Ukraine

The First National Communication on Climate Change

The United Nations Framework Convention on Climate Change

Kyiv 1998

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1. EXECUTIVE SUMMARY

1.1 Introduction

Climate change may be the most critical and complex environmental issue facing humanity in the last century. The United Nations Framework Convention on Climate Change (UN FCCC) is the first and major international legal instrument to address climate change issues at a global scale.
The ultimate objective of the Convention is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".
Ukraine signed the Convention in June 1992, the Parliament ratified it in October 1996, and Ukraine became the Party in August 1997. In compliance with Article 4.2b Ukraine has adopted 1990 as a base year for the estimation of anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol.
Article 4.6 of the Convention gives countries with economies in transition to market economies "a certain degree of flexibility" to meet their commitments in the frames of the FCCC. Due to the deep uncertainties related to transition period, futility of "business-as-usual" scenario development, there is a lack of sufficient quantitative information about some of mitigation and adaptation measures, and future projections in Ukraine.
This document is the First National Communication, by which Ukraine is complying with the obligation to communicate information to the Secretariat of the Intergovernmental Negotiating Committee for a UN FCCC, according to Article 4.2 and Article 12 of the Convention.
The elaboration of Ukrainian First National Communication was supervised by the Ministry of Environmental Protection and Nuclear Safety of Ukraine, relevant ministries, agencies and organizations taking an active part. The document was prepared by Agency for Rational Energy Use and Ecology.

1.2 National Circumstances

Ukraine is the second largest country in Europe (after the Russia) with an area of 603.7 thousand km^2. The population of the country (1995) is 51.7 million people.
Climate of Ukraine is of moderate-continental type, except of narrow belt of Southern Coast of Crimea with features of subtropics climate.
Since 1990 the Ukrainian economy is facing a very deep crisis and it is expected that a recovering trend will begin only after a period of depression and stagnation. The main reason is that Ukraine is not in the best position for a quick recovery because its limited energy resources and its obsolete and deformed industrial infrastructure. Since 1990 production has maintained a growing negative trend reaching up to 50% decrease in 1995 for the industrial production (Table 1–1). Now the trend has been maintained and it is not foreseeable a change until the end of 1998.
Ukraine is one of the least energy efficient countries in the world. Ukraine's use of energy relative to GDP is much higher than in Western Europe and the USA. The worst is, that the trend toward growing energy consumption per unit of GDP has also increased (Table 1–1).

Table 1–1. GDP, Inflation, Unemployment and Energy Intensity Trends

	1990	*1991*	*1992*	*1993*	*1994*	*1995*
GDP, 10^9 $	73.62	67.21	60.56	51.96	40.01	35.29
Unemployment, thousand person	-	9.8	128	180.9	216	126
Inflation, %	-	-	1310	4830	990	420
Energy Consumption, PJ	10342.9	10017.7	8907.2	7931.5	6900.2	6630.6
Energy Intensity, PJ per billion $	141	149	147	152	172	188

Ukrainian economy is in transition now. But Ukrainian Government pays much attention to the environmental protection. Many legislative documents have been adopted in the last time.

1.3 Inventory of greenhouse gas emissions and removals in Ukraine

The Framework Convention on Climate Change calls upon Parties to: "periodically update, publish, and make available to the Conference of Parties … national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties". This commitment was included in the Convention because it was clear to all countries that any effective climate policy must begin with an accurate inventory of gases that may influence global warming.
The GHG emissions presented here were calculated using the IPCC Guidelines for National Greenhouse Gas Inventories to ensure that the emission inventories submitted to the Framework Convention are consistent and

comparable across sectors and among nations. Ukraine has followed these guidelines, except where more detailed data or methodologies were available for major sources of emissions.
According to IPCC Methodology the Ukrainian inventory deals with the following five categories of GHG sources and sinks: energy systems (including transportation), industrial processes, agriculture, forestry and land-use change, and wastes.
Greenhouse gases Inventory in Ukraine include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) directly contributing to the greenhouse effect. In addition, indirect greenhouse gases, such as carbon monoxide (CO), oxides of nitrogen (NO_x), and nonmethane volatile organic compounds (NMVOCs) were taken into account.
For the 1990 base year, total GHG emissions in Ukraine were 232 882 Gg of carbon equivalent. CO_2 emissions were partly offset by an uptake of carbon in Ukrainian forests of 14 175 Gg of carbon equivalent in 1990 (Table 1–2).

Table 1–2. Ukrainian Greenhouse Gas Emissions, 1990, Gg

Gas/Source	Emissions (Full Molecular Weight)	Emissions (Direct and Indirect Effects; Carbon Equivalent)
Greenhouse Gases		
Net Carbon Dioxide	648 131	176 763
Fossil Fuel Combustion	668 332	182 272
Industrial processes	31 775	8 666
Total	700 107	190 938
Forestry (sink)	-51 976	-14 175
Methane	9 453	54 140
Energy	6 265	35 881
Agriculture	2 254	12 909
Waste	934	5 349
Nitrous Oxide	23.412	1 979
Energy	6.708	567
Chemistry	6.160	521
Waste	0.132	11
Forest fires	0.175	15
Agricultural soils	10.237	865
Photochemically Important Gases		
Carbon Monoxide (CO)	7 481	-
Nitrogen Oxides (NO_X)	1 243	-
Nonmethane Volatile Organic Compounds (NMVOCs)	656	-
Net Emissions		232 882

Due largely to fossil fuel consumption, carbon dioxide emissions accounted for the largest share - approximately 76 percent. Methane accounted for 23 percent of total emissions, which included contributions from agricultural activities and landfills, among others. The nitrous oxide emissions is less important comprising 1 percent of total emissions.
The relative and absolute contributions of indirect GHG to climate change is uncertain.

1.4 Policies and Measures to Mitigate Climate Change

1.4.1 Overall policy context

During the last years the whole number of programs for the economic development of Ukraine was elaborated and adopted, the most important of them were as follows:

1. Program of Restructuring of Ukrainian Economy, 1996;
2. National Energy Program, 1996;
3. Comprehensive State Energy Conservation Program of Ukraine, 1996;
4. National Development Programs of Industrial Sectors.

Resolutions, presented in these documents, were assumed as a basis to form the baseline scenario of the development of economy and its sectors, to assess projected GHG emissions levels and mitigation measures.

In correspondence with the baseline scenario of the economic development it is planned to provide main indices of the socio-economic development of the country (Table 1–3) in the period considered, up to 2015.

Table 1–3. The main features of socio-economic development of Ukraine up to 2015

Indices	1990	1995	2000	2005	2010	2015
GDP, billion $	73.62	35.26	41.30	58.82	84.07	97.17
GDP, %	100.0	47.9	56.1	79.9	114.2	132.0
Fuel combustion, PJ	9246.3	5531.5	6965.1	7557.7	8022.5	8551.9
Population, million of people	51.9	51.5	50.2	51.0	51.5	51.8
Housing fund, million of m^3	922.1	978.5	1018.5	1169.6	1255.0	1360.5

Alongside with the baseline scenario the indices for the optimistic and pessimistic scenarios of the economic development were forecasted. The differences for pessimistic and optimistic scenarios are generally in volumes of energy saving, which in optimistic scenario will be approximately 10-12% higher, and in pessimistic one - 25-30% lower.

1.4.2 Overall mitigation potential

Two groups of mitigation measures were considered in mitigation analyses: policy instruments and technological options.

All these measures have a high degree of a governmental support, since they are included in the programs of the development of the economy and its sectors in Ukraine, adopted by the administrative bodies of the state, as well as in the draft documents, which at present are being under consideration of the Cabinet of Ministers, of the Parliament and the administration of the President of the country. However the possibility of realization of these measures will to a great extent depend on the investments.

Realization of such options as implementation of energy efficiency technologies, machinery, equipment, appliances, pursuing an active energy saving policy and use of the additional renewable and nuclear energy will provide the annual energy saving at a level of 2000 - 1000-1100 PJ, 2005 - 1950-2100 PJ, 2010 - 3100-3200 PJ, 2015 - 4100-4200 PJ. These measures will require around $29-32 billion investments.

The analysis of measures effectiveness, according to the criterion of a relative effectiveness, shows, that measures, connected with the decrease of natural gas losses, with DSM, with the realization of cross-sectoral energy saving programs, are the most effective ones.

The implementation of non-traditional sources, optimization of the electric power and heat utilities, the sets for pure coal combustion, installation of constructions for the refining of wastewater silt at purification stations, are the most expensive measures for GHG emissions decrease from the economic view point.

However, it must be taken into consideration, that for a whole number of measures considered the GHG emissions decrease is an indirect effect. Expedience of their realization is conditioned, as a rule, by other economic and social factors.

1.5 Projections of Greenhouse Gas Emissions and Reduction Potentials in Ukraine

In the future direct GHG emissions are projected to be lower than the emissions of 1990 in any scenario of the economic development**,** despite the essential growth of GDP in a baseline and especially in optimistic scenarios of the economic development of Ukraine. This is supposed to be achieved by the whole set of measures for GHG emissions decrease and the increase of CO_2 uptakes in the Forestry.

Summaries of projections of anthropogenic emissions of CO_2, CH_4, N_2O and precursors are presented in the Table 1–4, Table 1–5, Table 1–6, Table 1–7.

Estimates for direct GHG emissions are slightly different from the Ukrainian Inventory. The difference between the assessments of indirect greenhouse gases is more essential.

The largest difference is due to updating of recent Guidelines from the Intergovernmental Panel on Climate Change. Other differences include updates in sources list (non-energy emissions in food sector, metallurgy, chemistry and construction).

Table 1–4. Summary of projections of anthropogenic emissions of CO_2, Gg

	1990	1995	2000	2005	2010	2015
Fuel combustion: energy and transformation industries	191296	135447	151037	173122	178539	189474
Fuel combustion: industry	220202	117182	149722	159284	168893	179562
Fuel combustion: construction	3890	4615	3462	3646	3845	4431
Fuel combustion: residential	97506	78860	91649	91317	96818	100047
Fuel combustion: agriculture	35611	22721	32255	34044	36085	37908
Fuel combustion: transport	49831	17922	41060	45985	52749	61866

Fuel combustion: other	64296	25648	34343	34072	32861	31848
Industrial processes	48815	22905	26514	27678	28225	29214
Total	711447	425299	530042	569149	598016	634352

Table 1–5. Summary of projections of anthropogenic emissions of CH_4, Gg

	1990	1995	2000	2005	2010	2015
Fuel combustion	292	215	233	208	209	200
Fugitive emissions from fuels	6227	4044	52737	4653	4107	3356
Industrial processes: Iron and Steel	333	98	104	104	104	105
Industrial processes: Food	68	71	57	58	57	58
Industrial processes: Construction	5	3	4	5	5	6
Livestock	2240	1700	1764	2001	2077	2154
Rice cultivation	15	11	12	13	16	22
Waste	934	1009	937	909	891	837
Total	10115	7150	8383	7951	7467	6738

Table 1–6. Summary of projections of anthropogenic emissions of N_2O, Gg

	1990	1995	2000	2005	2010	2015
Transport	0.4	0.2	0.2	0.2	0.2	0.2
Other energy sources	4.5	3.3	4.0	4.2	4.3	4.6
Industrial processes	23	7	22.5	25.8	26.0	26.1
Agricultural soils	10.2	5.1	7.6	8.5	9.4	10.2
Waste	0.1	0.1	0.4	0.6	0.9	1.2
Total	38.2	15.7	34.7	39.3	40.8	42.3

Table 1–7. Summary of projections of anthropogenic emissions of precursors, Gg

	1990	1995	2000	2005	2010	2015
CO	7295	4046	5964	5958	6255	6607
NO_2	2043	1140	1564	1605	1613	1666
$NMVOC_S$	1007	471	844	884	949	1043

In the Forestry it is projected to provide the increase of CO_2 uptakes Ukraine in 2015 approximately on 20 800 Gg CE (Table 1–8).

Table 1–8. Summary of projections of removals of CO_2 by sinks and reservoirs, Gg

	1990	1995	2000	2005	2010	2015
Forestry	-51555	-64490	-66265	-68189	-70361	-72461
Land-use change	-421	-396	-378	-359	-341	-323
Total removals	-51976	-64886	-66643	-68548	-70702	-72784

GHG emissions and removals in the considered period are given in Table 1–9 for the baseline scenario. The overall reduction potential of mitigation measures is approximately 100,000 Gg CE, and projected emissions decrease in 2015 is 45,889 Gg compared to 1990.

