Benefits and losses relating to its exploitation. Renewable and non-renewable resources.
- Contemporary system of world-wide economy and its effects on degradation of environmental resources. International co-operation as the prerequisite to achieve sustainable development.
- Civilisation threats related to conventional and nuclear energy sector. Renewable energy sources.
- The methods to protect biodiversity.
- Intensification of agricultural production and related hazards. Organic biodynamic farming.
- The issues of biological security, e.g. genetic engineering.
- The issues of the State ecological policy.

The wide scope of ecological issues and the knowledge on climate change resulting from anthropogenic activities are promoted in the State-own universities, on the faculties related to environmental protection. Also non-State-owned colleges provide education in the field of hazards to the environment, including those to climate. Moreover, post-graduate studies are managed for graduates of various speciality universities, where the issues in question are also presented.

The Executive Programme for the National Strategy for Ecological Education discussed above proposes, inter alia, that the academic teachers would arrange in their respective universities the cycles of open lectures as to be accessed by the whole academic centre (from the university or even from all the Municipality), those would be carried out by specialists in various disciplines related to environmental protection issues.

9.3. General information on training

Training courses in broadly understood environmental protection, including the issues of climate change, are managed in teachers' and youth's circles, State services relating to nature conservation, or self-governmental representatives. Such training courses are managed by both governmental and non-governmental organisations. The main directions for training comprise activities performed for the sake of efficient energy use in households, on self-governmental and enterprise levels, rational waste management, including waste re-use, and application of renewable energy sources.

9.4. Information centres

It is the Polish UNFCCC Executive Bureau, which provides information services concerning the issues of climate change, Climate Convention and Kyoto Protocol. The Bureau was appointed by Minister of Environment and it has been located in the Department of International Co-operation at the National Fund for Environmental Protection and Water Management.

An example of strong governmental centre for ecological information is the Bureau of Education and Public Relations at the Ministry of Environment. The responsibility scope of the Bureau includes, inter alia:

- to undertake and co-ordinate educational and promotional activities of the Ministry, as well as to co-ordinate activities related to the National Programme for Ecological Education and the conditions for its implementation;
- to prepare and manage monitoring of public ecological awareness with the use of available forms of public communication;
- to manage matters relating to provision of information on the environment and environmental protection, and to undertake actions aimed at public participation to proceedings in environmental protection matters in accordance to mandatory legal acts and international Conventions, including Climate Convention;
- to work jointly with external units on developing ecological education programmes for various levels of educational system;
- to manage matters relating to the co-operation with non-governmental ecological organisations.

In order to intensify the effectiveness of activities in the field of ecological education, those are undertaken in the framework of the implementation of sustainable development principles and Agenda 21, and of the tasks resulting from the National Strategy for Ecological Education, Information Centre on Ecological Education was established in 2000 at the National Fund for Environmental Protection and Water Management. Its major responsibilities include:

- to support the individuals or groups of by means of rendering information services;
- to establish platform for exchange of experience dedicated to groups from various circles relating not only to ecological education;
- to promote good and verified experience in the field of ecological education.

The group of non-governmental centres dealing with ecological education includes the Network of Ecological Education Centres, which currently includes 22 partners.

9.5. The public information campaigns and the involvement of governmental and non-governmental organisations

One of the most important activity aspects of non-governmental ecological organisations is to conduct broad educational action. It is aimed at raising the Poles' awareness concerning the benefits, which could be gained from activities aimed at reduction of greenhouse gas emission, and on hazards relating to absence of such activities, and on potential consequences of climate change.

This is the Polish Ecological Club, jointly with other non-governmental institutions, first of all the Institute for Sustainable Development (InE) and the Polish Foundation for Energy Efficiency (FEWE), that undertakes a number of works closely relating to examination of the climate protection in Poland, that is expected to result further in a reliable information for the public.

In 2000, the Institute for Sustainable Development organised competition titled "Our Municipality Protects Climate". The aim of the competition was to promote investment projects in the field of climate protection, hence to involve local communities into international actions aiming at environmental protection. Specific tasks of the competition included promotion of and rendering support to the best local projects which aim was to reduce greenhouse gases (including carbon dioxide, methane and nitrous oxide). The winners of the competition were granted recommendation for their own investment projects to be financially supported by the ECOFUND Foundation. The competition "Our Municipality Protects Climate" was a pilot in character. It was financed with the resources from the US Agency for International Development in the framework of the Local Government Partnership Programme. Moreover, for the Municipalities concerned with investing in renewable energy sources, climate protection and energy saving, the Institute for Sustainable Development prepared guidance titled "Our Municipality Protects Climate" pertaining to joining by local Self-Government the global environmentally sound actions.

The priority activity sectors of the ECOFUND include provision of financial support to projects in the field of reduction of greenhouse gases emission (energy saving, promotion of renewable energy sources, elimination of methane from coal mines and municipal landfills and freons from manufacturing processes). The ECOFUND promotes certain fields of its own activity also by means of competitions, e.g. for energy saving in heating systems, or reduction of air pollutant emission in health resorts and national parks, where such projects are endeavoured which include thermal modification measures in residential building in parallel with modernisation of respective boiler plants.

The institutions mentioned above, both the governmental and non-governmental ones, participate to preparation of information bulletins. The Institute of Environmental Protection publishes bulletin titled Climate Change which being contracted by the Ministry of Environment is prepared twice a year by the Polish UNFCCC Executive Bureau. The aim of this bulletin is to spread the issues of climate change relating to anthropogenic activities. The bulletin presents information on the national and international activities aiming at climate change mitigation, and on scientific researches and projects conducted in Poland and abroad. The bulletin is delivered free of charge to everyone concerned.

Ministry of Environment, in collaboration with the Polish Ecological Club and the Bureau for Supporting Ecological Lobbying, publishes a bimonthly titled The Bulletin – Regional Ecological Centre for Central and Eastern Europe, where information is presented on, inter alia, the State ecological policy, Climate Convention, initiatives undertaken for the sake of environmental protection, and hence on combating the greenhouse effect. Articles concerning unconventional energy sources and innovative technological solutions in the field of energy can be found in Ecological Bulletin published by the Upper-Silesian District of the Polish Ecological Club.

Also, radio and TV programmes broadcasted countrywide promote in a variety of forms the information on climate change, environmental hazards relating to civilisation, and the actions being undertaken for the sake of the environment we all dwell in.

9.6. Participation to international activities

In Central and Eastern Europe, the organisations concerned with climate protection established Climate Action Network in Central and Eastern Europe (CANCEE). The Polish partner to this organisation is the Polish Ecological Club.

In 2001, the Mazovian District of the Polish Ecological Club, will conclude implementation of three-year climatic project established in Central and Eastern Europe jointly by the Regional Environmental Center and the World Resource Institute, in Washington D.C. The aim of this project is to upgrade knowledge of the members of ecological organisations on the issues of climate change and on Climate Convention and its mechanisms, as well as to build understanding between the non-governmental ecological organisations dealing with environmental protection, and these public and governmental institutions, which manage co-operation in this field.

In academic year 2000/2001, the Polish non-governmental organisations joined an international campaign named The Bet. In the framework of this action, young representatives of non-governmental ecological organisations, schools, universities, and the public entered a bet with their government, to claim that they are in position to reduce CO_2 emission – that is one of the major greenhouse gases – by a definite percentage corresponding to the national obligation committed in accordance with the Kyoto Protocol, but in a fixed and a considerably shorter time-limit. Such campaign provides a lot of benefits, but first of all it has brought the attention of the public to the reasons for climate change, involved young people into activity relating to environmental protection, and forced more activities to be done in the field of ecological education at schools and universities. Moreover, this campaign – by means of making the public aware of the opportunity to reduce carbon dioxide emission in households by means of education and change in behaviour – can bring essential savings to the State, as well as to make politicians concerned with active participation to environmental protection.

In the period of 1997–2000, Poland participated to the Dutch SCORE Programme for the co-operation between the Dutch public and the Central European countries. The aim of this Programme was to establish persistent structures in these countries, those would support the growth in energy efficiency in its end-users. The Polish co-ordinator of the SCORE Programme was the Polish National Conservation Agency. Detailed action plan prepared in the framework of this programme includes, inter alia, education and awareness raising of the public in the field of efficient energy use. A programme for educating pupils, teachers and self-governmental personnel was prepared to this end, as well as Energy Efficiency Training and Advisory Centre was established.

ABBREVIATIONS

AGH	University of Mining and Metallurgy
AIJ	Activities Implemented Jointly
ASAP	Automated Shipboard Aerological Programme
BAHC	Biospheric Aspects of the Hydrological Cycle
BOD_5	Biochemical Oxygen Demand (in 5 days period)
BOŚ	Bank Ochrony Środowiska (Bank of Environmental Protection)
CALM	Circumpolar Active Layer Monitoring
CANCEE	Climate Action Network in Central and Eastern Europe
CGE-PL	Computable General Equilibrium–Poland
CHP	Combined Heat and Power plants
CORINAIR	Coordination d'Information Environmentale AIR emissions inventory
DDC	Data Distribution Centre
EFOM-PL	optimising supply model
ENRICH	European Network for Research in Global Change
EMEP	Environmental Monitoring and Evaluation Program
EU	European Union
EUMETSAT	Europe's Meteorological Satellite Organisation
FEWE	Polish Foundation for Energy Efficiency
FLUXNET	Global Terrestrial Network–Carbon
GAW	Global Atmosphere Watch of WMO
GCOS	Global Climate Observing System
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDL	Geophysical Fluid Dynamic Laboratory
GHGs	Greenhouse Gases
GISS	Goddard Institute for Space Studies
GOOS	Global Ocean Observing System
GSN	GCOS Surface Network
GTN-G	Global Terrestrial Network–Glaciers
GTN-P	Global Terrestrial Network–Permafrost
GUAN	GCOS Upper Air Network
GUS	Central Statistical Office
HRPT	High Rate Picture Transmission
IBL	Forestry Research Institute
IBW PAN	Institute of Hydroengineering PAN
ICP	Institute of Industrial Chemistry
IGBP	International Geosphere–Biosphere Programme
IHDP	International Human Dimensions Programme
IHP	International Hydrological Decade
IMGW	Institute of Meteorology and Water Management
InE	Institute for Sustainable Development
IO PAN	Institute of Oceanology PAN
IOŚ	Institute of Environmental Protection
IPA	International Permafrost Association
IPCC	Intergovernmental Panel on Climate Change
IUNG	Institute of Soil Science and Plant Cultivation
JI	Joint Implementation
KBN	State Committee for Scientific Research
LOICZ	Land Ocean Interactions in the Coastal Zone
LRDM-NE	Long-Run Dynamic Model for National Economy
LUCC	Land Use and Cover Change Project
METEOSAT	The EUMETSAT geostationary meteorological satellite
MG	Ministry of Economy
MOORED BUOYS	autonomic measurement buoys
MOŚZNiL	previous name of the Ministry of Environment
MSP	Ministry of the Treasury
MŚ	Ministry of Environment
MSWiA	Ministry of Interior and Administration
MTiGM	Ministry of Transport and Marine Management
NFOŚiGW	National Fund for Environmental Protection and Water Management