Table 1–9. Total GHG emissions/removals in the baseline scenario

	1990	1995	2000	2005	2010	2015
Direct GHG emissions						
CO_2, Gg	711447	425299	530042	569149	598016	634352
CO_2, Gg CE	194031	115991	144557	155222	163095	173005
CH_4, Gg	10115	7150	8383	7951	7467	6738
N_2O, Gg	38.2	15.7	34.7	39.3	40.8	42.3
Total, Gg CE	255192	158268	195503	204082	209310	215172
Total, % compared to 1990	100	62.02	76.61	79.97	82.02	84.32
CO_2 uptakes in forestry						
CO_2 uptakes, Gg	-51976	-64886	-66643	-68548	-70702	-72784
CO_2 uptakes, Gg CE	-14175	-17696	-18175	-18695	-19282	-19850
Net						
CO_2, Gg	659471	360413	463399	500601	527314	561568

Total, Gg CE	241017	140572	177328	185387	190028	195322
CO_2, % compared to 1990	100	58.32	73.57	76.92	78.84	81.04

In optimistic scenario of the economic development, the net GHG emission levels in 2015 will total above 220 Tg CE, that is approximately 10.7% lower than in 1990.
In pessimistic scenario net GHG emissions on the level of 2015 will total above 180 Tg CE or about 73% from the level of 1990.
A very wide range of change of indices, characterizing the future economic development and expected emission levels, is connected with a very high grade of uncertainty of future development of Ukrainian economy (Table 1–10).

Table 1–10. Ranges of fuel consumption and GHG emissions in 2015

	Pessimistic scenario	*Optimistic scenario*	*Range*	*Average deviation, %*
Fuel, PJ	7596.4	9787.2	2190.8	12.8
Direct GHG Emissions, Tg CE	195.2	245.4	50. 2	11.5
Sinks in Forestry, Tg CE	-19.9	-23.9	-4.0	9.1
Net GHG Emissions, Tg CE	175.3	221.5	46.2	11.6

1.6 Vulnerability and Adaptation Assessment in Ukraine

Given the country’s unstable economy and critical ecological problems, the consequences of climate change in Ukraine could be serious. The results of scientific research during the last few years show that climate change in Ukraine has significant impacts on agriculture, forestry, water and coastal resources. It is highly probable that crop yields could be changed significantly. Transformation of types, species composition, productivity and stability of forests is likely to take place in the course of climate warming within the territory of Ukraine. Coastal zone vulnerability is already a reality: the Black Sea level is rising 1.5 mm per year.
Thereby the following measures are to be realized in the nearest future:

- Optimization of current system of water resources management (for Dnieper basin, first and foremost), including increase of reservoirs usable storage, elevation of normal afflux horizons and lowering of drawdown level; alter regulations for runoff management through reservoirs;
- Providing alternative ways to cover peak loads in the power system in case of decrease of power production by Cascade of Dnieper hydropower plants;
- Development of National Program of Agriculture Development in Ukraine, which will include set of political, economic and technical measures, that will enable to prevent negative climate change impact on agricultural production. Acceleration of the land reform in Ukraine could be the first step in such direction;
- Promoting development of research programs to increase the genetic potential of domestic agricultural crops and animal breeds;
- Development of National Program on Coast Protection Measures that would include two main parts: scientific substantiation of trend and intensity of erosion processes within coastal zone of the Black and Azov Seas; and detailed plan of adaptation measures considering the most ‘unfavorable’ sea level rise scenarios designed up to 2050;
- Facilitating implementation of technological, administrative and financial measures to support forestry in climate change conditions, including measures on elongating timber stands life-time, forest protection against pests and diseases; introduction of stable wood species, which provide the best productivity under climate conditions being formed; rise of responsibility level of forest users for forestry integrity and others.

1.7 Research and Public Education

Paramount to successfully mitigating and adapting to climate change is an ability to understand, monitor, and predict future changes. This, in turn, requires substantial research on the global climate system and the dissemination of such information to better enable society to respond appropriately.
Ukrainian Country Study in the frames of US Country Studies Program Support for Climate Change Studies was the first large-scale program in such direction. This program is nationally integrated effort that seeks to expand knowledge of these processes that affect climate change and to develop integrated models to predict these effects.
Ultimately, of course, the public is the true arbiter of national response strategies and policies. Thus, the public must have a solid understanding of global change science, particularly the consequences of policy options. To

promote this understanding, relevant ministries and agencies direct efforts to general education, communication, and dissemination of climate change information.

1.8 The Future

Ukraine is currently examining the question of its future participation in the intergovernmental activities relating to the UN Framework Convention on Climate Change.

National Action Plan for GHG emission reduction and adaptation options implementation will be developed and submitted to Government for consideration. Public education concerning climate change problems is the essential element of National Action Plan implementation. The different forms of public education will be used, for example, training courses, issues of brochures, TV-programs, articles, etc.

Participation in U.S. Initiative on Joint Implementation (USIJI), which is a pilot program to reduce net GHG emissions and establish an empirical basis and framework for approaches to joint implementation, is envisaged.

2. INTRODUCTION

Climate change may be the most critical and complex environmental issue facing humanity in the last century. There are many uncertainties about the effects of increasing concentrations of carbon dioxide and other greenhouse gases (GHG) on temperatures; on the effects of temperature increases on other aspects of climate; and the causal effects on crops, rangelands, forests, and other parts of natural environment. But it is clear that global warming entails risk, risk not only that the kind of changes described above will take place but of other unexpected things. Small forcing can bring about changes in wind and ocean currents that greatly alter existing conditions. Strange and unforeseen effects can and probably will occur. With the carrying capacity of many parts of the world under stress from present level of population and economic activity, and the prospect of continuing and large increases in both in the decades immediately ahead, it might not take much more change to bring about the gravest consequences for people and most of Earth's present life systems.

The United Nations Framework Convention on Climate Change (UN FCCC) is the first and major international legal instrument to address climate change issues at a global scale. In June 1992 the representatives of 176 countries met at the highest level in Rio-de-Janeiro at the UN Conference to search for ways of joint activity for environmental protection. Signature of the UN FCCC by around 150 countries indicated that climate change is potentially a major threat to the world's ecology and economic development. 167 countries have ratified the Convention by September 1997.

The ultimate objective of the Convention is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

Ukraine signed the Convention in June 1992, the Parliament ratified it in October 1996 and became the Party in August 1997.

Ukraine is included in Annex 1 of the Convention. All of Annex 1 Parties are obliged to present the First National Communication composed of an inventory and projections of GHG emissions, national policies and measure to mitigate climate change, adaptation strategies within a six month period after it entering into force.

In compliance with Article 4.2b Ukraine has adopted 1990 as a base year for the estimating of anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol.

Article 4.6 of the Convention gives countries with economies in transition to market economies "a certain degree of flexibility" to meet their commitments in the frames of the FCCC. Due to the deep uncertainties related to transition period, futility of "business-as-usual" scenario development, there is a lack of sufficient quantitative information about some of mitigation and adaptation measures, and future projections in Ukraine.

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3. NATIONAL CIRCUMSTANCES

Ukraine is the second largest country in Europe (after the Russia) with an area of 603.7 thousand km^2. The population of the country (1995) is 51.7 million people, including urban population - 35.1 million, and rural population - 16.6 million. Around 73% of the total population are of Ukrainian origin. The capital of Ukraine is Kyiv.

Ukraine is situated in south-west of Eastern-European Plain. To the west of country Ukrainian Carpathians are located, to the south, along southern coast of the Black Sea - Crimean Mountains; from the south its coasts are washed by Black and Azov Seas. From the north to the south territory of Ukraine stretches from 52°22’54’’ to 44°23’18’’of n.l., almost for 900 km, and from the west to the east - from 22°08’42’’ to 40°13’05’’ of w.l., for 1,300 km.

Flat part of the territory of the country covers 95% of overall area (573.5 thousand km^2). In the northern part Polissya is situated - swampy lowland; left-bank region of Dnieper is occupied with Prydneprovskaya Lowland. From extreme north-east spurs of Middle-Russian Hills penetrate into Ukraine. In south-east Donetsk Ridge and Pryazovskaya Hills are situated. Central and western parts of right-bank of Dnieper are occupied with Prydneprovskaya, Volyn’ and Podol’sk Hills.

In the south of the country the Prychernomorskaya Lowland is located, which is connected with Northern-Crimean Plain through Perekop’s Isthmus.

Within flat territory natural zones are rather clearly marked. In the north zone of mixed forests is situated (19% of the territory). Forest-Steppe zone occupies 34% of country territory. Steppe zone is situated to the south of Ukraine and occupies about 40% of the territory. Carpathian and Crimean Mountains are characterized with altitudinal zonality of present landscapes.

Ukraine has rather dense river system. Rivers mostly belong to basins of Black and Azov Seas. The largest river of Ukraine is Dnieper, basin of which occupies a half of the country territory, and average runoff of which is 53.3 km^3.

There are significant deposits of a number of treasures of the soil in Ukraine - coal, oil, gas, iron ore, manganese, titanium, uranium, bauxites, nephelines, alunites, kaolines, rock-salt, potassium sulfate, etc.

Fertile soils are the most important resources for agriculture of the country. The most fertile soils in Ukraine are chernozems with humus content from 3 to 7% and with thickness of humus layer of 130 - 150 cm. They occupy more than 10% of territory. Besides, considerable areas are occupied with Grey Forest soils in Forest-Steppe zone and with Chestnut ones - in Steppe zone, which are featured with high fertility as well.

Table 3–1 presents general information on economical and natural potential of Ukraine.

Table 3–1. General information on economical and natural potential of Ukraine (1995)

Population,	millions of persons	51.7
Population increment,	%	0.35
Urban population,	millions of persons	35.1
Gross Domestic Product,	billions of US dollars	35.3
Income per capita,	US dollars	657
Share of industry in GDP,	%	67.3
Water consumption, including	km^3 (%)	26.93 (100)
agriculture		1.66 (6.2)
irrigation		6.2 (23)
industry		13.5 (50.1)
drinking water demands		4.64 (17.2)
other demands		0.93 (3.5)
Land fund, icluding	million ha	36
crops under cultivation	%	55.3
forested area	%	15.4
pastures and hay-fields	%	12.4
under water	%	4.0
perennial plantations	%	1.8
wood-bush plantations	%	1.5
swamps	%	1.5
other lands	%	8.1

3.1 Climate

Climate of Ukraine is of moderate-continental type, except of narrow belt of Southern Coast of Crimea with features of subtropic climate. Rather important factor of Ukraine climate formation is atmospheric circulation: prevailing western direction of air transfer presumes inflow of Atlantic air masses, from time to time air masses invade territory of the country from Asia continent, from northern latitudes, from Mediterranean Sea.
Differences in circulation conditions of the west and the east are clearly manifested in increase of continentality of climate from the west to the east. In regions of Carpathian and Crimean Mountains changes of climatic elements depend greatly upon altitude of region and exposure of mountainsides: with increase of altitude atmospheric pressure and temperature are lowered, amount of precipitation is increased, period of time with snow cover becomes longer, wind speed is increased. Influence of Volyn'-Podol'sk Plateau and Donetsk Ridge upon climatic conditions is of less significance. It results mainly in small decrease of temperature, changes of duration of snow cover laying.
Black and Azov Seas influence climate of Ukraine significantly too. Increase of air humidity and smoothing of diurnal cycle of air temperature are marked in coastal regions.
In Polissya region the climate is temperate, humid and is characterised with prevailing transfer of Atlantic air. Western part of Polissya is featured with increased cloudiness in summer season, relatively cool summer, soft winter and excessive precipitation. Average temperature in January is -4...-5°C, while in eastern part it reaches -7...-8°C. The most severe winters are in eastern part of Polissya, where their duration is 20 days longer approximately. Spring and autumn in Polissya are protracted, since inflow of humid sea air is accompanied with significant cloudiness and precipitation, which hinder air from heating in spring and its cooling in autumn. During summer seasons the lowest temperatures are observed in western part of Polissya, where average temperature in July is 17...18°C; to the east it increases up to 19...20°C. Annual precipitation makes 500 - 600 mm. During warm period about 70% of total precipitation falls, while 30% are referred to cold period. Sometimes droughts and dry winds are marked in Polissya.
Climate of Forest-Steppe zone is temperate continental. The lowest average temperatures of January are observed in eastern Forest-Steppe (-7...-8°C); to the west they increase to -4...-6°C. Summer is warm: average temperature in July to the west of the zone is 18...19°C, while to the east it equals to 19...21°C. Annual totals of precipitation are decreased from 700 - 550 mm in western region to 575 - 500 mm in eastern region. In Forest-Steppe zone number of days with hot dry winds is increased in comparison with Polissya zone. In eastern regions it approaches 11 days, in western - from 1 to 8 days.
Region of steppe atlantic-continental climate occupies whole Steppe zone of Ukraine, including steppe part of the Crimea. Climate there is featured with the most continentality and aridity, when compared with other zones of Ukraine. Summers are hot, winters are cold, in most cases with poor snowing. Average temperatures of January vary from -7°C in north-east to -2°C in south-east of the zone. Winters here are characterized with strong thaws, followed often by sharp cooling. Average monthly temperature in July is 21...30°C. Annual totals of precipitation are decreased from the north to the south. In southern regions of the zone they amount to 250 - 300 mm. Ukrainian Steppe is a region with the least relative air humidity, therefore droughts, dry winds and dusty storms are marked here most frequently.
In Carpathian Mountains significant rising of terrain causes sharp vertical zonality in distribution of climatic elements.
Lower in altitude Crimean Mountains are characterized with vertical zonality as well.