NOAA	National Oceanic and Atmospheric Administration
NPK	three-component fertiliser
OECD	Organisation for Economic Co-operation and Development
OZE	renewable energy sources
PAN	Polish Academy of Sciences
PDUS	Primary Data User Station
PGNiG	Polish Oil and Gas Company
PE	Act on Energy Law
PEN	Power Engineering Companies
PHARE	Poland and Hungary Assistance for Restructuring of the Economy
PLN	Polish New Zloty
POE	Non-governmental Environmental Organisations
ppm	parts per million by volume
ppb	parts per billion by volume
ppt	parts per trillion by volume
PROSK-E	simulation demand model
RP	Republic of Poland
RM	Council of Ministers
SFC DRIFTERS	Surface Drifters
SOOP	Ship of Opportunity Programme
START IGBP	System for Analysis, Research and Training
SUB-SFC	Sub-surface
TAR	Third Assessment Report
TIDE GAUGES	stations for sea level measurements
TIROS	Television Infrared Observation Satellite
TOVS	TIROS Operational Vertical Sounder
TPA	Third Party Access
UAM	Adam Mickiewicz University
UMK	Nicolas Copernicus University
UN	United Nations
UNESCO	United Nations Educational Scientific and Culture Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UKIE	State Committee for European Integration
URE	Energy Regulation Agency
USAID	US Agency for International Development
USD	United States Dollar
VOS	Volunteer Observing Ship
WCRP	World Climate Research Programme
WMO	World Meteorological Organisation
ZPE20	Assumptions for Energy Policy for Poland until 2020

Chemical species

CO_2	carbon dioxide
CH_4	methane
HFC	hydrofluorocarbons
NH_3	ammonia
N_2O	nitrous oxide
PFC	perfluorocarbons
SF_6	sulphur hexafluoride

BIBLIOGRAPHY

Analysis of market situation and the effectiveness of so far undertaken actions aimed at its improvement. Ministry of Labour and Social Policy, April 2000 (in Polish).

Application of SAFIRE software for preparation of scenarios for development of renewable energy sector in Poland by 2020. EC BREC European Renewable Energy Centre, at the Institute for Agricultural Construction Mechanisation and Electrification, 2000 (in Polish).

Assumptions for energy policy for Poland until 2020. Ministry of Economy. Warsaw, February 2000 (in Polish).

Demidowicz G., Deputat T., Górski T., Krasowicz S., Kuś J., Stuczyński T. Adaptation scenarios of agriculture in Poland to future climate changes. Environmental Monitoring and Assessment, 61: 133–144, 2000.

Demidowicz G., Deputat T., Górski T., Krasowicz S., Kuś J. 1999. Possible changes in plant production in relation to expected climate change in Poland. Conference Materials on „Climate in Poland. Change and Variability”, Łódź, 4–6 November 1999: 43–48. (in Polish).

Demographic prognosis for Poland by the Voivodship for the period of 1999–2030. GUS, Warsaw, 2000 (in Polish).

Deputat T. 1999. Consequences of climate change on phenology of selected cultivation plants. Conference Materials on „Climate in Poland. Change and Variability” Łódź, 4–6 November 1999: 49–56. (in Polish).

Development of greenhouse gas emission reduction policy and enhancement of their removal in major economy sectors, including analysis of legal and economic regulations in the field of the opportunity to apply the Joint Implementation mechanisms. Institute of Environmental Protection. Warsaw, 2000 (in Polish).

Directions for Industrial Policy for the Period of 1999–2000. Ministry of Economy (in Polish).

Effects of implementation of the national reform programme for hard coal mining in the period of 1998–2000. Ministry of Economy, 2001 (in Polish).

Environmental Protection. GUS Information and Publications. Warsaw. Yearbooks for the period of 1995–2000 (in Polish).

Environmental Protection in Poland. Guidance on legal regulations, administrative procedures and institutions. 3rd Edition. Institute of Environmental Protection, 2000. (in Polish)

Forestry 2000. GUS Information and Publications. Warsaw, 2000 (in Polish).

Fuel and energy management in the period of 1998–1999. GUS Information and Publications. Warsaw, 2000 (in Polish).

Gaj H. et al. Development and updating of macro-economic and sectoral scenarios for greenhouse gas emission reduction and sink by 2020. Institute of Environmental Protection, 1999 (in Polish).

Information on unemployment in December 2000. Ministry of Labour and Social Policy (in Polish).

Inventory of greenhouse gas emission and removal in Poland in 1988. Institute of Environmental Protection, 1997 (in Polish).

Inventory of greenhouse gas emission and removal in Poland in 1990. Institute of Environmental Protection, 1997 (in Polish).

Inventory of greenhouse gases CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 emission and removal in Poland in 1991 for the purpose of Climate Convention by the method and in the structure of the categories, IPCC Revised 1996. Institute of Environmental Protection, 2000 (in Polish).

Inventory of greenhouse gases CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 emission and removal in Poland in 1993 for the purpose of Climate Convention by the method and in the structure of the categories, IPCC Revised 1996. Institute of Environmental Protection, 2000 (in Polish).

Inventory of greenhouse gases emission and removal in Poland in 1994. Institute of Environmental Protection, 1997 (in Polish).

Inventory of greenhouse gases CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 emission and removal in Poland in 1995 for the purpose of Climate Convention by the method and in the structure of the categories, IPCC Revised 1996. Institute of Environmental Protection, 2000 (in Polish).

Inventory of greenhouse gases CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 emission and removal in Poland in 1996. Institute of Environmental Protection, 1998 (in Polish).

Inventory of greenhouse gases CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 emission and removal in Poland in 1997 r. Institute of Environmental Protection, 1999 (in Polish).

Inventory of greenhouse gases CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 emission and removal in Poland in 1998 for the purpose of Climate Convention by the method and in the structure of the categories, IPCC Revised 1996. Institute of Environmental Protection, 2000 (in Polish).

Inventory of greenhouse gases CO_2, CH_4, N_2O, PFCs, HFCs and SF_6 emission and removal in Poland in 1999 for the purpose of Climate Convention by the method and in the structure of the categories, IPCC Revised 1996. Institute of Environmental Protection, 2001 (in Polish).

Jurak D., Kaczmarek Z., Napiórkowski J., 1997. Impact of climate change on water resources in Poland. Publications of the Institute of Geophysics, Polish Academy of Science. E–1 (295). Warsaw.

Liszewska M., Osuch M., 1997. Assessment of the impact of global climate change simulated by the ECHAM1/LSG general circulation model onto hydrological regime of three Polish catchments, Acta Geophysica Polonica XLV, 4, 363–386.

List of the Acts adopted by the Parliament in 2000 and 2001 which were submitted on the initiative of the Council of Ministers, those included the provisions to harmonise the Polish legislation with that of the European Union (as for 21 May 2001) (in Polish).

List of the Governmental Draft Acts currently under consideration by the Parliament, those include provisions to harmonise the Polish legislation with that of the European Union (in Polish).

List of projects co-financed and approved to financing by the ECOFUND in the period of 1993–2000 in the field of greenhouse gas emission reduction. ECOFUND, 2001 (in Polish).

List of projects co-financed and approved to financing by the National Fund for Environmental Protection and Water Management in the period of 1997–2000 in the field of greenhouse gas emission reduction, 2001 (in Polish).

Minor Statistical Yearbook. GUS. Warsaw, 2000 (in Polish).

Miętus M. The role of regional atmospheric circulation in forming climate and oceanographic conditions in the Polish coastal zone of the Baltic Sea. Institute of Meteorology and Water Management, Marine Division in Gdynia. Thesis qualifying as assistant professor, 2001 (in Polish).

The National Case Study on the Sources and Sinks of Greenhouse Gases in Poland. Ministry of Environmental Protection Natural Resources and Forestry, 1995 (in Polish).

Nęcki J. Measurements of atmospheric concentration of greenhouse gases on Mt. Kasprowy Wierch. University of Mining and Metallurgy, Chair of Environmental Physics, Faculty of Physics and Nuclear Technique, 2001 (in Polish).

Pawłowska J. Existing system of climate observation and the current state of climate studies, and the plan for Poland's participation to climate observation system in global scale (GCOS). Institute of Environmental Protection, 2000 (in Polish).

Pawłowska J. The national activities relating to education and information policy in the field of climate change and Climate Convention. Institute of Environmental Protection, Warsaw, 2000 (in Polish).

Prządka Z. Results of testing greenhouse gas concentration study at the Borecka Forest Comprehensive Environmental Monitoring Station. Institute of Environmental Protection, 2001 (in Polish).

Radwański E. et al. Strategies for greenhouse gas emission reduction and removal by particular gas types (N_2O, HFCs, PFCs and SF_6) and sectors by 2020. Institute of Environmental Protection, Warsaw, 2001 (in Polish).

Report on the state of economy in 1999. Ministry of Economy. Warsaw, 2000. (in Polish)

Report on the state of industry in 1999. Ministry of Economy. Warsaw, 2000. (in Polish)

Report on the state of forest in Poland in 1999. In „Timber Industry", Journal of the Association of Forestry and Timber Engineers and Technicians, November, 2000. (in Polish)

Industrial Yearbook 2000. GUS. Warsaw, 2000 (in Polish).

Sathaye J., Meyers S. et al., Greenhouse Gas Mitigation Assessment: A Guidebook. Environmental Science and Technology Library, vol. 6. Kluwer Academic Publishers. 1995.

Second State Ecological Policy. Ministry of Environment, 2000 (in Polish).

Second National Report to the Conference of the Parties to the UN Framework Convention on Climate Change. Ministry of Environmental Protection, Natural Resources and Forestry, 1998.

Statistical Yearbook of the Republic of Poland. GUS. Warsaw. Yearbooks for the period of 1989–2000. (in Polish).

Strategy for development of renewable energy sector. Ministry of Environment, September 2000 (in Polish).

ANNEX A. EMISSIONS TRENDS [Gg]

Carbon Dioxide

Greenhouse Gas Source and Sink Categories	Years										
	1988*	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Emission with removals	441 879	336 034	324 201	330 776	322 981	329 635	305 292	329 914	321105	307 629	286 233
Total Emissions	**477 584**	**381 482**	**367 689**	**372 311**	**363 980**	**372 293**	**348 926**	**373 202**	**362300**	**338 095**	**329 739**
1. Energy	463 051	371 485	357 711	360 988	353 912	362 166	338 028	363 592	350962	326 963	319 088
A. Fuel Combustion	462 998	371 433	357 661	360 927	353 842	362 083	337 942	363 498	350876	326 858	318 963
1. Energy industries	260 537	236 582	233 002	223 009	202 570	200 331	187 346	195 987	192784	184 916	180 001
2. Manufacturing Industries and Construction	62 994	49 999	37 186	37 259	52 896	68 068	68 122	74 682	70024	63 186	53 271
3. Transport	28 238	29 103	27 815	30 475	27 675	29 533	25 285	28 098	26662	28 127	31 382
4. Other Sector	111 229	55 749	59 658	70 184	70 701	64 151	56 324	64 106	60857	50 103	54 011
5. Other	NA	NA	NA	NA	NA	NA	865	625	549	526	298
B. Fugitive Emissions from Fuels	53	52	50	61	70	83	86	94	86	105	125
1. Solid Fuels	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2. Oil and Natural Gas	53	52	50	61	70	83	86	94	86	105	125
2. Industrial Processes	13 574	9 212	9 247	10 603	9 248	9 422	10 144	8 938	10 664	10 487	10 609
A. Mineral Products	12 036	7715	8301	7971	8467	8292	9364	8193	9872	9790	9 983
B. Chemical Industry	29	29	313	25	201	29	199	163	136	79	61
C. Metal Production	738	544	633	337	580	359	581	582	656	618	565
D. Other Production	771	924	NA	802	NA	742	NA	NA	NA	NA	NA
E. Production HFCs, PFCs i SF_6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Consumption HFCs, PFCs i SF_6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
G. Other				1 468							
3. Solvent and Other Product Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Agriculture	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
A. Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Manure Management	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Agricultural Soils	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
G. Other											
5. Land-Use Change and Forestry**	–34 746	–44 663	–42 757	–40 815	–40 179	–41 953	–42 880	–42 616	–40 521	–29 821	–43 464
A. Changes in Forestry and Other Wood Biomass Stocks	–24 990	–34 514	–32 531	–30 460	–30 151	–31 427	–33 125	–31 996	–29 880	–19 151	–39 767
B. Forest and Grassland Conversion	959	785	75	720	190	705	157	81	101	87	42
C. Abandonment of Managed Lands	–10 715	–10 934	–7558	–11 075	–7368	–11 231	–7125	–7919	–7905	–7881	0
D. CO_2 Emissions and Removals ** from Soil	NE	NE	–2743	NE	–2850	NE	–2782	–2782	–2837	–2876	–3 739
E. Other											
6. Waste											
A. Solid Waste Disposal on Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Waste-water Handling	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other											
7. Other											
Memo Items											
International Bunkers:	0	0	0	0	2021	0	2122	2069	2228	2092	1724
Aviation					248		308	280	346	342	346
Marine					1773		1814	1789	1882	1750	1378
Multilateral Operations											
CO_2 Emissions from Biomass			5002		16 375		16 054	21 199	21 199	16 079	15200

* Base year. ** Net removals.

0 – Values estimated less than 0.5 Gg, NA – Not Applicable, NE – Not Estimated.

Source: MŚ.

Methane

Greenhouse Gas Source and Sink Categories	Years										
	1988*	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 Equivalent Emissions (100–year GWP value – 21)	65 961	58 821	54 369	51 954	51 072	51 807	51 597	47 292	47 838	49 035	47 250
Total Emissions	**3141**	**2801**	**2589**	**2474**	**2432**	**2467**	**2457**	**2252**	**2279**	**2335**	**2250**
1. Energy	1295	1031	951	821	933	955	983	998	992	874	828
A. Fuel Combustion	47	37	26	28	56	59	56	56	55	53	50
1. Energy industries	11	9	2	8	2	8	2	2	2	2	2
2. Manufacturing Industries and Construction	18	15	2	10	3	14	3	4	4	4	3
3. Transport	7	7	8	8	8	9	9	9	9	7	7
4. Other Sector	10	6	14	2	43	28	42	41	40	40	38
5. Other	1	0	0	0	0	0	0	0	0	0	0
B. Fugitive Emissions from Fuels	1248	994	925	793	877	896	927	942	937	821	778
1. Solid Fuels	1043	799	759	628	706	724	742	746	745	626	586
2. Oil and Natural Gas	205	195	166	165	171	172	185	196	192	195	192
2. Industrial Processes	16	13	10	8	10	10	11	11	12	9	8
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	12	10	8	7	7	7	8	9	9	7	6
C. Metal Production	4	3	2	1	3	3	3	2	3	2	2
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
G. Other											
3. Solvent and Other Product Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Agriculture	863	850	773	704	656	647	615	591	598	582	509
A. Enteric Fermentation	806	793	715	647	606	597	565	545	551	534	469
B. Manure Management	56	55	56	56	49	49	49	45	46	47	39
C. Rice Cultivation											
D. Agricultural Soils											
E. Prescribed Burning of Savannas											
F. Field Burning of Agricultural Residues	1	2	2	1	1	1	1	1	1	1	1
G. Other											
5. Land-Use Change and Forestry	1	0	0	0	0	0	0	0	0	0	0
A. Changes in Forestry and Other Wood Biomass Stocks											
B. Forest and Grassland Conversion	1	0	0	0	0	0	0	0	0	0	0
C. Abandonment of Managed Lands											
D. CO_2 Emissions and Removals from Soil											
E. Other											
6. Waste	966	907	855	941	833	855	848	652	677	870	905
A. Solid Waste Disposal on Land	835	767	735	844	736	761	759	562	588	784	825
B. Waste-water Handling	131	140	120	97	97	94	89	90	89	86	80
C. Waste Incineration											
D. Other											
7. Other											
Memo Items											
International Bunkers:	0.00	0.00	0.00	0.00	0.21	0.00	0.22	0.22	0.23	0.21	0.17
Aviation					0.01		0.01	0.01	0.01	0.01	0.01
Marine					0.21		0.21	0.21	0.22	0.20	0.16
Multilateral Operations											0.00
CO_2 Emissions from Biomass											

* Base year.
0 – Values Estimated Less than 0.5 Gg, NA – Not Applicable, NE – Not Estimated.
Source: MŚ.

Nitrous oxide

Greenhouse Gas Source and Sink Categories	Years										
	1988*	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 Equivalent Emissions (100–year GWP value – 310)	21 700	19 530	16 120	15 500	15 500	15 500	16 740	16 740	16 740	16 120	23 250
Total Emissions	**70**	**63**	**52**	**50**	**50**	**50**	**54**	**54**	**54**	**52**	**75**
1. Energy	7	6	6	6	7	6	7	7	7	8	7
A. Fuel Combustion	7	6	6	6	7	6	7	7	7	8	7
1. Energy industries	4	3	3	3	3	3	3	3	3	3	2
2. Manufacturing Industries and Construction	1	1	1	0	1	1	1	2	1	1	1
3. Transport	1	1	1	2	1	1	1	1	1	2	2
4. Other Sector	1	1	1	1	2	1	2	1	2	2	2
5. Other							0	0	0		0
B. Fugitive Emissions from Fuels											
1. Solid Fuels											
2. Oil and Natural Gas											
2. Industrial Processes	20	16	13	13	13	14	16	16	16	13	12
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	20	16	13	13	13	14	16	16	16	13	12
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4. Agriculture	43	41	33	31	30	30	31	31	31	31	56
A. Enteric Fermentation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Manure Management	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	20
C. Rice Cultivation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Agricultural Soils	43	41	33	31	30	30	31	31	31	31	36
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	0	0	0	0	0	0	0	0	0	0	0
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land-Use Change and Forestry	0	0	0	0	0	0	0	0	0	0	0
A. Changes in Forestry and Other Wood Biomass Stocks	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Forest and Grassland Conversion	0	0	0	0	0	0	0	0	0	0	0
C. Abandonment of Managed Lands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. CO_2 Emissions and Removals from Soil	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste											
A. Solid Waste Disposal on Land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Waste-water Handling	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Waste Incineration	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other											
7. Other	0	0	0	0	0	0	0	0	0	0	0
Memo Items											
International Bunkers:					0.131		0.137	0.134	0.144	0.135	0.111
Aviation					0.016		0.020	0.018	0.022	0.022	0.022
Marine					0.115		0.117	0.116	0.122	0.113	0.089
Multilateral Operations											
CO_2 Emissions from Biomass											

* Base year.
0 – Values Estimated Less than 0.5 Gg, NA – Not Applicable, NE – Not Estimated.
Source: MŚ.

HFCs, PFCs i SF_6

Greenhouse Gas Emissions	Years									
	1995*		1996		1997		1998		1999	
	P	A	P	A	P	A	P	A	P	A
HFCs	0.240	0.017	0.216	0.052	0.453	0.148	0.595	0.207	0.681	0.377
PFCs	0.122	0	0.116	0.001	0.120	0.001	0.122	0.001	0.12	0.003
SF_6	0.001	0.0001	0.000	0.000	0.00012	0.0000	0.00024	0.000	0.001	0.001

* Base year.
P – potential emission.
A – actual emission.
Source: MŚ.