3.2 Economics

The economy of Ukraine, up to declaration of independence in 1991, was developing as a part of an economic system of the USSR under circumstances of both central planning system and practically insulated markets of the USSR and Comecon countries. Structure and levels of prices of goods and services differed from those on the world market highly. The regional and global ecological problems were practically ignored.
Proceeding from general economical interests of the former USSR and available natural resources potential top priority was given to the development of heavy industrial sectors (Fuel & Energy Complex, Metallurgy, Machinery & Equipment) and Agriculture.
In 1991 Ukraine set about restructuring of the economy towards the market development and democratic state formation. However, the transient period turned very painful, and the country entered serious and growing economic crisis, which was featured by the following:

- drop of industrial output, especially in industries of low energy intensity, and, as a consequence, GDP decrease and its energy intensity growth;
- swelling problems of payment for critical energy carriers import, that determines constant negative external trade balance and problem energy supply in the country;
- steady rising budget deficit;
- high inflation rates;
- abrupt standard of living decrease for the most part of population;

- social tension growth (Table 3–2).

Table 3–2. Economics. GDP, Inflation and Unemployment Trends

	1990	1991	1992	1993	1994	1995
GDP, 10^9 $	73.62	67.21	60.56	51.96	40.01	35.29
Unemployment, thousand person	-	9.8	128	180.9	216	126
Inflation, %	-	-	1310	4830	990	420

Source: Ministry of Economy

At present, the economy escape from the crisis is considered to be connected with the following: production stabilization and its following progress, privatization passage, legislation settling, improvement of taxation sphere and currency regulations, restoration of economic contacts with CIS countries and support of developed ones.

3.3 Energy Use

Ukraine belongs to high energy intensity countries. In 1990 specific energy consumption per GDP unit produced exceeded that of developed countries. For the posterior years this index has been dropping back due to considerable production fall in the country (Table 3–3).

Table 3–3. Energy Intensity

	1990	1991	1992	1993	1994	1995
GDP, 10^9 $	73.62	67.21	60.56	51.96	40.01	35.29
Energy Consumption, PJ	10342.9	10017.7	8907.2	7931.5	6900.2	6630.6
Energy Intensity, PJ per billion $	141	149	147	152	172	188

High level of outdated and outworn energy intensive production together with low privatization rates and absence of bankruptcy mechanism, deficiency of domestic fuel and energy resources, not sufficient amount of capital stock at enterprises and environmental problems have led to high energy cost levels, low efficiency of social production and energy crisis deepening.

Production decrease and energy recession have resulted in balance of payments crisis, external indebtedness growth and nonpayment problems aggravation. According to the Government estimates (as for the fall 1995), energy supply matter has transformed into the national security problem. Ukrainian trade balance for 1996 showed that costs for raw stuff and materials for Fuel and Energy Complex made up more than 50%. Energy carriers deficit is covered mainly by import from Russia, that leads to the necessity of diversification of energy carriers import sources. In 1995 Ukrainian total needs in primary domestic energy resources were met for 40-50%, including coal - for 83%, gas - for 21%, oil - for 16% (Table 3–4). For the latest years, production of main types of energy resources, mainly coal, tends to decrease.

Table 3–4. Primary Energy Production and Consumption

	1990	1991	1992	1993	1994	1995
Production						
Coal (mln t)	130.7	108.7	105.4	91.0	75.9	65.6
Oil (mln t)	5.3	4.9	4.2	4.1	4.0	4.1
Natural gas (bln m^3)	28.1	24.3	20.9	19.2	18.3	18.2
Biomass (mln t)	4.3	4.0	3.7	4.1	4.0	3.9
Import						
Coal (mln t)	21.1	12.7	11.7	8.7	7.5	16.0
Oil (mln t)	54.3	49.6	35.3	19.7	15.8	13.3
Natural gas (bln m^3)	87.3	89.5	89.1	79.8	69.1	66.3
Oil products (mln t)	11.5	13.1	5.0	6.2	6.5	9.5
Export						
Coal (mln t)	20.0	13.7	7.8	3.5	4.6	2.4
Oil products (mln t)	11.3	8.4	6.4	1.1	1.7	1.4
Consumption						
Coal (mln t)	131.8	107.7	109.3	96.2	78.8	79.2
Oil and oil products (mln t)	59.6	59.2	38.4	29.0	24.8	25.4
Pure natural gas (bln m^3)	118.7	118.2	114.1	102.799	92.5	85.4
Biomass (mln t)	4.3	4	3.7	4.1	4	3.9

Power production and consumption structure in Ukraine have undergone considerable transformation. Total power production decreased from 296.3 to 192.5 bln kWh between the years 1990 and 1995 (Table 3–5), though fixed capacity did not change and made about 54.6 GWt, from these - 66.5% of electricity was generated at TPP, 25% - at NPP, 8.5% - at HPP and HPSP. The heat generation dropped from 68% in 1990 to 56% in 1995.

Table 3–5. Electric Power Production Trends, billion kWh

	1990	1991	1992	1993	1994	1995
Thermal Power Plants	201.7	182.5	162.4	135.9	115.8	107.0
Hydropower Plants	10.7	11.9	8.1	11.2	12.3	10.1
Blockstations	7.7	7.2	6.8	6.0	4.6	4.9
Nuclear Power Plants	76.2	75.1	73.7	75.2	68.8	70.5
TOTAL	296.3	276.7	251.0	228.3	201.5	192.5
Balance with CIS countries	0.16	1.14	1.12	1.56	0.57	1.27
Export excluding CIS	-28.13	-15.44	-5.77	-2.71	-1.59	-4.10
Export Netto	-27.97	-14.31	-4.65	-1.15	-1.02	-2.83
Total Consumption	268.33	262.39	246.35	227.15	200.48	189.67

In electricity consumption volume, industry's share decreased from 64% in 1990 to 54% in 1995, while residential sector's share grew up from 9% to 19% (Table 3–6).

Table 3–6. Electric Power Consumption Trends, billion kWh

	1990	1991	1992	1993	1994	1995
Industry	146.2	137.7	126.3	108.0	88.6	81.1
Agriculture	20.5	20.7	19.1	18.4	16.8	13.6
Transport	14.4	13.6	12.5	12.1	10.8	10.3
Service	17.6	17.8	17.2	16.7	15.7	14.8
Others	7.5	7.5	6.1	5.8	4.9	4.5
TOTAL	206.2	197.3	181.2	161.0	136.8	124.3
Household	21.1	24.2	24.9	26.9	26.8	27.0
Urban				17.5	17.4	18.0
Rural				9.4	9.3	9.0
Total Netto	227.3	221.5	206.1	187.9	163.6	151.3
Total Brutto	268.3	262.4	246.3	227.2	200.6	189.8

Since 1991, the state has been paying much attention to the energy sector development. In 1994 Ukrainian Parliament adopted the Concept on Fuel and Energy Complex Development up to 2010; based on which National Energy Program of Ukraine was developed in 1996.

The Concept and the Program determine energy policy of the state, its main priorities: energy conservation, domestic energy resources use, renewable energy sources development, targeted investments into strategic fields of the economy.

To fulfill national energy conservation policy Ukrainian Parliament adopted Law of Ukraine "On Energy Conservation", and special state body - State Committee for Energy Conservation was formed. The Government of Ukraine elaborated Comprehensive National Program on Energy Conservation, which was approved by the Parliament in 1996.

In 1995 Parliament of Ukraine approved Program of Restructuring of Ukrainian Economy, which envisaged considerable decrease of energy intensive production processes.

As energy sector is under reformation, the problem of development and adoption of general economic regulations becoming more actual. Such regulations are designed for the functioning of state monopoly and competition in energy sector, state regulation (role and terms of licensing, terms for granting subsidies, concessions, energy carriers exchange functioning), improving taxation and price policy.

3.4 Environment

In the former Soviet Union the environmental legislation was very poor. The Law of the Parliament "On Environmental Protection" was among the first legislation acts of the independent Ukraine. Later the following legal provision was adopted by the Parliament of Ukraine: Law of Ukraine "On Protection of Atmosphere"(1992), Law of Ukraine "On Wildlife" (1994), Law of Ukraine "On Changes and Amendments to the Code of Ukraine with concern to Administrative Infringements"(1993), which empowers the bodies of the Ministry for Environmental Protection and Nuclear Safety of Ukraine to take legal steps in the case of administrative infringements in the field of environmental safety, Resolution of the Parliament of Ukraine "On the Red Book of Ukraine" (1992), Resolution of the Parliament of Ukraine "On Adopted Terms and Conditions of Restriction, Temporary Suspension (Stoppage), or Cessation of Activities of Enterprises, Institutions, Organizations and Projects in the Case of their Infringement of the Law on Environmental Protection Provisions" (1992), Resolution of the Parliament of Ukraine "On Conditions of Import (or Transit) of Waste Products and Utility Waste on the Territory of Ukraine" (1993), Law of Ukraine "On Changes and Amendments to the Criminal Code and Criminal Procedure Code of Ukraine" (1994), which specify criminal and fiduciary responsibilities for infringement of conditions of import (or transit) of waste products and utility waste on the territory of Ukraine, Law of Ukraine “On Ecological Examination” (1995).

Besides, some Decrees of the President of Ukraine were enforced, namely: “On Protection and Development of Natural Reserves of Ukraine” (1993), “On Wildlife Reserves in Ukraine” (1993).

In 1997 the National Climate Program was adopted by the Cabinet of Ministries.

4. GREENHOUSE GAS INVENTORY

Central to any study of climate change is the development of an emission inventory that identifies and quantifies a country's primary sources and sinks of GHG. The inventory process is important for two reasons: (1) it provides a basis for the ongoing development of a comprehensive and detailed methodology for estimating sources and sinks of greenhouse gases, and (2) it provides a common and consistent mechanism that enables all signatory countries to the United Nations' Framework Convention on Climate Change to estimate emissions and to compare the relative contributions of different emission sources and greenhouse gases to climate change. Moreover, systematically and consistently estimating emissions at the national and international levels is a prerequisite for evaluating the cost-effectiveness and feasibility of pursuing possible mitigation strategies and adopting emission reduction technologies.

This chapter summarizes the sources and sinks of Ukraine GHG emissions and uptakes. The emission estimates presented here were calculated using the IPCC Guidelines for National Greenhouse Gas Inventories [6, 18], to ensure that the emission inventories submitted to the Framework Convention are consistent and comparable across sectors and among nations. Ukraine has followed these guidelines, except where more detailed data or methodologies were available for major sources of emissions.

4.1 Ukrainian Greenhouse Gas Emissions

Greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor and ozone (O_3) directly contributing to the greenhouse effect.

Chlorofluorocarbons (CFCs), a family of human-made compounds, its substitute hydrofluorocarbons (HFCs), and other compounds, such as perfluorinated carbons (PFCs), are also greenhouse gases. In addition, there are other "photochemically important" gases, such as carbon monoxide (CO), oxides of nitrogen (NO_x), and nonmethane volatile organic compounds (NMVOCs) that are not greenhouse gases, but contribute indirectly to the greenhouse effect. These are commonly referred to as "tropospheric ozone precursors" because they influence the rate at which ozone and other gases are created and destroyed in the atmosphere.

Although carbon dioxide, methane, and nitrous oxide occur naturally in the atmosphere, their recent atmospheric build-up appears to be largely the result of human activities. This build-up has altered the composition of the Earth's atmosphere and may affect future global climate. Since 1800, atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased by 30, 145 and 15 percent respectively [18].

Use of chlorofluorocarbons is phased out under the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer.

Ukrainian Inventory carrying out in accordance with UN FCCC commitments, touches upon three direct GHG: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and three "photochemically important" gases: carbon monoxide (CO), oxides of nitrogen (NO_x), and nonmethane volatile organic compounds (NMVOCs).

The concept of global warming potential (GWP) has been developed to compare the abilities of each greenhouse gas to trap heat in the atmosphere. Carbon dioxide was chosen as the "reference" gas. Gases are presented in units of gigagrams of carbon equivalent (Gg CE). Carbon comprises 12/44 of carbon dioxide by weight.

The GWP of a greenhouse gas is a ratio of global warming - or radiative forcing (both direct and indirect) - from one kilogram of a greenhouse gas to one kilogram of carbon dioxide over a period of time. This report uses the 100-year GWPs recommended by the IPCC (Table 4–1).

Table 4–1. Global Warming Potential of Greenhouse Gases, 100 Years

Gas	*GWP*
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310

The Ukrainian inventory deals with the following five categories of GHG sources and sinks: energy systems (including transportation), industrial processes, agriculture, forestry and land-use change, and wastes.

The current Ukraine Greenhouse Gas Inventory for 1990 is summarized in Table 4–2. The totals presented in the summary tables in this chapter may not equal the sum of the individual source categories due to rounding. For the base year total GHG emissions were 232 882 Gg of carbon equivalent. CO_2 emissions were partly offset by an uptake of carbon in Ukrainian forests of 14 175 Gg of carbon equivalent in 1990.