ANNEX B. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1988 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. All Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion Activities:	91.84	0.0093	0.0014
Liquid Fuels	73.96	0.0133	0.0028
Gaseous Fuels	55.61	0.0450	0.0001
Solid Fuels	99.69	0.0035	0.0013
Biomass	0.00	0.1121	0.0020
Other Fuels			
1.A.1. Energy and Transformation:	95.86	0.0039	0.0013
Liquid Fuels	74.66	0.0017	0.0005
Gaseous Fuels	55.65	0.0013	0.0001
Solid Fuels	98.20	0.0040	0.0014
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.2. Industry (ISIC):	91.64	0.0277	0.0007
Liquid Fuels	78.89	0.0026	0.0006
Gaseous Fuels	55.15	0.0722	0.0001
Solid Fuels	117.88	0.0036	0.0011
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.3. Transport:	75.06	0.0190	0.0034
Liquid Fuels	73.61	0.0200	0.0036
Gaseous Fuels			
Solid Fuels	100.07	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Commercial/Institutional:	91.91	0.0159	0.0014
Liquid Fuels	0.0000	0.0000	0.0000
Gaseous Fuels	55.77	0.0014	0.0023
Solid Fuels	98.37	0.0077	0.0013
Biomass		0.1970	0.0022
Other Fuels			
1.A.5. Residential:	89.52	0.0083	0.0013
Liquid Fuels	56.78	0.0014	0.0001
Gaseous Fuels	56.51	0.0014	0.0001
Solid Fuels	96.55	0.0024	0.0014
Biomass	0.00	0.2100	0.0020
Other Fuels			
1.A.6. Agriculture/Forestry:	77.65	0.0042	0.0034
Liquid Fuels	73.83	0.0046	0.0038
Gaseous Fuels	55.09	0.0014	0.0001
Solid Fuels	96.19	0.0024	0.0014
Biomass	0.00	0.0006	0.0020
Other Fuels			
1.A.7. Other:	80.22	0.0221	0.0022
Liquid Fuels	72.57	0.0282	0.0025
Gaseous Fuels	55.74	0.0014	0.0001
Solid Fuels	107.34	0.0024	0.0014
Biomass			
Other Fuels			

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors		
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/Mg]		
	Production	Processing	
1.B.1. Coal mining:			
1.B.1.a. Underground mining	4.363	1.038	
1.B.1.b. Surface mining	0.013	0.000	
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	
1.B.2.a. Oil:	0.01169	0.00011	
i. Exploration	6.31500	0.06180	
ii. Transport	0.00000	0.00000	
iii. Rafining/Storage	0.00000	0.00000	
iv.a. Wholesale Distribution	0.00000	0.00000	
iv.b. Retail Dystribution	0.00000	0.00000	
1.B.2.b. Natural Gas:	0.01889	0.34837	
i. Production	0.00022	0.06463	
ii+iii. Consumption	0.02569	0.45165	
2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Iron and Steel Production:			
Contact Processes:			
Sinter	8.100		
Open Hearth Steel	52.000		
Steel Casting	62.000		
Iron Casting	61.000	0.200	
Non-Contact processes:			
Blast Furnace Charging	0.220		
Converter Steel	11.260		
Electric Steel	4.300	0.120	
Ferroalloys	541.900		
Coke		0.200	
2.B. Non-Ferrous Metals Production:			
Aluminium Production	804.340		
2.C. Inorganic Chemicals:			
Nitric Acid Production			3.400
Nitrogen Fertilizer Production[*]	1.500		
Ammonia Production	1.000	4.900	5.000
Sodium Carbonate Production	25.000		
Carbon Black Production		10.000	
Agricultural Liming	0.440		
Urea Production			1.000
2.D. Organic Chemicals:			
Ethylene Production	0.300		
2.E. Non-Metalic Mineral Products:			
Cement Production	500.000		
Lime Production	800.000		
2.F. Other:			
Sugar Production	232.800		
Wine Production[**]	58.000		
Beer Production[**]	10.000		
Spirits Production[**]	100.000		

4. Agriculture	CH_4 Emission Factors [kg/Animal]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation*** & Manure Management		
(Total Number of Livestock 101.56 million):	22.78	0.553
1. Cattle	69.563	2.002
a. Non-dairy	47.976	1.220
b. Dairy	94.336	2.900
3. Sheep	8.889	0.190
4. Swine	1.500	1.430
5. Horses****	18.000	1.390
6. Other	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0157	
Mineralization	0.0157	
4.F. Field Burning of Agricultural Residues	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
	0.0030	0.0002

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factors in [kg/hl].
*** Emission factor for enteric fermentation relates to total livestock number: 35.370 million.
**** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		0.79
5.B. Forest and Grassland Conversion	71.07	
5.C. Abandonment of Managed Lands		2.38
6. Waste	CH_4 Emission Factors	
6.A. Landfils [kgCH_4/t]	513.333	
6.B. Wastewater [GgCH_4/GgBOD_5]	0.220	
6.D. Other Waste		

ANNEX C. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1990 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. All Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion Activities:	91.55	0.0092	0.0014
Liquid Fuels	75.50	0.0144	0.0029
Gaseous Fuels	55.82	0.0411	0.0001
Solid Fuels	99.78	0.0033	0.0013
Biomass	0.00	0.1065	0.0020
Other Fuels			
1.A.1. Energy and Transformation:	96.41	0.0036	0.0013
Liquid Fuels	83.27	0.0017	0.0005
Gaseous Fuels	55.19	0.0013	0.0001
Solid Fuels	98.25	0.0036	0.0014
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.2. Industry (ISIC):	92.49	0.0283	0.0007
Liquid Fuels	78.16	0.0027	0.0006
Gaseous Fuels	55.42	0.0754	0.0001
Solid Fuels	118.20	0.0024	0.0010
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.3. Transport:	74.20	0.0192	0.0035
Liquid Fuels	73.51	0.0196	0.0036
Gaseous Fuels			
Solid Fuels	100.08	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Commercial/Institutional:	84.49	0.0053	0.0011
Liquid Fuels	72.22	0.0029	0.0006
Gaseous Fuels	55.92	0.0014	0.0023
Solid Fuels	97.57	0.0077	0.0013
Biomass			
Other Fuels			
1.A.5. Residential:	83.37	0.0092	0.0011
Liquid Fuels	56.78	0.0014	0.0001
Gaseous Fuels	56.50	0.0014	0.0001
Solid Fuels	95.16	0.0024	0.0013
Biomass	0.00	0.2100	0.0020
Other Fuels			
1.A.6. Agriculture/Forestry:	80.50	0.0041	0.0031
Liquid Fuels	73.79	0.0049	0.0038
Gaseous Fuels	55.12	0.0014	0.0001
Solid Fuels	95.85	0.0024	0.0014
Biomass	0.00	0.0006	0.0020
Other Fuels			
1.A.7. Other:	91.69	0.0024	0.0012
Liquid Fuels	76.81	0.0029	0.0006
Gaseous Fuels	55.80	0.0014	0.0001
Solid Fuels	98.48	0.0024	0.0014
Biomass	0.00	0.0006	0.0020
Other Fuels			

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

<table>
<tr><th>GHG Source/Sink Categories</th><th colspan="3">Aggregate Emission Factors</th></tr>
<tr><td rowspan="2">1.B. Fugitive Emissions from Fuels</td><td colspan="3">CH_4 Emission Factors [kg/Mg]</td></tr>
<tr><td colspan="2">Production</td><td>Processing</td></tr>
<tr><td>1.B.1. Coal mining:</td><td colspan="2"></td><td></td></tr>
<tr><td>1.B.1.a. Underground mining</td><td colspan="2">4.363</td><td>1.038</td></tr>
<tr><td>1.B.1.b. Surface mining</td><td colspan="2">0.013</td><td>0.000</td></tr>
<tr><td>1.B.2. Oil and Natural Gas</td><td colspan="2">CO_2 Emission Factors [kg/GJ]</td><td>CH_4 Emission Factors [kg/GJ]</td></tr>
<tr><td>1.B.2.a. Oil:</td><td colspan="2">0.01565</td><td>0.00015</td></tr>
<tr><td>i. Exploration</td><td colspan="2">6.31500</td><td>0.06180</td></tr>
<tr><td>ii. Transport</td><td colspan="2">0.00000</td><td>0.00000</td></tr>
<tr><td>iii. Rafining/Storage</td><td colspan="2">0.00000</td><td>0.00000</td></tr>
<tr><td>iv.a. Wholesale Distribution</td><td colspan="2">0.00000</td><td>0.00000</td></tr>
<tr><td>iv.b. Retail Dystribution</td><td colspan="2">0.00000</td><td>0.00000</td></tr>
<tr><td>1.B.2.b. Natural Gas:</td><td colspan="2">0.01941</td><td>0.37295</td></tr>
<tr><td>i. Production</td><td colspan="2">0.00019</td><td>0.05981</td></tr>
<tr><td>ii+iii. Consumption</td><td colspan="2">0.02393</td><td>0.44672</td></tr>
<tr><td>2. Industrial Processes</td><td>CO_2 Emission Factors [kg/Mg]</td><td>CH_4 Emission Factors [kg/Mg]</td><td>N_2O Emission Factors [kg/Mg]</td></tr>
<tr><td>2.A. Iron and Steel Production:</td><td></td><td></td><td></td></tr>
<tr><td>Contact Processes:</td><td></td><td></td><td></td></tr>
<tr><td>Sinter</td><td>8.100</td><td></td><td></td></tr>
<tr><td>Open Hearth Steel</td><td>52.000</td><td></td><td></td></tr>
<tr><td>Steel Casting</td><td>62.000</td><td></td><td></td></tr>
<tr><td>Iron Casting</td><td>61.000</td><td>0.200</td><td></td></tr>
<tr><td>Non-Contact processes:</td><td></td><td></td><td></td></tr>
<tr><td>Blast Furnace Charging</td><td>0.220</td><td></td><td></td></tr>
<tr><td>Converter Steel</td><td>11.260</td><td></td><td></td></tr>
<tr><td>Electric Steel</td><td>4.300</td><td>0.120</td><td></td></tr>
<tr><td>Ferroalloys</td><td>541.900</td><td></td><td></td></tr>
<tr><td>Coke</td><td></td><td>0.200</td><td></td></tr>
<tr><td>2.B. Non-Ferrous Metals Production:</td><td></td><td></td><td></td></tr>
<tr><td>Aluminium Production</td><td>804.340</td><td></td><td></td></tr>
<tr><td>2.C. Inorganic Chemicals:</td><td></td><td></td><td></td></tr>
<tr><td>Nitric Acid Production</td><td></td><td></td><td>3.400</td></tr>
<tr><td>Nitrogen Fertilizer Production*</td><td>1.500</td><td></td><td></td></tr>
<tr><td>Ammonia Production</td><td>1.000</td><td>4.900</td><td>5.000</td></tr>
<tr><td>Sodium Carbonate Production</td><td>25.000</td><td></td><td></td></tr>
<tr><td>Carbon Black Production</td><td></td><td>10.000</td><td></td></tr>
<tr><td>Agricultural Liming</td><td>0.440</td><td></td><td></td></tr>
<tr><td>Urea Production</td><td></td><td></td><td>1.000</td></tr>
<tr><td>2.D. Organic Chemicals:</td><td></td><td></td><td></td></tr>
<tr><td>Ethylene Production</td><td>0.300</td><td></td><td></td></tr>
<tr><td>2.E. Non-Metalic Mineral Products:</td><td></td><td></td><td></td></tr>
<tr><td>Cement Production</td><td>500.000</td><td></td><td></td></tr>
<tr><td>Lime Production</td><td>800.000</td><td></td><td></td></tr>
<tr><td>2.F. Other:</td><td></td><td></td><td></td></tr>
<tr><td>Sugar Production</td><td>232.800</td><td></td><td></td></tr>
<tr><td>Wine Production**</td><td>58.000</td><td></td><td></td></tr>
<tr><td>Beer Production**</td><td>10.000</td><td></td><td></td></tr>
<tr><td>Spirits Production**</td><td>100.000</td><td></td><td></td></tr>
</table>

4. Agriculture	CH_4 Emission Factors [kg/Mg]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation*** & Manure Management (Total Number of Livestock 95.92 million):	22.918	0.576
1. Cattle	70.670	2.042
a. Non-dairy	47.976	1.220
b. Dairy	94.336	2.900
3. Sheep	8.889	0.190
4. Swine	1.500	1.430
5. Horses****	18.000	1.390
6. Other	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0157	
Mineralization	0.0157	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0002

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factors in [kg/hl].
*** Emission factor for enteric fermentation relates to total livestock number: 34.613 million.
**** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		1.08
5.B. Forest and Grassland Conversion	62.78	
5.C. Abandonment of managed lands		2.43
6. Waste	CH_4 Emission Factors	
6.A. Landfils [kgCH_4/t]	513.333	
6.B. Wastewater [GgCH_4/GgBOD_5]	0.220	
6.D. Other Waste		

ANNEX D. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1991 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion:	90.81	0.0066	0.0016
Liquid Fuels	74.24	0.0154	0.0026
Gaseous Fuels	54.17	0.0013	0.0010
Solid Fuels	98.12	0.0027	0.0015
Biomass	0.00	0.1739	0.0020
Other Fuels			
1.A.1. Energy Industries:	96.07	0.0010	0.0014
Liquid Fuels	75.56	0.0023	0.0005
Gaseous Fuels	55.93	0.0014	0.0001
Solid Fuels	98.13	0.0008	0.0014
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.2. Manufacturing Industries and Construction:	95.40	0.0050	0.0016
Liquid Fuels	76.20	0.0025	0.0016
Gaseous Fuels	54.80	0.0013	0.0008
Solid Fuels	111.99	0.0065	0.0019
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.3. Transport:	73.82	0.0216	0.0032
Liquid Fuels	73.69	0.0217	0.0032
Gaseous Fuels			
Solid Fuels	98.85	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Other Sectors:	79.91	0.0181	0.0015
Liquid Fuels	73.68	0.0047	0.0038
Gaseous Fuels	53.55	0.0012	0.0012
Solid Fuels	91.35	0.0090	0.0014
Biomass	0.00	0.2995	0.0020
Other Fuels			

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors	
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/Mg]	
	Production	Processing
1.B.1. Coal mining:	2.924	0.694
1.B.1.a. Underground mining	4.363	1.038
1.B.1.b. Surface mining	0.013	0.000
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]
1.B.2.a. Oil:	0.0167	0.0002
i. Exploration	6.3150	0.0618
ii. Transport	0.0000	0.0000
iii. Rafining/Storage	0.0000	0.0000
iv.a. Wholesale Distribution	0.0000	0.0000
iv.b. Retail Dystribution	0.0000	0.0000
1.B.2.b. Natural Gas:	0.0174	0.3543
i. Production	0.0570	0.1023
ii. Transmission and Distribution	0.0051	0.4328

2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Mineral Products:			
Cement Production	500.00		
Lime Production	785.00		
Soda Ash Production	415.00		
Agricultural Liming	0.44		
2.B. Chemical Industry:			
Ammonia Production	1.00	4.90	5.00
Nitric Acid Production			3.40
Carbide Production	1100.00		
Nitrogen Fertilizer Production*	1.50		
Carbon Black Production		10.00	
Urea Production			1.00
Ethene Production	0.30		
2.C. Iron and Steel Production:			
Contact Processes:			
Sinter	8.10		
Open Hearth Steel	52.00		
Steel Casting	62.00		
Iron Casting	61.00	0.20	
Non-Contact processes:			
Blast Furnace Charging	0.22		
Converter Steel	11.26		
Electric Steel	4.30	0.12	
Coke		0.20	
Ferroalloys	3900.00		
Aluminium	1800.00		

4. Agriculture	CH_4 Emission Factors [kg/Mg]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation** & Manure Management (Total Number of Livestock 94.328 million):	20.494	0.597
1. Cattle	71.969	2.089
a. Non-dairy	94.336	2.900
b. Dairy	47.976	1.220
3. Sheep	8.889	0.190
6. Horses ***	18.000	1.390
8. Swine	1.500	1.430
9. Poultry	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0157	
Mineralization	0.0157	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0001

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factor for enteric fermentation relates to total livestock number (without poultry): 34.885 million.
*** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		1.02
5.B. Forest and Grassland Conversion	14.18	
5.C. Abandonment of Managed Lands		1.71
5.D. CO_2 Emissions and Removals from Soil		0.62
6. Waste	CH_4 Emission Factors	
6.A. Solid Waste Disposal on Land [GgCH_4/Gg]	0.090	
6.B. Waste-water Handling [GgCH_4/GgBOD_5]	0.220	
6.C. Waste Incineration		
6.D. Other		

ANNEX E. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1992 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. All Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion Activities:	90.710	0.007	0.001
Liquid Fuels	73.700	0.016	0.003
Gaseous Fuels	55.679	0.034	0.000
Solid Fuels	98.393	0.003	0.001
Biomass	99.396	0.004	0.002
Other Fuels	94.726	0.010	0.002
1.A.1. Energy and Transformation:	95.524	0.003	0.001
Liquid Fuels	74.135	0.002	0.000
Gaseous Fuels	54.881	0.001	0.000
Solid Fuels	97.247	0.003	0.001
Biomass	104.532	0.015	0.002
Other Fuels	94.726	0.010	0.002
1.A.2. Industry (ISIC):	92.917	0.026	0.001
Liquid Fuels	78.333	0.002	0.001
Gaseous Fuels	54.712	0.083	0.000
Solid Fuels	111.994	0.001	0.001
Biomass			
Other Fuels			
1.A.3.1. Transport – mobile sources:	73.460	0.022	0.003
Liquid Fuels	73.436	0.022	0.003
Gaseous Fuels			
Solid Fuels	100.069	0.002	0.000
Biomass			
Other Fuels			
1.A.3.2. Transport – stationary sources:	98.451	0.002	0.001
Liquid Fuels			
Gaseous Fuels	55.030	0.001	0.000
Solid Fuels	99.179	0.002	0.001
Biomass			
Other Fuels			
1.A.4. Commercial/Institutional:	91.264	0.002	0.001
Liquid Fuels	79.095	0.003	0.001
Gaseous Fuels	56.087	0.001	0.000
Solid Fuels	98.131	0.002	0.001
Biomass			
Other Fuels Inne			
1.A.5. Residential:	84.446	0.002	0.001
Liquid Fuels	56.778	0.001	0.000
Gaseous Fuels	56.536	0.001	0.000
Solid Fuels	96.765	0.002	0.001
Biomass	97.989	0.001	0.002
Other Fuels			
1.A.6. Agriculture/Forestry:	83.305	0.004	0.003
Liquid Fuels	73.687	0.005	0.004
Gaseous Fuels	55.099	0.001	0.000
Solid Fuels	95.818	0.002	0.001
Biomass	97.989	0.001	0.002
Other			

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors		
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/GJ]		
	Production	Processing	
1.B.1. Coal mining:			
1.B.1.a. Underground mining	4.363	1.038	
1.B.1.b. Surface mining	0.013	0.000	
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	
1.B.2.a. Oil:	0.028	0.000	
i. Exploration	6.315	0.062	
ii. Transport	0.000	0.000	
iii. Rafining/Storage	0.000	0.000	
1.B.2.b. Natural Gas:	0.025	0.473	
i. Production	0.000	0.065	
ii+iii. Consumption	0.025	0.452	
2. Industrial Processes	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
	181.502	0.139	0.221
2.A. Iron and Steel Production	30.550	0.056	0.000
2.B. Non-Ferrous Metals Production:	59.927		
Aluminium Production	804.340		
2.C. Inorganic Chemicals:	179.956	0.911	1.557
Nitric Acid Production			3.400
Other	216.117	1.094	1.187
2.D. Organic Chemicals	0.080		
2.E. Non-Metalic Mineral Products:	552.530		
Cement Production	500.000		
Lime Production	800.000		
2.F. Other (ISIC)	33.180		
4. Agriculture	CH_4 Emission Factors [kg/Animal]		
	4.A. Enteric Fermentation	4.B. Manure Management	
4. A & B. Enteric Fermentation & Manure Management (Total Number of Livestock 121.13 million):	5.341	0.459	
1. Cattle	73.186	2.109	
a. Non-dairy	49.432	1.220	
b. Dairy	94.336	2.900	
3. Sheep	8.889	0.190	
4. Swine	1.500	1.430	
5. Horses	18.000	1.390	
6. Other	0.000	0.069	
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]		
Fertilizers	0.0125		
Manure	0.0181		
Papilionaceous Plants	0.0157		
Mineralization	0.0157		
4.F. Field Burning of Agricultural Residues	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]	
	0.0030	0.0001	

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		0.95
5.B. Forest and Grassland Conversion	18.96	
5.C. Abandonment of Managed Lands		2.19
6. Waste	CH_4 Emission Factors	
6.A. Landfils [kgCH_4/t]	0.090	
6.B. Wastewater [GgCH_4/GgBOD_5]	0.220	
6.D. Other Waste		