Table 4–2. Ukrainian Greenhouse Gas Emissions, 1990, Gg

Gas/Source	Emissions (Full Molecular	Emissions (Direct and Indirect Effects;

	Weight)	Carbon Equivalent)
Greenhouse Gases		
Net Carbon Dioxide	648 131	176 763
Fossil Fuel Combustion	668 332	182 272
Industrial processes	31 775	8 666
Total	700 107	190 938
Forestry (sink)	-51 976	-14 175
Methane	9 453	54 140
Energy	6 265	35 881
Agriculture	2 254	12 909
Waste	934	5 349
Nitrous Oxide	23.412	1 979
Energy	6.708	567
Chemistry	6.160	521
Waste	0.132	11
Forest fires	0.175	15
Agricultural soils	10.237	865
Photochemically Important Gases		
Carbon Monoxide (CO)	7 481	-
Nitrogen Oxides (NO_X)	1 243	-
Nonmethane Volatile Organic Compounds (NMVOCs)	656	-
Net Emissions		232 882

Figure 4-1 illustrates the relative contribution of the primary greenhouse gases to Ukrainian emissions in 1990. The shares of different sectors in GHG emissions are presented at the Figure 4-2.

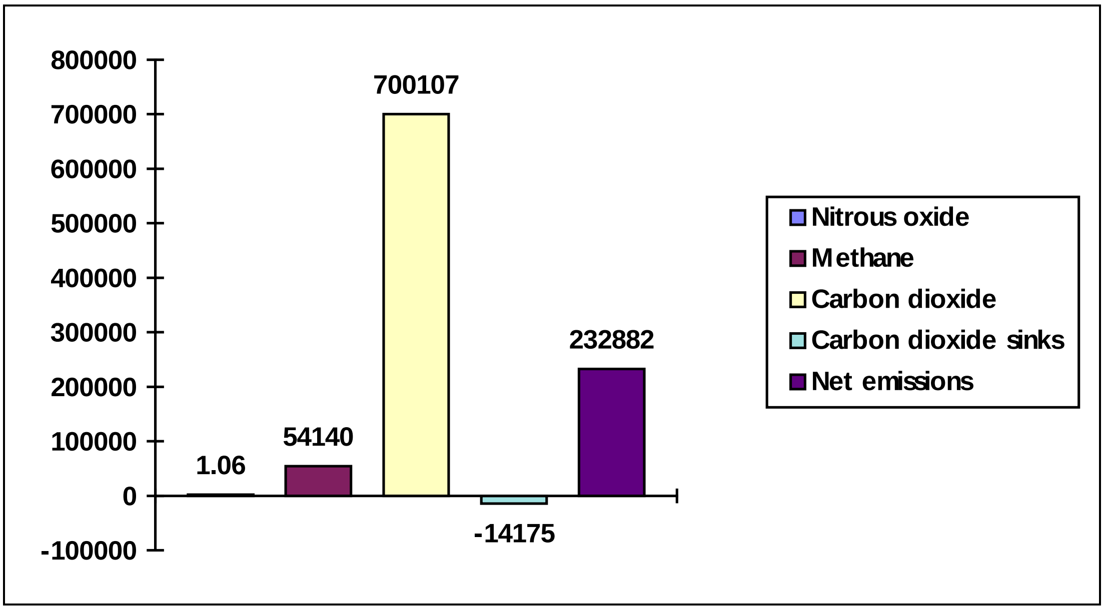

Figure 4-1. Greenhouse Gases emissions in 1990, Gg

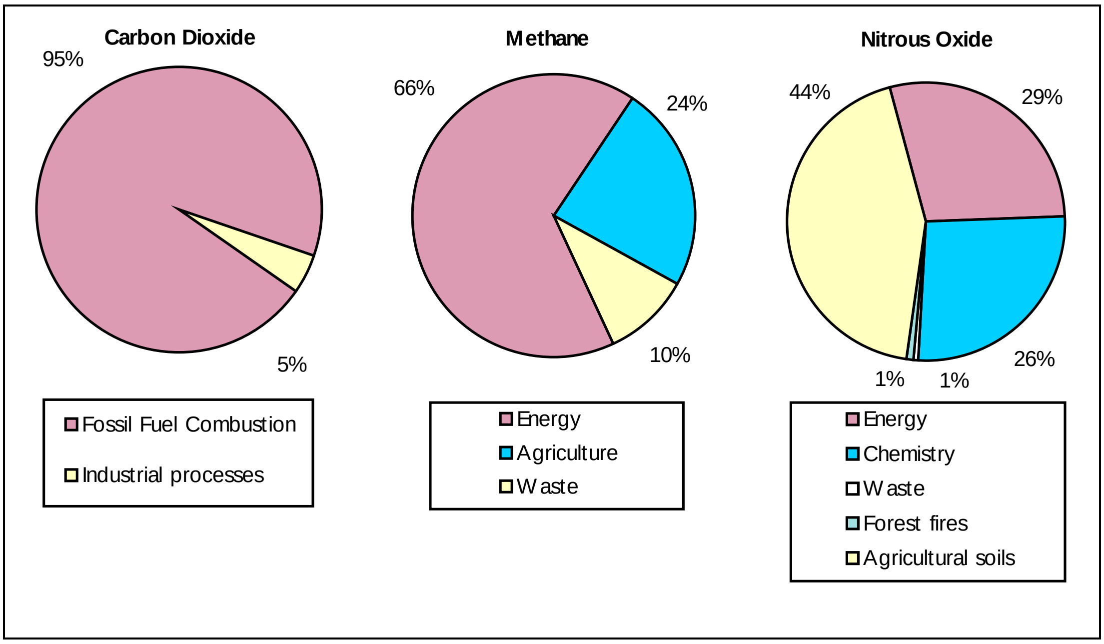

Figure 4-2. Sources of Greenhouse Gases in 1990, %

Due largely to fossil fuel consumption, carbon dioxide emissions accounted for the largest share - approximately 76 percent. Methane accounted for 23 percent of total emissions, which included contributions from agricultural activities and landfills, among others. The nitrous oxide emissions are less important comprising 1 percent of total emissions.

The emissions of the photochemically important gases CO, NO_x, and NMVOCs are not included in Figure 4-2, because there is no agreed-upon method to estimate their contribution to climate change. These gases only affect radiative force indirectly.

Statistical data for the development of the National GHG Emission Inventory for 1990 were collected and analyzed according to the IPCC Methodology. Official statistical data from Ukrainian Ministries and Departments were used. Information gaps in several emission source categories have produced a high level of uncertainty in the results. All statistical data used and emission assessments have previously appeared in official Ukrainian publications [14].

The following sections present the anthropogenic sources of greenhouse gas emissions, briefly discuss the emissions pathway, summarize the emissions estimates, and explain the relative importance of emissions from each source category.

4.2 Energy Sector and Transportation

Fuel combustion and fugitive emissions from fuels were considered in category "Energy sector and transportation" as the main sources of greenhouse gases.

After the disintegration of the Union of Soviet Socialist Republics (USSR), the most important problem for Ukraine was dependence from energy import. However, for the last few years, domestic fossil fuel production has been diminishing steadily. Coal production decreased from 164.2 million metric tons (MMT) in 1990 to 130 MMT in 1994; oil production decreased from 5.2 MMT in 1990 to 4.2 MMT in 1993; and natural gas production decreased from 19.8 billion m^3 in 1990 to 19.4 billion m^3 in 1993 [11,21]. Despite the low level of domestic oil production, Ukraine has large facilities for oil refining, which are capable of processing 60 MMT of oil per year [11,15]. Gas is transported from Russia to a number of European countries through the Ukrainian territory at a rate of more than 100 billion m^3 per year.

In 1990 total fossil fuel consumption in Ukraine totaled 9,365.73 PJ (Table 4–3). The main consumers of fuel are electricity and heat production, and industry (Figure 4-3).

Table 4–3. Fossil Fuel Consumption in Ukraine by Sectors

Sector	*PJ*	*Percent*
Energy	4,046.33	43.20
Industry	2,834.39	30.26
Transportation	791.78	8.45
Agriculture	325.14	3.47
Household & Services	1,263.31	13.49
Others	104.78	1.12
Total	9,365.73	100

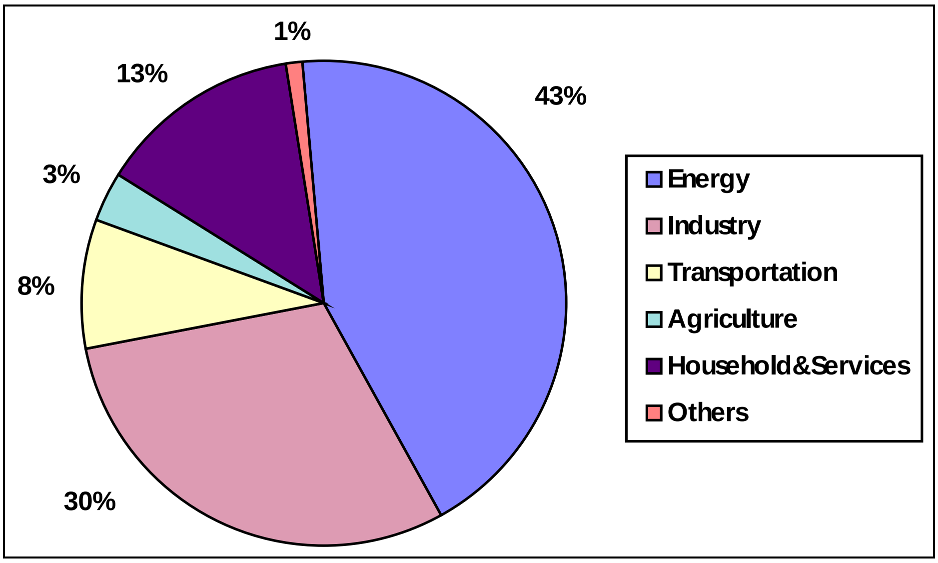

Figure 4-3. Fossil Fuel Consumption by Sectors in Ukraine

The 1990 Energy Balance of Ukraine [15] was the main source of statistical data of fuel consumption. However, the types of fuel and sectors included in this document differ from the IPCC Methodology. Therefore special software was designed to reformat the official statistical data according to the IPCC worksheets format; to calculate fuel production, import, export, and other parameters; and to transform the data into the units used by the IPCC.

Carbon dioxide (CO_2) emissions for 1990 were estimated according to both the "bottom-up" and "top-down" methods. The bottom-up method used data on fuel and energy resources consumed in seventeen sectors of the Ukrainian economy. The top-down method used data on total values of fuel consumption. Carbon dioxide emission factors were taken from the IPCC Methodology [6].

Estimates of emissions from fuel combustion are presented in Table 4–4. Non-CO_2 emission assessments were taken from national statistical information [13] for stationary sources.

Table 4–4. GHG Emissions for Fossil Fuel Combustion for stationary sources, Gg

Source	*CO_2*	*CH_4*	*N_20*	*CO*	*NO_x*	*NMVOCs*
Fuel Combustion	668,332.0	35.6	6.7	3,273.0	760.7	265.1

Methane emission factors for fuel production, transportation, and primary processing were assessed according to Ukrainian experts data and IPCC Guidelines. Table 4–5 presents CH_4 emission estimates in Ukraine for 1990, and Table 4–6 - the corresponding emission factors. In order to account Ukrainian circumstances minimum and maximum emissions and emission factors were calculated by national experts.

Table 4–5. CH_4 Emissions for the Fuel Production, Transportation, Processing and Storage in Ukraine, Gg

Sources	*Base*	*Minimum*	*Maximum*
Coal	2,784.87	2,180.35	3,610.12
Oil and gas	3,444.52	1,696.38	4,558.65
Total	6,229.39	3,876.73	8,168.77

Table 4–6. CH_4 Emission Factors for the Production, Transportation, Processing, and Storage of Fossil Fuels in Ukraine

Activity	*Units*	*Emissions Factor*
Underground mining		
Coal mining (Donetsk Basin)	m^3 CH_4/t	25.5
Coal mining (Lviv-Volyn Basin)	m^3 CH_4/t	12.8
Postmining activity	m^3 CH_4/t	2.0
Surface mining		
Coal mining	m^3 CH_4/t	1.2
Postmining activity	m^3 CH_4/t	0.2
Oil-refining systems		
Prospecting and drilling	kg CH_4/drill-hole	no data
Production	kg CH_4/PJ	4,500
Transportation	kg CH_4/PJ	745

Activity	Units	Emissions Factor
Processing	kg CH_4/PJ	1,000
Storage	kg CH_4/PJ	180
Natural gas systems		
Extraction	kg CH_4/PJ	450,000
Processing, distribution, and storage	kg CH_4/PJ	600,000
Venting and Flaring	kg CH_4/PJ	14,000

There are no published statistical data on GHG emissions from mobile sources in Ukraine for 1990. The main source of emissions is road vehicles, which in 1990 consumed more than 10 MMT of petroleum, 14 MMT of diesel fuel, about 48 thousand metric tons of propane-butane, and 284 million m^3 of natural gas [3]. Road vehicles in Ukraine have a very low fuel efficiency; they use 1.4 to 1.5 times more fuel than similar automobiles and buses in developed countries. Consequently, GHG emissions per km are higher. Table 4–7 presents estimates of GHG emissions from mobile sources.