ANNEX F. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1993 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion:	87.41	0.0139	0.0016
Liquid Fuels	74.01	0.0149	0.0026
Gaseous Fuels	54.63	0.0013	0.0010
Solid Fuels	97.54	0.0031	0.0015
Biomass	0.00	0.2311	0.0020
Other Fuels			
1.A.1. Energy Industries:	96.57	0.0010	0.0014
Liquid Fuels	74.33	0.0024	0.0008
Gaseous Fuels	56.27	0.0014	0.0001
Solid Fuels	98.68	0.0008	0.0014
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.2. Manufacturing Industries and Construction:	91.02	0.0044	0.0016
Liquid Fuels	76.68	0.0025	0.0013
Gaseous Fuels	55.19	0.0014	0.0006
Solid Fuels	102.99	0.0050	0.0018
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.3. Transport:	73.72	0.0216	0.0032
Liquid Fuels	73.70	0.0216	0.0032
Gaseous Fuels			
Solid Fuels	98.85	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Other Sectors	71.13	0.0437	0.0016
Liquid Fuels	73.55	0.0049	0.0036
Gaseous Fuels	54.23	0.0012	0.0014
Solid Fuels	90.34	0.0090	0.0014
Biomass	0.00	0.2742	0.0020
Other Fuels			

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors		
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/Mg]		
	Production		Processing
1.B.1. Coal mining:	2.871		0.682
1.B.1.a. Underground mining	4.363		1.038
1.B.1.b. Surface mining	0.013		0.000
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]		CH_4 Emission Factors [kg/GJ]
1.B.2.a. Oil:	0.0208		0.0002
i. Exploration	6.3150		0.0618
ii. Transport	0.0000		0.0000
iii. Rafining/Storage	0.0000		0.0000
iv.a. Wholesale Distribution	0.0000		0.0000
iv.b. Retail Dystribution	0.0000		0.0000
1.B.2.b. Natural Gas:	0.0165		0.3403
i. Production	0.0465		0.0976
ii. Transmission and Distribution	0.0051		0.4328
2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Mineral Products:			
Cement Production	500.00		
Lime Production	785.00		
Soda Ash Production	415.00		
Agricultural Liming	0.44		
2.B. Chemical Industry:			
Ammonia Production	1.00	4.90	5.00
Nitric Acid Production			3.40
Carbide Production	1100.00		
Nitrogen Fertilizer Production*	1.50		
Carbon Black Production		10.00	
Urea Production			1.00
Ethene Production	0.30		
2.C. Iron and Steel Production:			
Contact Processes:			
Sinter	8.10		
Open Hearth Steel	52.00		
Steel Casting	62.00		
Iron Casting	61.00	0.20	
Non-Contact processes:			
Blast Furnace Charging	0.22		
Converter Steel	11.26		
Electric Steel	4.30	0.12	
Coke		0.20	
Ferroalloys	3900.00		
Aluminium	1800.00		

4. Agriculture	CH_4 Emission Factors [kg/Mg]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation** & Manure Management (Total Number of Livestock 81.942 million):	21.181	0.593
1. Cattle	72.136	2.095
a. Non-dairy	94.336	2.900
b. Dairy	47.976	1.220
3. Sheep	8.889	0.190
6. Horses***	18.000	1.390
8. Swine	1.500	1.430
9. Poultry	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0157	
Mineralization	0.0157	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0002

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factor for enteric fermentation relates to total livestock number (without Poultry): 28.612 million.
*** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		0.94
5.B. Forest and Grassland Conversion	23.73	
5.C. Abandonment of Managed Lands		1.71
5.D. CO_2 Emissions and Removals from Soil		0.66
6. Waste	CH_4 Emission Factors	
6.A. Solid Waste Disposal on Land [$GgCH_4$/Gg]	0.090	
6.B. Waste-water Handling [$GgCH_4$/$GgBOD_5$]	0.220	
6.C. Waste Incineration		
6.D. Other		

ANNEX G. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1994 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. All Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion Activities:	87.81	0.0142	0.0015
Liquid Fuels	73.33	0.0151	0.0026
Gaseous Fuels	55.88	0.0379	0.0001
Solid Fuels	99.23	0.0032	0.0014
Biomass	0.00	0.1694	0.0022
Other Fuels	96.09	0.0024	0.0014
1.A.1. Energy and Transformation:	96.37	0.0036	0.0013
Liquid Fuels	74.48	0.0017	0.0005
Gaseous Fuels	55.97	0.0181	0.0001
Solid Fuels	98.26	0.0035	0.0014
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.2. Industry (ISIC):	90.76	0.0194	0.0011
Liquid Fuels	75.21	0.0110	0.0026
Gaseous Fuels	55.26	0.0760	0.0001
Solid Fuels	104.95	0.0028	0.0012
Biomass	0.00	0.0150	0.0020
Other Fuels	96.09	0.0024	0.0014
1.A.3. Transport:	73.47	0.0219	0.0031
Liquid Fuels	73.46	0.0219	0.0031
Gaseous Fuels			
Solid Fuels	100.08	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Commercial/Institutional:	72.10	0.0314	0.0016
Liquid Fuels			
Gaseous Fuels	56.51	0.0014	0.0001
Solid Fuels	97.29	0.0027	0.0016
Biomass	0.00	0.1932	0.0022
Other Fuels			
1.A.5. Other:	78.95	0.0078	0.0020
Liquid Fuels	72.62	0.0120	0.0027
Gaseous Fuels	55.83	0.0014	0.0001
Solid Fuels	95.73	0.0024	0.0014
Biomass	0.00	0.2100	0.0020
Other Fuels			

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors		
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/Mg]		
	Production	Processing	
1.B.1. Coal mining:			
1.B.1.a. Underground mining	4.363	1.038	
1.B.1.b. Surface mining	0.013	0.000	
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	
1.B.2.a. Oil:	0.02397	0.00023	
i. Exploration	6.31500	0.06180	
ii. Transport	0.00000	0.00000	
iii. Rafining/Storage	0.00000	0.00000	
iv.a. Wholesale Distribution	0.00000	0.00000	
iv.b. Retail Dystribution	0.00000	0.00000	
1.B.2.b. Natural Gas:	0.01765	0.35314	
i. Production	0.00023	0.06806	
ii+iii. Consumption	0.02400	0.45722	
2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Iron and Steel Production:			
Contact Processes:			
Sinter	8.100		
Open Hearth Steel	52.000		
Steel Casting	62.000		
Iron Casting	61.000	0.200	
Non-Contact processes:			
Blast Furnace Charging	0.220		
Converter Steel	11.260		
Electric Steel	4.300	0.120	
Ferroalloys	541.900		
Coke		0.200	
2.B. Non-Ferrous Metals Production:			
Aluminium Production	804.340		
2.C. Inorganic Chemicals:			
Nitric Acid Production			3.400
Nitrogen Fertilizer Production[*]	1.500		
Ammonia Production	1.000	4.900	5.000
Sodium Carbonate Production	25.000		
Carbon Black Production		10.000	
Agricultural Liming	0.440		
Urea Production			1.000
2.D. Organic Chemicals:			
Ethylene Production	0.300		
2.E. Non-Metalic Mineral Products:			
Cement Production	500.000		
Lime Production	800.000		
2.F. Other:			
Sugar Production	232.800		
Wine Production[**]	58.000		
Beer Production[**]	10.000		
Spirits Production[**]	100.000		

4. Agriculture	CH_4 Emission Factors [kg/Mg]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation*** & Manure Management		
(Total Number of Livestock 82.270 million):	20.815	0.595
1. Cattle	71.246	2.063
a. Non-dairy	47.976	1.220
b. Dairy	94.336	2.900
3. Sheep	8.889	0.190
4. Swine	1.500	1.430
5. Horses ****	18.000	1.390
6. Other	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0157	
Mineralization	0.0157	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0001

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factors in [kg/hl].
*** Emission factor for enteric fermentation relates to total livestock number: 28.65 million.
**** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		0.98
5.B. Forest and Grassland Conversion	83.60	
5.C. Abandonment of Managed Lands		2.53
6. Waste	CH_4 Emission Factors	
6.A. Landfils [kgCH_4/t]	89.83	
6.B.1. Industrial Wastewater [kgCH_4/m^3]	0.078	
6.B.2. Municipal Wastewater [kgCH_4/m^3]	0.007	
6.D. Other Waste		

ANNEX H. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1995 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion:	86.58	0.0142	0.0017
Liquid Fuels	68.45	0.0152	0.0029
Gaseous Fuels	53.72	0.0013	0.0010
Solid Fuels	98.19	0.0029	0.0015
Biomass	0.00	0.2353	0.0020
Other Fuels			
1.A.1. Energy Industries:	96.03	0.0008	0.0014
Liquid Fuels	73.36	0.0024	0.0007
Gaseous Fuels	54.97	0.0014	0.0001
Solid Fuels	97.39	0.0007	0.0014
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.2. Manufacturing Industries and Construction:	93.05	0.0047	0.0018
Liquid Fuels	76.19	0.0031	0.0019
Gaseous Fuels	54.71	0.0013	0.0006
Solid Fuels	103.90	0.0050	0.0020
Biomass	0.00	0.0148	0.0020
Other Fuels			
1.A.3. Transport:	65.77	0.0219	0.0034
Liquid Fuels	65.75	0.0219	0.0034
Gaseous Fuels			
Solid Fuels	97.30	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Other Sectors	68.39	0.0508	0.0016
Liquid Fuels	71.13	0.0048	0.0033
Gaseous Fuels	53.13	0.0012	0.0012
Solid Fuels	94.19	0.0090	0.0014
Biomass	0.00	0.2760	0.0020
Other Fuels			
1.A.5. Other	71.52	0.0025	0.0045
Liquid Fuels	71.52	0.0025	0.0025

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors	
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/Mg]	
	Production	Processing
1.B.1. Coal mining:	2.956	0.702
1.B.1.a. Underground mining	4.363	1.038
1.B.1.b. Surface mining	0.013	0.000
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]
1.B.2.a. Oil:	0.0246	0.0002
i. Exploration	6.3150	0.0618
ii. Transport	0.0000	0.0000
iii. Rafining/Storage	0.0000	0.0000
iv.a. Wholesale Distribution	0.0000	0.0000
iv.b. Retail Dystribution	0.0000	0.0000
1.B.2.b. Natural Gas:	0.0164	0.3507
i. Production	0.0518	0.0965
ii+iii. Consumption	0.0045	0.4362

2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Mineral Products:			
Cement Production	500.00		
Lime Production	785.00		
Soda Ash Production	415.00		
Agricultural Liming	0.44		
2.B. Chemical Industry:			
Ammonia Production	1.00	4.90	5.00
Nitric Acid Production			3.40
Carbide Production	1100.00		
Nitrogen Fertilizer Production*	1.50		
Carbon Black Production		10.00	
Urea Production			1.00
Ethene Production	0.30		
2.C. Iron and Steel Production:			
Contact Processes:			
Sinter	8.10		
Open Hearth Steel	52.00		
Steel Casting	62.00		
Iron Casting	61.00	0.20	
Non-Contact processes:			
Blast Furnace Charging	0.22		
Converter Steel	11.26		
Electric Steel	4.30	0.12	
Coke		0.20	
Ferroalloys	3900.00		
Aluminium	1800.00		

4. Agriculture	CH_4 Emission Factors [kg/Mg]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation** &Manure Management (Total Number of Livestock 80.813 million):	19.429	0.609
1. Cattle	70.686	2.043
a. Non-dairy	94.336	2.900
b. Dairy	47.976	1.220
3. Sheep	8.889	0.190
6. Horses ***	18.000	1.390
8. Swine	1.500	1.430
9. Poultry	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0157	
Mineralization	0.0157	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0001

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factor for enteric fermentation relates to total livestock number (without poultry): 29.073 million.
*** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		1.03
5.B. Forest and Grassland Conversion	31.05	
5.C. Abandonment of Managed Lands		1.48
5.D. CO_2 Emissions and Removals from Soil		0.58
6. Waste	CH_4 Emission Factors	
6.A. Solid Waste Disposal on Land [$GgCH_4$/Gg]	0.0898	
6.B. Waste-water Handling [$GgCH_4$/$GgBOD_5$]	0.220	
6.C. Waste Incineration		
6.D. Other		

ANNEX I. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1996 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion:	86.65	0.0132	0.0017
Liquid Fuels	68.93	0.0141	0.0027
Gaseous Fuels	54.28	0.0013	0.0009
Solid Fuels	98.28	0.0030	0.0015
Biomass	0.00	0.1874	0.0020
Other Fuels			
1.A.1. Energy Industries:	95.40	0.0008	0.0014
Liquid Fuels	72.83	0.0023	0.0007
Gaseous Fuels	55.01	0.0013	0.0001
Solid Fuels	97.44	0.0007	0.0014
Biomass	0.00	0.0150	0.0020
Other Fuels			
1.A.2. Manufacturing Industries and Construction:	87.98	0.0043	0.0018
Liquid Fuels	76.11	0.0029	0.0016
Gaseous Fuels	55.57	0.0013	0.0006
Solid Fuels	104.99	0.0046	0.0020
Biomass	0.00	0.0079	0.0020
Other Fuels			
1.A.3. Transport:	65.87	0.0220	0.0034
Liquid Fuels	65.86	0.0220	0.0034
Gaseous Fuels			
Solid Fuels	99.00	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Other Sectors	70.80	0.0453	0.0016
Liquid Fuels	71.47	0.0036	0.0026
Gaseous Fuels	53.25	0.0012	0.0013
Solid Fuels	93.69	0.0092	0.0014
Biomass	0.00	0.2778	0.0020
Other Fuels			
1.A.5. Other	72.11	0.0020	0.0046
Liquid Fuels	72.11	0.0020	0.0046

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors		
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/Mg]		
	Production	Processing	
1.B.1. Coal mining:	2.987	0.709	
1.B.1.a. Underground mining	4.363	1.038	
1.B.1.b. Surface mining	0.013	0.000	
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	
1.B.2.a. Oil:	0.0246	0.0003	
i. Exploration	6.3150	0.0618	
ii. Transport	0.0000	0.0000	
iii. Rafining/Storage	0.0000	0.0000	
iv.a. Wholesale Distribution	0.0000	0.0000	
iv.b. Retail Dystribution	0.0000	0.0000	
1.B.2.b. Natural Gas:	0.0161	0.3568	
i. Production	0.0544	0.1000	
ii+iii. Consumption	0.0034	0.4413	
2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Mineral Products:			
Cement Production	500.00		
Lime Production	785.00		
Soda Ash Production	415.00		
Agricultural Liming	0.44		
2.B. Chemical Industry:			
Ammonia Production	1.00	4.90	5.00
Nitric Acid Production			3.40
Carbide Production	1100.00		
Nitrogen Fertilizer Production*	1.50		
Carbon Black Production		10.00	
Urea Production			1.00
Ethene Production	0.30		
2.C. Iron and Steel Production:			
Contact Processes:			
Sinter	8.10		
Open Hearth Steel	52.00		
Steel Casting	62.00		
Iron Casting	61.00	0.20	
Non-Contact processes:			
Blast Furnace Charging	0.22		
Converter Steel	11.26		
Electric Steel	4.30	0.12	
Coke		0.20	
Ferroalloys	3900.00		
Aluminium	1800.00		

4. Agriculture	CH_4 Emission Factors [kg/Animal]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation** & Manure Management (Total Number of Livestock 73.393 million):	20.781	0.610
1. Cattle	70.461	2.035
a. Non-dairy	94.336	2.900
b. Dairy	47.976	1.220
3. Sheep	8.889	0.190
6. Horses ***	18.000	1.390
8. Swine	1.500	1.430
9. Poultry	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0151	
Mineralization	0.0157	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0002

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factor for enteric fermentation relates to total livestock number (without poultry): 26.221 million.
*** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		0.99
5.B. Forest and Grassland Conversion	19.48	
5.C. Abandonment of Managed Lands		1.76
5.D. CO_2 Emissions and Removals from Soil		0.62
6. Waste	CH_4 Emission Factors	
6.A. Solid Waste Disposal on Land [GgCH_4/Gg]	0.0898	
6.B. Waste-water Handling [GgCH_4/GgBOD_5]	0.220	
6.C. Waste Incineration		
6.D. Other		

ANNEX J. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1997 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion:	84.80	0.0132	0.0017
Liquid Fuels	68.28	0.0134	0.0026
Gaseous Fuels	53.88	0.0013	0.0010
Solid Fuels	98.10	0.0029	0.0015
Biomass	0.00	0.1853	0.0020
Other Fuels			
1.A.1. Energy Industries:	94.99	0.0009	0.0014
Liquid Fuels	73.86	0.0026	0.0007
Gaseous Fuels	55.15	0.0012	0.0001
Solid Fuels	97.03	0.0007	0.0014
Biomass	0.00	0.0142	0.0019
Other Fuels			
1.A.2. Manufacturing Industries and Construction:	86.22	0.0045	0.0018
Liquid Fuels	74.66	0.0028	0.0017
Gaseous Fuels	54.29	0.0013	0.0006
Solid Fuels	105.27	0.0051	0.0020
Biomass	0.00	0.0080	0.0020
Other Fuels			
1.A.3. Transport:	64.34	0.0217	0.0033
Liquid Fuels	64.32	0.0217	0.0033
Gaseous Fuels			
Solid Fuels	96.00	0.0023	0.0000
Biomass			
Other Fuels			
1.A.4. Other Sectors	69.64	0.0460	0.0017
Liquid Fuels	70.71	0.0052	0.0034
Gaseous Fuels	53.51	0.0012	0.0013
Solid Fuels	94.06	0.0089	0.0014
Biomass	0.00	0.2796	0.0020
Other Fuels			
1.A.5. Other	69.23	0.0025	0.0043
Liquid Fuels	69.23	0.0025	0.0043

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors		
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/Mg]		
	Production	Processing	
1.B.1. Coal mining:	2.995	0.711	
1.B.1.a. Underground mining	4.363	1.038	
1.B.1.b. Surface mining	0.013	0.000	
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	
1.B.2.a. Oil:	0.0241	0.0002	
i. Exploration	6.3150	0.0618	
ii. Transport	0.0000	0.0000	
iii. Rafining/Storage	0.0000	0.0000	
iv.a. Wholesale Distribution	0.0000	0.0000	
iv.b. Retail Dystribution	0.0000	0.0000	
1.B.2.b. Natural Gas:	0.0160	0.3558	
i. Production	0.0538	0.0981	
ii+iii. Consumption	0.0035	0.4411	
2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Mineral Products:			
Cement Production	500.00		
Lime Production	785.00		
Soda Ash Production	415.00		
Agricultural Liming	0.44		
2.B. Chemical Industry:			
Ammonia Production	1.00	4.90	5.00
Nitric Acid Production			3.40
Carbide Production	1100.00		
Nitrogen Fertilizer Production*	1.50		
Carbon Black Production		10.00	
Urea Production			1.00
Ethene Production	0.30		
2.C. Iron and Steel Production:			
Contact Processes:			
Sinter	8.10		
Open Hearth Steel	52.00		
Steel Casting	62.00		
Iron Casting	61.00	0.20	
Non-Contact processes:			
Blast Furnace Charging	0.22		
Converter Steel	11.26		
Electric Steel	4.30	0.12	
Coke		0.20	
Ferroalloys	3900.00		
Aluminium	1800.00		

4. Agriculture	CH_4 Emission Factors [kg/Animal]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation** &Manure Management (Total Number of Livestock 81.421 million):	20.626	0.567
1. Cattle	70.513	2.037
a. Non-dairy	94.336	2.900
b. Dairy	47.976	1.220
3. Sheep	8.889	0.190
6. Horses ***	18.000	1.390
8. Swine	1.500	1.430
9. Poultry	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0157	
Mineralization	0.0157	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0001

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factor for enteric fermentation relates to total livestock number (without poultry): 26.684 million.
*** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		0.93
5.B. Forest and Grassland Conversion	23.03	
5.C. Abandonment of Managed Lands		1.75
5.D. CO_2 Emissions and Removals from Soil		0.63
6. Waste	CH_4 Emission Factors	
6.A. Solid Waste Disposal on Land [$GgCH_4$/Gg]	0.0898	
6.B. Waste-water Handling [$GgCH_4/GgBOD_5$]	0.220	
6.C. Waste Incineration		
6.D. Other		