Table 4–7. GHG Emissions from Mobile Sources in Ukraine

Source	Annual Fuel Consumption (10^3 tons)	Aggregate Emission Factors (g/kg)			Total Emissions (Gg)		
		CO	NO_x	NMVOCs	CO	NO_x	NMVOCs
Heavy-Duty Trucks							
Gasoline	5,184.00	400	40	36	2,073.60	207.36	186.62
Diesel	2,560.00	20	20	5	51.20	51.20	12.80
Butane	31.70	150	25	30	4.76	0.79	0.95
Natural gas	162.40	140	22	25	22.74	3.57	4.06
Cars							
Gasoline	3,800.00	400	40	36	1,520.00	152.00	136.80
Natural gas	12.00	150	25	30	1.80	0.30	0.36
Buses							
Gasoline	1,301.00	400	40	36	520.40	52.04	46.84
Diesel	320.00	20	20	5	6.40	6.40	1.60
Butane	4.40	150	25	30	0.66	0.11	0.13
Natural gas	29.14	140	22	25	4.08	0.64	0.73
Total					4,205.64	474.41	390.89

4.3 Industrial Processes

Greenhouse gas emissions from industrial processes were calculated according to the IPCC Methodology [6, 18]. The following industrial chemical processes were considered: nitric acid manufacture [2], adipic acid manufacture [9], CO_2 production and use (the main source is ammonia manufacture, the main consumer is carbamide manufacturing), cement production (calculations were based on clinker production volume), lime production and use (the main consumers are the sugar industry and construction), limestone use (the main consumers are iron and steel production [20], and glass manufacture), and soda manufacture and use. Emission estimates for carbon dioxide and nitrogen oxides (Table 4–8 and Table 4–8) are based on statistical data on production volumes [14] and national emission factors obtained from stoichiometric equations for chemical reactions.

Table 4–8. CO_2 Emissions from Industrial Processes in Ukraine, Gg

Source	Emissions
Cement production	8,745.31
Lime manufacture and use	4,531.40
Soda manufacture and use	987.41
Limestone and Dolomite use	10,968.95
CO_2 use and production	6,543.38
Total	31,776.45

Table 4–9. NO_x Emissions from Nitric and Adipic Acids Production in Ukraine, Gg

Source	Emissions
Nitric acid manufacture	7.51
Adipic acid manufacture	0.82
Total	8.33

Table 4–10 contains CO, NO_X, NMVOCs emissions estimations for a number of industrial processes. Production volumes were obtained from the national statistics, and emission factors were taken from industrial emission standards for the former USSR.

Table 4–10. Indirect Greenhouse Gas Emissions from Industrial Processes

Production	Volume	Emission Factors, kg/t			Emissions, Gg		
	1000 tons	CO	NO_x	NMVOCs	CO	NO_x	NMVOCs
Blast-Furnace Sinter	60,926.50	32.80	0.40	-	1,998.49	24.37	-
Iron-Ore Pellets	27,916.80	0.27	0.31	-	7.54	8.65	-
Coke	34,666.80	3.11	0.30	-	107.81	10.40	-
Rolled Ferrous Metal Produce	38,600.00	1.63	0.41	-	62.92	15.83	-
Steel Pipes	6,500.00	1.63	0.41	-	10.60	2.67	-
Steel	52,600.00	2.35	0.62	-	123.61	32.61	-
Pig-Iron	44,900.00	-	0.09	-	-	4.04	-
Nitric Acid	2,780.20	3.19	-	-	8.87	-	-
Ammonia	5,149.59	1.06	0.77	-	5.46	3.97	-
Phosphate Fertilizers	593.00	0.21	0.04	-	0.12	0.02	-
Oil, primary refining	58,981.30	0.03	0.001	0.90	1.77	0.06	53.08
Clinker	17,500.00	20.00	2.28	-	350.00	39.90	-
Lime	8,677.00	59.30	3.19	-	514.55	27.68	-
Soda Ash	1,119.50	7.02	0.15	-	7.86	0.17	-
Acetic Acid	156.34	24.76	-	59.58	3.87	-	9.32
Formaline	205.21	2.97	-	0.42	0.60	-	0.09
Total					**2205.07**	**170.37**	**62.49**

4.4 Agriculture

The main sources of GHG emissions in the category "Agriculture" were enteric fermentation and manure management in domestic livestock, rice cultivation and nitric fertilizers use. Crop residue burning is not widely used in Ukraine, so this source of emissions was not considered.

Initial data for the inventory of GHG emissions from agricultural activities were taken from statistics [14] and documents of the Ukrainian Agrarian University.

The emission factors for livestock were taken from the IPCC Guidelines [6]. The factors for manure were based on the fact that the Crimean region has a warm climate, other regions of the Ukraine have a temperate climate. For example, the emission factor for swine manure management is a weighted average based on the percent of total swine in the Crimean region in 1990 (2.4%) and the Eastern Europe emission factor for a warm climate, plus the percent of total swine in other regions (97.6%) and the Eastern Europe emission factor for a temperate climate: $(0.024 \times 11) + (0.976 \times 7) = 7.10$ (Table 4–11).

Table 4–11. Emissions Factors for Ukrainian Livestock

Source	Enteric Fermentation, (kg CH_4/ head/year)	Animal Wastes, (kg CH_4/ head/year)
Nondairy cattle	56	13.36
Dairy cattle	81	19.40
Goats	5	0.17
Sheep	5	0.16

Swines	5	7.10
Horses	5	0.61

The IPCC Methodology was used for estimating GHG emissions from rice cultivation. Three regions in Ukraine (the Crimean, Herson, and Odessa regions), have small areas under rice cultivation. The total harvested area in 1990 was 0.0281 Mha. The emission factor was defined using an average temperature of 25°C. The average growing period is 103 days.

Table 4–12 presents CH_4 emissions from agriculture in Ukraine in 1990.

Table 4–12. CH_4 Emissions from Agriculture in Ukraine, 1990

Source	*CH_4 Emissions, Gg*
Enteric Fermentation	1,702.63
Manure Management	536.40
Rice Cultivation	15.17
Total	**551.570**

Assessments of N_2O emissions from nitric fertilizers were based on the IPCC Methodology and national statistics and totaled 10.237 Gg.

4.5 Forestry and Land-Use Change

In forestry and land-use change, CO_2 is mainly emitted as a result of the decay of damaged aboveground biomass and the burning of biomass at harvesting; and forest fires. Forests also sequester carbon (C) in the process of photosynthesis.

Several activities included in the IPCC Methodology for the forestry and land-use change category do not play any significant role in Ukraine. These include conversion of forest to agricultural land, conversion of grasslands and pastures, and abandonment of managed lands, excluding the abandonment zone in the Chernobyl region.

Emissions and uptake of CO_2 from forest management and afforestation of Chernobyl zone were estimated according to the IPCC Methodology [6]. For the calculation of the aboveground biomass growth rate, the C ratio in dry matter, and the wet-to-dry wood-weight ratio, data from national statistical publications were used [7, 8, 10, 19].

A method similar to the IPCC for forest clearing was used to estimate CO_2 emissions from forest fires. The difference between brush fires, which primarily destroy forest floor, and top fires, which destroy the tree layer, was taken into account. Average CO_2 emissions and uptake estimates were obtained for 1990 through an analysis of forest fires during a 9-year period (1986-1994).

Table 4–13 shows the estimates of CO_2 emissions and uptake from forestry and land-use management.

Table 4–13. CO_2 Emissions and Removals in the Category "Land Use Change and Forestry"

Source	*CO_2 Emissions and Removals, Gg*
Forest Managed	-72,321.3
Harvests	20,683.7
Forest Fires	81.8
Abandonment of Lands	-420.6
Total	**-338.8**

4.6 Waste

The IPCC Methodology [6] was used to determine CH_4 emissions from solid and liquid wastes.

One of the most important ecological problems in Ukraine is MSW management, annual increment of solid wastes totals 1.5 to 2% [16, 17]. According to national statistics, MSW was estimated to be 11 million tons in 1990, about 8% of which was treated on incineration plants in Kyiv, Kharkov, and Sevastopol. Methane was not recuperated from landfills in Ukraine in 1990 and CH_4 emissions from MSW totaled 885.5 Gg.

N_2O emissions from solid waste incineration were estimated according to IPCC methodology. The volume of incineration totaled 880 thousand tons, emission factor was taken as the average value of 26-270 grams of N_2O per ton of waste. N_2O emissions from waste incineration totaled 0.13 Gg in 1990.

Under Ukrainian conditions, rural wastewater decomposes under aerobic conditions. Therefore only urban wastewater was taken into account. In 1990, 3,684 million m^3 of municipal wastewater were made in Ukraine, of which 3,597 million m^3 (97%) were processed in sewage disposal facilities [12]. Wastewater treated under anaerobic conditions accounts for 15% of the total wastewater in Ukraine. To calculate CH_4 emissions from municipal wastewater, biochemical oxygen demand (BOD) in municipal wastewater was defined as 0.05 kg/person/ day. Applying the IPCC CH_4 emission factor of 0.22 Gg CH_4/Gg BOD, emissions from municipal wastewater were estimated as 40.7 Gg CH_4. Taking into account recuperation of 6.24 Gg CH_4 on sewage disposal facilities in Kyiv and Kharkov [4], methane emissions from liquid wastes totaled 34.46 Gg. Table 4–14 presents the results of the emissions assessment for industrial wastewater.

Table 4–14. CH_4 Emissions Assessment for Industrial Wastewater in Ukraine

Industry	*Annual Wastewater, million m^3*	*Wastewater Treated at Disposal Facilities, million m^3*	*CH_4 Annual Emission, Gg*
Iron and steel	1,790.0	755.0	1.08
Nonferrous metals	25.9	11.1	0.02
Fertilizer	537.5	320.1	1.94
Food and beverages	197.4	68.7	5.08
Pulp and paper	102.1	93.6	1.04
Petrochemical	26.5	14.9	0.41
Textiles	31.8	31.5	0.94
Miscellaneous*		85.8	3.60
Total		1,380.70	14.11

* Microbiologic industry, transport, construction, and building materials production are accounted.

4.7 References

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5. POLICIES AND MEASURES TO MITIGATE CLIMATE CHANGE

5.1 Overall policy context

In the last time the whole number of programs for the economic development of Ukraine was elaborated and adopted, the most important of them were as follows:

1. National Energy Program [1];
2. Program of Restructuring of Ukrainian Economy [2];
3. Comprehensive State Energy Conservation Program of Ukraine [3];
4. National Development Programs of Industrial Sectors [4-9].

These documents were assumed as a basis for forming the baseline scenario of the development of economy and its sectors, for assessing projected GHG emissions and mitigation measures.
In correspondence with the baseline scenario of the economic development it is planned to provide main indices of the socio-economic development of the country (Table 5–1) in the period considered, up to 2015.

Table 5–1. The main indices of socio-economic development of Ukraine till 2015

Indices	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
GDP, billion $	73.62	35.26	41.30	58.82	84.07	97.17
GDP, %	100.0	47.9	56.1	79.9	114.2	132.0
Fuel combustion, PJ	9246.3	5531.5	6965.1	7557.7	8022.5	8551.9
Population, million	51.9	51.5	50.2	51.0	51.5	51.8
Housing fund, million m^3	922.1	978.5	1018.5	1169.6	1255.0	1360.5

Alongside with the baseline scenario the indices for the optimistic and pessimistic scenarios of the economic development were forecasted. These scenarios differ in terms of crisis peak, duration of economic recovery and further rate of development.
An active and consistent reformation and large-scale economic restructuring (firstly in high intensive industrial sectors) and the increase of its liquidity, considerable increase of Ukrainian goods competitiveness, promotion of energy saving problem in Ukraine are projected in the baseline scenario.
The performance of a balanced financial policy is envisaged. Reforms towards simplifying taxation system, expansion of its base and achieving GDP re-distribution through the state budget up to an ultimate level of 40% of GDP is forecasted.
The increase of budget expences effectiveness, the reduction of dotations and capital transfers structure optimisation are envisaged in budget policy as well as the support of budget deficit at a minimal level (not more than 3.5% from GDP). Realization of money-credit policy should provide the achievement of money stabilization, support of credit system, stimulation of credits towards long-term investment as well as the support of productions, which provide a deep transformation of national mineral-raw resources and build-up the output of import replacing products and export potential of the country.
In correspondence with the forecast of the development of material production sectors in 2001-2005 according to optimistic assessment the accelerated development of metallurgy, chemical and petrochemical industry as well as machine building is envisaged.
Such character of structural shifts will be reflected to a certain extent on the increase of volumes and infrastructure of energy consumption. The change of economic conditions for sectors functioning is also projected, and first of all, the introduction of an active state regulation of energy resources consumption, realization of energy saving measures.
Acceleration of service sector development, in the first turn, due to the development of paid services of the financial economic sector, the increase of a specific weight of paid services in socio-oriented economic sectors, appearence of new types of services, connected with the expansion of informational exchange, etc., are envisaged.
According to optimistic projections of the national economy development positive changes will take place in the period forecasted due to a relative reduction of energy resources import and increase of the Ukrainian coal export. Under these conditions it is possible to achieve a positive net export (1% of GDP) till 2000 with its further growth up to 2% in 2005.
The performance of an active state policy regarding a stimulation of export production in Ukraine is forecasted. The analysis shows, that in the years of crisis the less production recession was marked in those sectors, which have an access to external trade markets. Under the limited domestic demand of some sectors' products it was export-oriented production which allowed to avoid their degradation. To regulate export production the forecast envisages the revision of production structure, active search of new external markets and restitution of lost ones, structural and technological rehabilitation of production. Mutual coordination of scientific-technical policy with the policy of currency, external economic and taxation-budget regulation should be provided.

Forecast show, that in 1998-2010 a real achievement of economic stabilization with a further development of the country economy is possible. This conclusion is based on economic potential for the development of a number of sectors (agriculture, metallurgy, machinery and equipment, light industry) as well as on the possibility of a gradual solution of energy supply problem in the country.
Activization of investment processes through the increase of a share of basic capital cumulation in a total volume of capital creation should be important for a forecasted period.
Country's withdrawal from crisis is possible only in conditions of the activization of a positive state influence on the production and social processes towards all-round stimulation of producers and strengthening a real social defence of population.

5.2 Overall mitigation potential

Two groups of mitigation measures were considered in mitigation analyses: policy instruments and technological options (Table 5–2).

Table 5–2. The assessments of mitigation options till 2015

	Annual GHG emissions reduction, Gg				*Cost ratio of the option (capital investment cumulative for the period) /Direct Benefit (annual)*	*Indirect economic impacts*		*Consistency with national environmental goals*		*Potential effective-ness of imple-mentation policies*	*Sustain-ability of options*	*Consistency with national development goals*	*Data availability for evaluation*	
Option	CO_2	CH_4	N_2O	*C*	*thousand dollars USA per Tg-CE*	*Increase in domestic employ-ment*	*Decrease in import payments*	*Reducing emissions of air pollutants*	*Effectiveness in limi-ting other environmen-tal impacts*				*Tecnology characte-rization*	*Cost of implemen-tation programs*
Energy consumption measurement	17114.3	0.383	0.161	4683.3	26.289	High	High	Medium	Low	High	High	High	High	Low
DSM	4315.78	0.097	0.041	1181.1	70.892	High	Medium	Medium	Low	High	High	High	High	Low
Industrial processes	1078	156	10.25	2054.0	100.553	Low	High	Medium	Medium	Medium	High	High	High	Low
Energy saving,	230671	5.167	2.17	63123.3	335.458	Low	High	High	Medium	Medium	High	High	High	Low
including														
cross sectoral:	59528	1.333	0.56	16289.9	120.934	Low	High	High	Medium	Medium	High	High	High	Low
efficiency lighting equipment	4836.65	0.108	0.046	1323.6	8.930	High	High	High	Medium	High	High	High	High	Low
motor drive systems improvement	26415.55	0.592	0.249	7228.7	17.305	High	High	High	Medium	High	High	High	High	Low
efficient combustion of poor fuel	1302.175	0.029	0.012	356.3	732.601	High	High	High	Medium	Low	High	High	High	Low
improvement of heat supply systems	10789.45	0.242	0.102	2952.6	260.880	Low	High	High	Medium	Medium	High	High	High	Low
utilization of secondary energy resources	12649.7	0.283	0.119	3461.6	199.604	Low	High	High	Medium	Medium	High	High	High	Low
sectoral:	168724.7	3.779	1.587	46171.6	414.938	Low	High	High	Medium	Medium	High	High	High	Low
energy saving in Fuel&Energy Complex,	35344.75	0.792	0.333	9672.2	581.395	Low	High	High	Medium	Low	High	High	High	Low
including:														
optimization of structure of	21578.9	0.483	0.203	5905.1	717.360	High	High	High	Medium	Low	High	High	High	Low

	Annual GHG emissions reduction, Gg				*Cost ratio of the option (capital investment cumulative for the period) /Direct Benefit (annual)*	*Indirect economic impacts*		*Consistency with national environmental goals*		*Potential effective-ness of imple-mentation policies*	*Sustain-ability of options*	*Consistency with national development goals*	*Data availability for evaluation*	
Option	CO_2	CH_4	N_2O	*C*	*thousand dollars USA per Tg-CE*	*Increase in domestic employ-ment*	*Decrease in import payments*	*Reducing emissions of air pollutants*	*Effectiveness in limi-ting other environmen-tal impacts*				*Tecnology characte-rization*	*Cost of implemen-tation programs*
generating capacities, technological improvements														
high efficiency gas supply system	2604.35	0.058	0.025	712.7	241.838	Low	High	High	Medium	Medium	High	High	High	Low
up-to-date technologies of coal production	2046.28	0.046	0.019	559.9	413.394	Low	High	High	Medium	Medium	High	High	High	Low
energy saving in industry,	76642.3	1.717	0.721	20973.2	422.654	Low	High	High	Medium	Medium	High	High	High	Low
including:														
energy saving in metallurgy	19346.6	0.433	0.182	5294.2	372.024	Low	High	High	Medium	Medium	High	High	High	Low
energy saving in mechanical engineering	6324.85	0.142	0.060	1730.8	483.793	Low	High	High	Medium	Medium	High	High	High	Low
energy saving in chemical industry	8557.15	0.192	0.081	2341.7	368.053	Low	High	High	Medium	Medium	High	High	High	Low
energy saving in constructing materials industry	6696.9	0.15	0.063	1832.6	180.050	Low	High	High	Medium	Medium	High	High	High	Low
energy saving in food industry	13393.8	0.3	0.126	3665.2	167.954	Low	High	High	Medium	Medium	High	High	High	Low
energy saving in others industrial sectors	22323	0.5	0.21	6108.7	666.667	Low	High	High	Medium	Low	High	High	High	Low
Energy saving in constructing sector	930.125	0.021	0.009	254.6	251.509	Low	High	High	Medium	Medium	High	High	High	Low

	Annual GHG emissions reduction, Gg				*Cost ratio of the option (capital investment cumulative for the period) /Direct Benefit (annual)*	*Indirect economic impacts*		*Consistency with national environmental goals*		*Potential effective-ness of imple-mentation policies*	*Sustain-ability of options*	*Consistency with national development goals*	*Data availability for evaluation*	
Option	CO_2	CH_4	N_2O	*C*	*thousand dollars USA per Tg-CE*	*Increase in domestic employ-ment*	*Decrease in import payments*	*Reducing emissions of air pollutants*	*Effectiveness in limi-ting other environmen-tal impacts*				*Tecnology characte-rization*	*Cost of implemen-tation programs*
Energy saving in agriculture	11161.5	0.25	0.105	3054.4	370.920	Low	High	High	Medium	Medium	High	High	High	Low
Energy saving in residential sector	24183.3	0.542	0.228	6617.8	115.354	Low	High	High	Medium	Medium	High	High	High	Low
Energy saving in transport sector	20462.8	0.458	0.193	5599.7	483.793	Low	High	High	Medium	Medium	High	High	High	Low
Implementation of 3 GW at NPPs	14882	0.333	0.14	4072.5	Uncertain	High	High	Low	Low	Low	High	High	High	Uncertain
Untraditional resources	42785.8	0.958	0.403	11708.4	715.308	Medium	High	High	Medium	Low	High	High	High	Low
Reducing methane emissions in coal mining	0	710		4066.4	82.163	Medium	Medium	Uncertain	Uncertain	High	High	High	High	Low
Shift from oil motor fuel to gas	1850	1.115	0.06	516.0	668.449	Low	Medium	High	Uncertain	Low	High	High	High	Low
Reduction of leaks in gas systems	0	1400	0	8018.2	0.595	Low	Medium	Medium	Uncertain	High	High	High	High	Low
Waste treatment	0	540	-0.9	3016.6	330.797	Medium	Low	Uncertain	Medium	Medium	High	High	High	Low
Installation of equipment for processing of waste water sediment	0	19	0	108.8	2985.075	Medium	Low	High	High	Low	High	High	High	Low
Set of measures for NOx abatement						Low	Low	Low	Medium	Uncertain	High	High	High	Low
Total	310241.3	2832.998	12.301	101876.6	312.5									

Policy instruments

State regulation of rational energy use in all sectors, including:

- legislation, supporting energy saving and environmental protection policies;
- standard regulations on fuel and energy consumption, GHG emissions etc.;
- fees, taxes, subsidies, prices, stimulating implementation of efficiency technologies and equipment;
- research, development and demonstration programs to improve and disseminate information;
- energy and environmental audit, R&D centers, information and personnel training centers, energy management at the enterprises, licensing requirements, patent rules, etc.;
- demand side management;
- energy consumption measurement.

This portfolio of policy instruments will promote sustainable development of Ukraine and lead to the restructuring of economy. A strong role of energy-intensive sectors (energy, metallurgy, heavy mechanical engineering, etc.) will not be continued under market conditions. Low energy use sectors, services and agriculture are favourable.

Technological options

Implementation of energy efficient technologies are the most important for reducing GHG emissions.

Cross-sectoral energy saving options: implementation of efficiency lighting, motor drive systems improvement, more efficient poor fuel combustion, improvement of the heat supply systems, utilization of secondary energy resources etc. Energy conservation assessment is 800 PJ with an investment of $ 2 billion.

Sectoral energy saving options:

The most effective measures are follows:

Energy Supply: technological and efficiency improvements in power sector, high efficiency gas supply system etc. Energy conservation assessment is 450-500 PJ with an investment of $ 5-6 billion.

Metallurgy: improvements in coke making, recycling of blast furnace, coke oven and converter gases, wide implementation of electric arc furnaces, decrease of output of the most energy intensive production etc. Energy conservation assessment is 240-280 PJ with an investment of around $ 2 billion.

Mechanical Engineering: implementation of efficiency technologies of metal processing, use of high quality raw materials etc. Energy conservation assessment is 75-90 PJ with an investment of $ 800-900 mln.

Chemical industry: improvement of the technologies of ammonia, calcium soda and phosphoric fertilizers production etc. Energy conservation assessment is 105-120 PJ with an investment of $ 825-925 mln.

Building materials industry: improvement of technological processes of cement, glass, brick, wall materials production, etc. Energy conservation assessment is 75-95 PJ with an investment of $ 320-350 mln.

Food industry: improvement of technological processes of sugar, spirit, vegetable oil production, etc. Energy conservation assessment is 170-190 PJ with an investment of $ 600-650 mln.

Construction sector: improvement of technological processes of concrete, cement, asphalt, brick production etc. Energy conservation assessment is 10-15 PJ with an investment of $ 60-70 mln.

Agriculture: reduction of a share of energy intensive plants, improvement of post-harvest drying and storage, switch to low carbon energy sources, etc. Energy conservation assessment is 140-160 PJ with an investment of $ 1-1.3 billion.

Residential sector: switch to energy sources/equipment with low-carbon emissions, improvement of insulation for existing and new building shells, shift to more efficiency household equipment, etc. Energy conservation assessment is 300-350 PJ with an investment of $ 750-850 mln.

Transport: transport demand management, improvement of vehicle technical efficiency, fuel switch, improvement of traffic flow, etc. Energy conservation assessment is 250-300 PJ with investment of $ 2.5-3 billion.

Fuel substitution: Increase share of nuclear fuel, renewable, secondary and non-traditional energy resources. Shift from coal and petroleum to natural gas, utilization of coalbed methane and biogas.

Reduction of losses in gas supply system. Replacement of high-bleed devices with pneumatic, pipeline leak mitigation, improved maintenance. Methane reduction potential is 2-2.2 billion m^3 with an investment of $ 4-6 mln.

Improvement of industrial processes, not related to energy saving. Investment assessment is approximately $ 200 mln.

Improvement of waste treatment. The integrated management of the wastes and at first place their reduction and construction of regional centers for their treatment and detoxication would provide annual utilization of 5.8-6.2 mln tons of wastes and require investments of approximately $ 1-1.1 billion.

Realization of such options will provide the annual energy saving at a level of 2000 - 1000-1100 PJ, 2005 - 1950-2100 PJ, 2010 - 3100-3200 PJ, 2015 - 4100-4200 PJ. These measures will require around $29-32 billion investments.

The differences for pessimistic and optimistic scenarios are generally in volumes of energy saving, which in optimistic variant will be approximately 10-12% higher, and in pessimistic one - 25-30% lower.

All these measures have a high degree of a governmental support, since they are included in the programs of the development of the economy and its sectors in Ukraine, adopted by the administrative bodies of the state, as well as in the draft documents, which at present are being under consideration of the Cabinet of Ministers, of the Parliament and the administration of the President of the country.

However the possibility of realization of these measures will to a great extent depend on the investments. If until the recent time a state budget had been considered as a major source of investments, then today it is clear, that the state can be not only a single source, but just a considerable source of investments. Therefore the problem of investments is being the main one.

That is why the analysis of measures effectiveness, which was carried on according to some criteria, where the criterion of a relative effectiveness played a major role, is of a considerable interest. It was determined as a relation of direct GHG emissions decrease to the necessary investments for their realization in particular measures. The executed ranging of measures according to this criterion shows, that measures, connected with the decrease of natural gas losses, with DSM, with the realization of cross-sectoral energy saving programs, are the most effective ones.