ANNEX K. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1998 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion:	83.58	0.0134	0.0019
Liquid Fuels	68.71	0.0107	0.0029
Gaseous Fuels	54.51	0.0013	0.0010
Solid Fuels	96.90	0.0027	0.0015
Biomass	0.00	0.2271	0.0045
Other Fuels			
1.A.1. Energy Industries:	94.32	0.0009	0.0014
Liquid Fuels	71.80	0.0025	0.0008
Gaseous Fuels	55.42	0.0013	0.0001
Solid Fuels	96.78	0.0007	0.0014
Biomass	0.00	0.0279	0.0046
Other Fuels			
1.A.2. Manufacturing Industries and Construction:	86.04	0.0049	0.0017
Liquid Fuels	74.28	0.0029	0.0015
Gaseous Fuels	54.29	0.0013	0.0005
Solid Fuels	102.87	0.0050	0.0020
Biomass	0.00	0.0254	0.0043
Other Fuels			
1.A.3. Transport:	65.57	0.0173	0.0039
Liquid Fuels	65.56	0.0173	0.0039
Gaseous Fuels			
Solid Fuels	97.38	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Other Sectors:	64.27	0.0509	0.0023
Liquid Fuels	70.35	0.0057	0.0036
Gaseous Fuels	54.58	0.0012	0.0014
Solid Fuels	89.72	0.0094	0.0014
Biomass	0.00	0.2810	0.0046
Other Fuels			
1.A.5. Other:	69.23	0.0023	0.0044
Liquid Fuels	69.23	0.0023	0.0044

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors		
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg/Mg]		
	Production	Processing	
1.B.1. Coal mining:	2.521	0.599	
1.B.1.a. Underground mining	3.665	0.872	
1.B.1.b. Surface mining	0.013	0.000	
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	
1.B.2.a. Oil:	0.0271	0.0003	
i. Exploration	6.3150	0.0618	
ii. Transport	0.0000	0.0000	
iii. Rafining/Storage	0.0000	0.0000	
iv.a. Wholesale Distribution	0.0000	0.0000	
iv.b. Retail Dystribution	0.0000	0.0000	
1.B.2.b. Natural Gas:	0.0159	0.3565	
i. Production	0.0537	0.0995	
ii+iii. Consumption	0.0034	0.4416	
2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Mineral Products:			
Cement Production	500.00		
Lime Production	785.00		
Soda Ash Production	415.00		
Agricultural Liming	0.44		
2.B. Chemical Industry:			
Ammonia Production	1.00	4.90	5.00
Nitric Acid Production			3.40
Carbide Production	1100.00		
Nitrogen Fertilizer Production*	1.50		
Carbon Black Production		10.00	
Urea Production			1.00
Ethene Production	0.30		
2.C. Iron and Steel Production:			
Contact Processes:			
Sinter	8.10		
Open Hearth Steel	52.00		
Steel Casting	62.00		
Iron Casting	61.00	0.20	
Non-Contact processes:			
Blast Furnace Charging	0.22		
Converter Steel	11.26		
Electric Steel	4.30	0.12	
Coke		0.20	
Ferroalloys	3900.00		
Aluminium	1800.00		

4. Agriculture	CH_4 Emission Factors [kg/Animal]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation** & Manure Management (Total Number of Livestock 81.285 million):	19.928	0.571
1. Cattle	71.755	2.082
a. Non-dairy	94.336	2.900
b. Dairy	47.976	1.220
3. Sheep	8.889	0.190
6. Horses ***	18.000	1.390
8. Swine	1.500	1.430
9. Poultry	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.0125	
Manure	0.0181	
Papilionaceous Plants	0.0157	
Mineralization	0.0157	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0001

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factor for enteric fermentation relates to total livestock number (without poultry): 26.793 million.
*** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [TC/ha]	CO_2 Net Removal Factors [TC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		0.59
5.B. Forest and Grassland Conversion	30.58	
5.C. Abandonment of Managed Lands		1.74
5.D. CO_2 Emissions and Removals from Soil		0.63
6. Waste	CH_4 Emission Factors	
6.A. Solid Waste Disposal on Land [GgCH_4/Gg]	0.079	
6.B. Waste-water Handling [GgCH_4/GgBOD_5]	0.220	
6.C. Waste Incineration		
6.D. Other		

ANNEX L. AGGREGATE EMISSION/REMOVAL FACTORS EMPLOYED IN 1999 GREENHOUSE GAS INVENTORY

Table 1. Aggregate emission factors used in fuel combustion activities

GHG Source/Sink Categories	Aggregate Emission Factors		
1. Energy	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	N_2O Emission Factors [kg/GJ]
1.A. Fuel Combustion:	83.62	0.0132	0.0019
Liquid Fuels	69.75	0.0102	0.0031
Gaseous Fuels	53.57	0.0013	0.0011
Solid Fuels	97.16	0.0027	0.0015
Biomass	0.00	0.2288	0.0046
Other Fuels			
1.A.1. Energy Industries:	94.64	0.0009	0.0014
Liquid Fuels	71.72	0.0025	0.0007
Gaseous Fuels	54.93	0.0013	0.0001
Solid Fuels	97.15	0.0007	0.0014
Biomass	0.00	0.0267	0.0044
Other Fuels			
1.A.2. Manufacturing Industries and Construction:	84.79	0.0050	0.0018
Liquid Fuels	74.44	0.0028	0.0015
Gaseous Fuels	54.67	0.0014	0.0008
Solid Fuels	103.37	0.0051	0.0020
Biomass	0.00	0.0279	0.0046
Other Fuels			
1.A.3. Transport:	67.77	0.0153	0.0040
Liquid Fuels	67.77	0.0153	0.0040
Gaseous Fuels			
Solid Fuels	99.00	0.0024	0.0000
Biomass			
Other Fuels			
1.A.4. Other Sectors:	66.10	0.0469	0.0022
Liquid Fuels	71.19	0.0057	0.0036
Gaseous Fuels	52.63	0.0012	0.0015
Solid Fuels	91.16	0.0092	0.0014
Biomass	0.00	0.2798	0.0046
Other Fuels			
1.A.5. Other:	71.25	0.0028	0.0045
Liquid Fuels	71.25	0.0028	0.0045

Table 2. Aggregate emission factors used in fugitive emissions from fuels, industrial processes and agriculture

GHG Source/Sink Categories	Aggregate Emission Factors		
1.B. Fugitive Emissions from Fuels	CH_4 Emission Factors [kg CH_4/Mg]		
	Production	Processing	
1.B.1. Coal mining:	3.031	0.463	
1.B.1.a. Underground mining	4.749	0.726	
1.B.1.b. Surface mining	0.013	0.000	
1.B.2. Oil and Natural Gas	CO_2 Emission Factors [kg/GJ]	CH_4 Emission Factors [kg/GJ]	
1.B.2.a. Oil:	0.0307	0.0003	
i. Exploration	6.3150	0.0618	
ii. Transport	0.0000	0.0000	
iii. Rafining/Storage	0.0000	0.0000	
iv.a. Wholesale Distribution	0.0000	0.0000	
iv.b. Retail Dystribution	0.0000	0.0000	
1.B.2.b. Natural Gas:	0.0159	0.3585	
i. Production	0.0549	0.1001	
ii+iii. Consumption	0.0033	0.4422	
2. Industrial Processes	CO_2 Emission Factors [kg/Mg]	CH_4 Emission Factors [kg/Mg]	N_2O Emission Factors [kg/Mg]
2.A. Mineral Products:			
Cement Production	500.00		
Lime Production	785.00		
Soda Ash Production	415.00		
Agricultural Liming	0.44		
2.B. Chemical Industry:			
Ammonia Production	1.00	4.90	5.00
Nitric Acid Production			3.40
Carbide Production	1100.00		
Nitrogen Fertilizer Production*	1.50		
Carbon Black Production		10.00	
Urea Production			1.00
Ethene Production	0.30		
2.C. Iron and Steel Production:			
Contact Processes:			
Sinter	8.10		
Open Hearth Steel	52.00		
Steel Casting	62.00		
Iron Casting	61.00	0.20	
Non-Contact processes:			
Blast Furnace Charging	0.22		
Converter Steel	11.26		
Electric Steel	4.30	0.12	
Coke		0.20	
Ferroalloys	3900.00		
Aluminium	1800.00		

4. Agriculture	CH_4 Emission Factors [kg/Animal]	
	4.A. Enteric Fermentation	4.B. Manure Management
4. A & B. Enteric Fermentation** & Manure Management (Total Number of Livestock 80.581 million):	18.022	0.482
1. Cattle	65.214	2.019
a. Non-dairy	90.000	3.000
b. Dairy	38.220	0.950
3. Sheep	10.150	0.180
6. Horses ***	18.000	1.320
8. Swine	1.500	1.110
9. Poultry	0.000	0.078
4.D. Agricultural Soils	N_2O Emission Factors (N_2O released from 1 ton of used fertilizer) [Mg N_2O/Mg N]	
Fertilizers	0.008	
Manure	0.010	
Pastures range and paddock	0.020	
Papilionaceous Plants	0.010	
Crop Residue	0.010	
Cultivation of Organic Soils	–	
	CH_4 Emission Factors [kg/Mg dry mass]	N_2O Emission Factors [kg/Mg dry mass]
4.F. Field Burning of Agricultural Residues	0.0030	0.0001

* Emission factors in NH_3[kg/t] used for nitrogen fertilizer production.
** Emission factor for enteric fermentation relates to total livestock number (without poultry): 26.037million.
*** Estimated data.

Table 3. Agregate emission and removal factors related to land use change and forestry and waste

GHG Source/Sink Categories	Aggregate Emission/Removal Factors	
5. Land Use Change and Forestry	CO_2 Net Emission Factors [tC/ha]	CO_2 Net Removal Factors [tC/ha]
5.A. Changes in Forest and Other Woody Biomass Stocks		1.28
5.B. Forest and Grassland Conversion	11.23	
5.C. Abandonment of Managed Lands****		
5.D. CO_2 Emissions and Removals from Soil		0.82
6. Waste	CH_4 Emission Factors	
6.A. Solid Waste Disposal on Land [$GgCH_4$/Gg]	0.079	
6.B. Waste-water Handling [$GgCH_4$/$GgBOD_5$]	0.220	
6.C. Waste Incineration		
6.D. Other		

**** Do not occur in Polish conditions.