The implementation of non-traditional sources, optimization of the electric power and heat utilities, the sets for poor coal combustion, installation of constructions for the refining of wastewater silt at purification stations, are the most expensive measures for GHG emissions decrease from the economic view point.

However, it must be taken into consideration, that for a whole number of measures given the GHG emissions decrease is an indirect effect. Expedience of their realization is conditioned, as a rule, by other factors.

Realization of measures mentioned above will give a considerable social effect, first of all by the creation of new working places, for example in machinery and equipment sector, construction, energy saving management, etc. A total number of new working places according to evaluations of national experts on the level of 2010-2015 can make up to 250-300 thousand.

5.3 References

1. National Energy Program, 1996.
2. Program of Restructuring of Ukrainian Economy, 1995.
3. Comprehensive State Energy Conservation Program of Ukraine, 1996.
4. National Program of the Development of Mining and Smelting complex, 1995.
5. National Program of the Ukrainian Motor-car-construction Development, 1993.
6. National Program of Receptacles and Packing Materials Production, 1993.
7. National Program of the Development of Aluminum Production, 1993.
8. National Complex Program of the Development of Titanic Industry of Ukraine «Titanium of Ukraine», 1994.
9. Complex Program of the Development of Copper Production, its Alloys and Intermediate Goods «Copper of Ukraine», 1995.

6. PROJECTIONS OF GREENHOUSE GAS EMISSIONS AND REDUCTION POTENTIALS IN UKRAINE

6.1 Energy sector

In order to assess GHG emissions and mitigation options the following sectors and subsectors of economy were considered:

1) Fuel & Energy Complex (FEC) and subsectors:
   - Electric Power & Heat Supply
   - Coal Industry
   - Oil & Gas Industry
   - Oil Refining

   Electric Power & Heat Supply subsector fuel consumption was forecasted only for utilities supervised by Ministry of Energy of Ukraine. Heat and electric power generation by industrial and residential power units was taken into account in corresponding sectors, because of historical planning practice orientated not to functional but sectoral approach.
2) Industry and main subsectors:
   - Metallurgy
   - Chemical Industry
   - Machinery and Equipment
   - Building Materials Industry
   - Food Industry
   - Other Industrial Sectors
3) Construction Sector
4) Agriculture
5) Residential and Commercial Sector
6) Transport
7) Other Sectors of Economy

These sectors are selected as a result of historical planning practice and economic development forecasting together with the fact that these sectors are the main sources of GHG emissions.

A deep crisis of Ukrainian economy considerably complicates the assessment of future GHG emissions. It is extremely difficult to project the terms of economy stabilization, directions and rates of further economic development, up-to-date technologies implementation and energy efficiency improvement.

Also it is impossible to apply mathematical models and methodologies used in the developed countries and earlier used for planning development of Ukrainian economy including the regressive analysis, production functions and input - output models.

Accounting and iterative equilibrium models to forecast the development of economy and GHG emissions were used. Optimization models were applied to develop mitigation scenarios and to estimate mitigation options.

Coal, natural gas, coalbed methane, residual fuel oil, diesel oil, other oil products were considered as primary fuels. In metallurgy coke and coke gas, and in a residential sector coal briquettes and firewood, were taken into account.

As a basis for forecasting fuel for combustion national experts used National Programs of the development of Ukrainian economy, FEC, some sectors adopted or being under consideration by the Ukrainian Government (see Chapter 5).

While forecasting fuel combustion in sectors and subsectors (Table 6–1) mitigation options included in a baseline scenario were evaluated (see Chapter 5, [1]).

Table 6–1. Fuel combustion in baseline scenario, PJ

Fuel	*1990*	*2000*	*2005*	*2010*	*2015*
Gas*	4208	3099	3419	3727	4033
Fuel oil	834	471	508	536	536
Coal**	2634	2247	2348	2382	2508
Gasoline	497	371	405	445	506
Diesel oil	629	511	524	534	561
Others	444	376	354	399	408
Total	9246	6965	7558	8023	8552

* including natural, coke and oil refining gases etc.

** including coal, coke, coal briquettes etc.

The study results of projected GHG emissions are summarized in Table 6–2 and Figure 6-1.

Table 6–2. GHG emissions from fuel combustion in baseline scenario

Gas	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
CO_2, Gg	662633	402394	503528	541471	569791	605138
CO_2, Gg CE	180718	109744	137326	147674	155398	165038
CH_4, Gg	291.7	215.0	233.1	207.5	209.3	200.0
N_2O, Gg	4.9	3.5	4.2	4.4	4.5	4.8
Direct GHG emissions, Gg CE	182803	111271	139016	149234	156977	166589

Note: GWP factors for CO_2 - 1, for CH_4 - 21, for N_2O - 310 (IPCC, 1995)

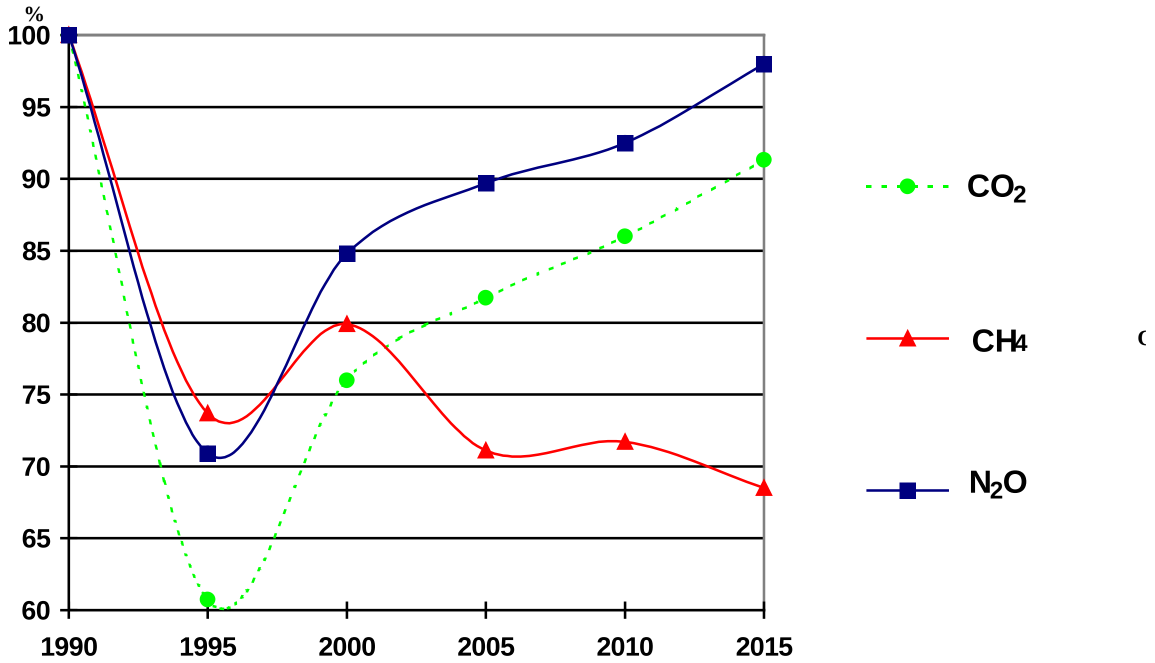

Figure 6-1. Trends of GHG emissions from fuel combustion in baseline scenario

As Table 6–2 shows GHG emissions from fuel combustion in a baseline scenario during the considered period are expected to be lower than levels of 1990.

In order to estimate prospective GHG emissions from industrial processes, production trends for chemical industry, metallurgy, building materials industry and other industrial sectors were forecasted.

GHG emissions trends from industrial processes are presented in Table 6–3.

Table 6–3. GHG emissions trends from industrial processes

Gas	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
CO_2, Gg	48815	22905	26514	27678	28225	29214
CO_2, Gg CE	13313	6247	7231	7549	7698	7967
CH_4, Gg	406.5	172.7	164.7	166.4	166.5	168.5
N_2O, Gg	23.0	7.1	22.5	25.8	25.9	26.0
Direct GHG emissions, Gg CE	17586	7836	10077	10683	10841	11130

Summary of projections of anthropogenic emissions of precursors is given at the Table 6–4.

Table 6–4. Summary of projections of anthropogenic emissions of precursors, Gg

	1990	*1995*	*2000*	*2005*	*2010*	*2015*
CO	7295	4046	5964	5958	6255	6607
NO_2	2043	1140	1564	1605	1613	1666
NMVOCs	1007	471	844	884	949	1043

6.2 Forestry

Ukraine is a country with a forestry deficit. Forest land fund totals 10 million hectares, 8.6 million hectares being covered by afforestation, which makes 14.3% of a country area (this is the forested lands index). For Ukraine the 20% average level is regarded as the optimal forested lands index (that is such one, when forests influence on the environment the most favorably, fulfill their functions effectively).

Total timber stock of Ukraine is estimated in 1.3 billion m^3. Evergreen plantations occupy 45% of a total area, including pine (Pinus silvestris L.) - 36%. Hard deciduous plantations total 41%, including oak (Quercus robur L.) and beech (Fagus sylvatica L.) - 33%.

Average growing-stock volume of forested area totals 4.0 m^3/hectar/yr and varies from 5.0 m^3/hectar/yr in the Ukrainian Carpathians up to 2.5 m^3/hectar/yr in steppe zone.

It is determined in the Ukrainian legislation (Forest Code), that forests of Ukraine carry out ecological functions predominantly and as a consequence have a limited exploitation importance.

According to the economic destination, sites and functions carried out, Ukrainian forests are divided into two groups.

The first group includes forests carrying out predominantly defense functions, forest reserves, plantations, having scientific and historical importance (including genetic reserves, etc.). The second group includes forests, having defense and limited exploitation importance. The area of the first group forests totals 5.1 million hectares or 52% of a forest fund.

All forests are a state property. 72% of them are in a constant use of state forestry enterprises, the rest being transferred to agricultural enterprises for use (24%), residential and other organizations (4%).

Five natural zones are distinguished in Ukraine, each of them having its own peculiarities in forestry (Figure 6-2).

Figure 6-2. Natural zones in Ukraine

The increase of forested lands of Ukraine will allow to improve in general the unfavorable ecological situation, since a forest is a powerful natural factor, which influences the climate, soils, surface drainage forming, produces oxygen, filtrates air and water, prevents floods, etc.

Ukraine has land areas not used in agriculture and available for afforestation (not less than 500 thousands hectares). Shelterbelts plantations were created only for 50% of agricultural areas. Intensity of erosion processes still remains a considerable one. Today legislation does not stimulate wide croplands shelterbelts planting. Besides the importance of agroforest-melioration effect of shelterbelts is misjudged by farmers.

Plantations' withering is one of the serious problems, essentially influencing on forests productivity for the last decade. Any scientific conception to explain the decrease of forest plantations sustainability to unfavorable factors does not exist yet. The withering of oak, pine and other plantations is periodically marked in various regions of Ukraine.

Methods, proposed by IPCC and national experts [2, 3], were used for the assessment of GHG emissions in forestry.

Baseline and mitigation scenarios of the forestry development in Ukraine were developed.

"Program of the Development of Forestry and Forest Industry in Ukraine for the Period till 2015" and "National Program of the Development of Agricultural Production in Ukraine for 1996-2005" were put into the basis of a baseline scenario. The extensive development (increasing forest plantations) and only inconsiderably qualitative improvement of forests, are established in this scenario, taking into account a difficult financial situation of the state. Fire control measures and measures of fight with forest vermin and diseases are planned with inconsiderable qualitative and quantitative shifts.

In baseline scenario natural process of a slow reforestation without creating artificial plantations is envisaged on lands in the abandonment zone of the Chernobyl NPP.

The data of the National Academy of Sciences of Ukraine, given in the "Program of the Development of Forestry and Forest Industry in Ukraine for the Period till 2015", taking into account not only the extensive increase of forest plantations areas, but a considerable qualitative improvement of a forest fund, were put into the basis of a mitigation scenario. In this scenario the indices, put in the project of «Program of Liquidation of ChNPP Accident Consequences for 1996-2000» and scientific elaboration of the Ukrainian Research Institute of Forestry and Agrosilviculture (UkrRIFA) and the Ukrainian Scientific-Research Institute of Mountain Forestry (UkrSRIMF), were used.

Compared to the baseline scenario the mitigation scenario takes into account the following factors:

- Scientific optimization of volumes and structure of forest harvesting.
- Afforestation of eroded lands in ravines, washes, sands.
- The increase of plantations of shelterbelts forests.
- The creation of plantations of forest species (including fast growing) to receive forest products of long-term use.
- Afforestation of lands, contaminated as a result of accident at the Chernobyl NPP and not used in agriculture.
- The increase of forest plantations biomass productivity due to the use of a genetically improved species in forest plantations.
- The optimal increase of regions under forests in Ukraine.
- Improvement of forests protection from fires (gradual 70% decrease of average annual level of fires from the level of 1986-1994), the increase of forests protection effectiveness from vermin and diseases (resulted in the growth of biomass increment).

Initial data and balance of carbon dioxide emissions/uptakes in scenarios are given in Table 6–5. Factors presented in Table 6–5 are aggregated ones. For the forest plantations, managed forest and urban forests these factors are calculated by multiplying annual growth rate in dry matter, carbon fraction in dry matter and CO_2/C ratio with account of shares of different species groups [2, 3]. Methodology of other factors estimation is developed by national experts and explained in details in Ukrainian Country Study on Climate Change [2, 3].

Table 6–5. Carbon Dioxide Emissions/Uptakes in Forestry in Ukraine

		Baseline scenario				*Mitigation scenario*			
	1995	*2000*	*2005*	*2010*	*2015*	*2000*	*2005*	*2010*	*2015*
Forest plantations, thousand hectares	42.5	45.3	46.3	50.0	53.0	80.0	101.0	117.0	129.0
Factor, t C/hectare	2.31	2.31	2.31	2.31	2.31	2.33	2.37	2.43	2.53
CO_2 Uptake, Gg	359	385	392	425	447	682	879	1041	1195
Managed forest, million hectares	8.78	8.868	8.98	9.106	9.261	9.0	9.32	9.77	10.31
Factor, t C/hectare	2.37	2.40	2.44	2.47	2.51	2.44	2.53	2.65	2.80
CO_2 Uptake, Gg	76298	78038	80341	82470	85232	80520	86460	94930	105849
Urban forests, thousand hectares	95	96	97	98	99	97.5	100	104	108
Factor, t C/hectare	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
CO_2 Uptake, Gg	941	950	960	970	979	964	990	1030	1071
Forest harvests, million m^3	13.1	13.1	13.5	13.5	14.2	15.1	17.0	19.0	21.0
Factor, t C/m^3	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
CO_2 Emissions, Gg	12969	12969	13365	13365	14058	14949	16830	18810	20790
Abandonment of lands, thousand hectares	54.0	51.5	49.0	46.5	44.0	50.0	30.0	5.0	0
Factor, t C/hectare	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
CO_2 Uptake, Gg	396	378	359	341	323	367	220	37	0
Forest fires, thousand hectares	4.2	4.2	4.2	4.2	4.2	2.1	1.8	1.5	1.2
Factor, t C/hectare	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16
CO_2 Emissions, Gg	139	139	139	139	139	70	59	51	40
Forest rate	14.5	14.7	14.9	15.1	15.3	14.9	15.4	16.2	17.1
Net CO_2 Uptake, Gg	**64886**	**66643**	**68548**	**70702**	**72784**	**67514**	**71660**	**78177**	**87285**

Comparison of emissions/uptakes balances in baseline and mitigation scenarios (Figure 6-3) evidences that the increase of CO_2 uptakes makes about 11 800 Gg in 2015, additional expenses in the mitigation scenario of about $1220 million taking place.

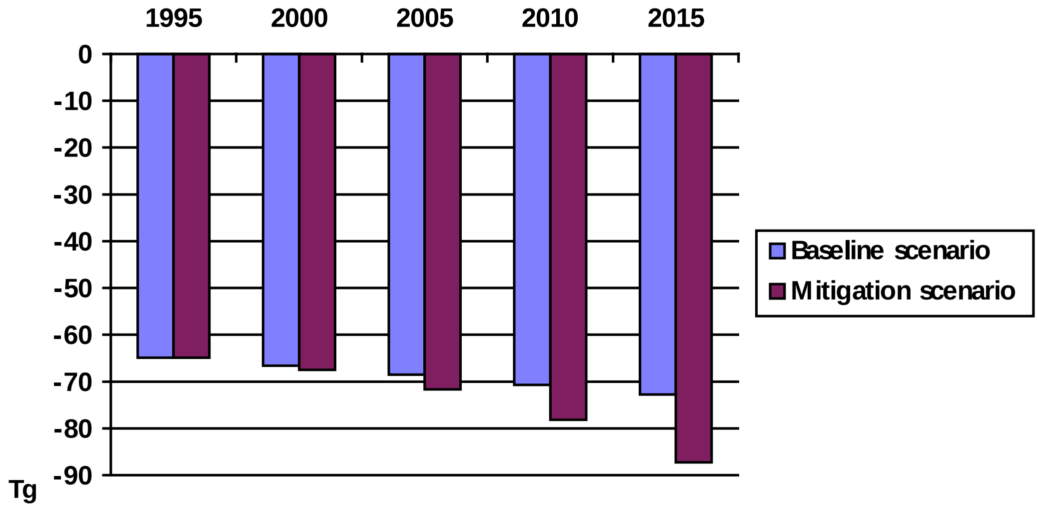

Figure 6-3.Emissions/removals balances in baseline and mitigation scenarios

6.3 Carbon dioxide emissions assessment

Projections of anthropogenic emissions/uptakes of CO_2 from fuel combustion, industrial processes and in forestry were considered in previous subchapters.

Summary of CO_2 emissions is presented in the Table 6–6.

Table 6–6. Summary of projections of anthropogenic emissions of CO_2, Gg

	1990	*1995*	*2000*	*2005*	*2010*	*2015*
Fuel combustion: energy and transformation industries	191296	135447	151037	173122	178539	189474
Fuel combustion: industry	220202	117182	149722	159284	168893	179562
Fuel combustion: construction	3890	4615	3462	3646	3845	4431
Fuel combustion: residential	97506	78860	91649	91317	96818	100047
Fuel combustion: agriculture	35611	22721	32255	34044	36085	37908
Fuel combustion: transport	49831	17922	41060	45985	52749	61866
Fuel combustion: other	64296	25648	34343	34072	32861	31848
Industrial processes	48815	22905	26514	27678	28225	29214
Total	711447	425300	530042	569148	598015	634350

The high level of uncertainty of the future economic development and its functioning is essential note of all countries with the transition economy including Ukraine. Consequently the projected fuel combustion, industrial production and, hence, emissions vary considerably.

Therefore side by side with the baseline scenario pessimistic and optimistic scenarios have been developed. Variations of CO_2 emissions in these scenarios determine the uncertainty range (Table 6–7).

Table 6–7. The projected CO_2 emissions in the various scenarios of economic development, Gg

Scenario/Category	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
Baseline						
Fuel combustion	662632	402394	503528	541471	569791	605138
Industrial processes	48815	22905	26514	27678	28225	29214
Total	711447	425299	530042	569149	598016	634352
Pessimistic						
Fuel combustion	662632	402394	466207	494388	517417	541348
Industrial processes	48815	22905	25359	26092	26622	27778
Total	711447	425299	491566	520480	544039	569126

Optimistic						
Fuel combustion	662632	402394	541725	599926	649712	692425
Industrial processes	48815	22905	27360	30708	31602	32107
Total	711447	425299	569085	630634	681314	724532

As a Table 6–7 shows the future direct CO_2 emissions are expected to exceed the 1990 level only in optimistic scenario in 2015 and this excess will total approximately 1%.

6.4 Agriculture

Livestock, rice cultivation and the use of nitric fertilizers were considered as the emissions sources in the Ukrainian agriculture. GHG emissions factors were taken in correspondence with IPCC recommendations. Emissions assessment was carried out for three scenarios of the economic development of Ukraine - optimistic, pessimistic and baseline. Officially ratified documents, where the problems of the economic and agricultural development of the country are considered, were used to form these scenarios.
In accordance with the baseline forecast, livestock and poultry trends in the country, and rice cultivation areas are given in Table 6–8. GHG emissions in agriculture in the baseline scenario are presented in Table 6–9.

Table 6–8. Livestock and poultry trends, and rice cultivation areas in Ukraine

	1990	*1995*	*2000*	*2005*	*2010*	*2015*
Dairy cattle, thousand of heads	8 528	7 818	6 800	6 600	6 400	6 200
Beef cattle, thousand of heads	16 667	11 152	13 200	16 400	17 599	18 800
Sheep and goats, thousand of heads	9 003	3 200	4 000	5 010	5 996	7 000
Horses, thousand of heads	754	740	800	897	999	1 300
Swine, thousand of heads	19 950	13 250	15 500	19 000	19 667	20 000
Poultry, million of heads	255	146	190	205	215	230
Rice cultivation areas, hectares	0.0281	0.02	0.023	0.025	0.030	0.040

Table 6–9. Projected methane and nitrous oxide emissions in agriculture

Emission sources	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
CH_4 emissions, Gg						
Livestock	2240	1698	1763	2001	2077	2154
Rice	15.17	10.79	12.41	13.51	16.19	21.59
Total	2255.17	1708.79	1775.41	2014.51	2093.19	2175.59
N_2O emissions, Gg						
Nitric fertilizers	10.2	5.12	7.6	8.5	9.4	10.15
Direct GHG emission , Gg CE	13777	10227	10814	12259	12782	13321

As it is seen from Table 6–9, future GHG emissions in agriculture in the baseline scenario are expected to be lower, than the emission levels of 1990.
Uncertainty analysis in this category was carried out on the basis of forecasting cattle, poultry, areas under rice and nitric fertilizers use in pessimistic and optimistic scenarios of the economic development. Variations of methane and nitrous oxide emissions in these scenarios determine the uncertainty range (Table 6–10).
As it is seen from Table 6–10, the emission levels in 2015 are expected to exceed the level of 1990 only in the optimistic scenario of the economic development. However, this excess is comparatively small and totals approximately 1.33% for CH_4 and 8.3% for N_2O.

Table 6–10. Projected methane and nitrous oxide emissions in agriculture in various scenarios

Scenario	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
CH_4 emissions, Gg						
Pessimistic	2255	1709	1771	1848	1924	2008
Baseline	2255	1709	1775	2014	2093	2175
Optimistic	2255	1709	1801	1981	2135	2285
N_2O emissions, Gg						
Pessimistic	10.2	5.12	6.2	7.1	7.9	8.5
Baseline	10.2	5.12	7.6	8.5	9.4	10.15
Optimistic	10.2	5.12	8.0	9.1	10.1	11.05

The assessment of mitigation options in agriculture are carried on by national and US experts. It is one of series of country studies funded by the United States Environmental Protection Agency (EPA), and was prepared by Winrock International Institute for Agricultural Development for the Global Change Division of EPA. The main attention is paid to the livestock production, especially to cattle industry in Ukraine, a major livestock-producing country. The first steps of this work were reflected in Report [4]. The objectives of the study were to compile information and prepare recommendations regarding the livestock of Ukraine and the potential for reducing methane emissions to: (1) sensitize decision-makers in government, science and agriculture; (2) prepare for a pilot program to demonstrate strategies to reduce the methane emissions; (3) demonstrate the need to increase livestock productivity in Ukraine; and (4) stimulate development of the livestock sector in Ukraine.

The results of this study and interactions with Ukrainian institutions and individuals clearly identify concepts and ideas to reduce methane emissions in cattle while also increasing product output per feed resource input. Most of these have been previously discussed by scientists (World Bank, 1993), including Ukrainian and Russian experts. The economic structure driving producer decisions is changing, and are expected to allow and encourage economically sound and efficient resource use for milk and meat production.

The core of recommendations for mitigating methane emissions in Ukraine is as follows:

1. Improve production efficiency. Efficiency is achieved by increasing milk and meat production per cow, which requires better quality feeds and often more feed per cow. However, the amount of feed units needed to produce a given amount of milk can be reduced as fewer cows are necessary. Meeting the maintenance requirement of the total herd will require a smaller proportion of feed in relation to that needed for milk production. Increasing the production efficiency would result in fewer cows, requiring less total feed to produce the same amount of milk. Increasing the daily weight gain decreases the time needed to bring animals to slaughter weight. Reducing the number of cows and the feed requirement would make more land area available to produce food crops for consumption and export, reduce the labor required per kg of milk and meat produced, and reduce capital expenditures for buildings, equipment, and so forth, while increasing profit.
2. Improve forage quality. Grasses and legumes should be harvested at early bloom stage, thus increasing digestible energy by 10% to 15% and digestible protein by 30% to 50%.
3. Improve crop production. High yielding and drought resistant varieties of maize, soybean, rapeseed, lucerne, and other crops for livestock feed should be developed to produce under Ukrainian conditions. Modern harvesting machines and repair parts are necessary for timely harvest of forages and grains. Storage losses of hay and grain can be reduced by providing adequate on-farm storage facilities.
4. Improve pastures. Improved pastures and pasture rotation practices are not used extensively in Ukraine. Many pastures are overgrazed. Pastures seeded to a mixture of grass and legumes and properly managed and fertilized could provide high quality feed for dairy cows and heifers during about 5 month of the year.
5. Provide adequate protein, minerals, and vitamines. Improving the quality of forages could be one of the most cost-effective ways to increase protein. An adequate supply of minerals and vitamins is also needed to balance the diets. If domestic sources are not available, these nutrients should be imported.
6. Reduce milk fed to calves. If the price of milk increases and it becomes more economic to feed grain, dry calf starter should replace milk at an earlier age.
7. Provide veterinary supplies. Since few pharmaceuticals are produced in Ukraine, arrangements should be made to import vaccines, antibiotics, and other drugs needed to treat and prevent diseases and parasites of livestock.
8. Install modern milking equipment.
9. Increase the genetic potential. Better methods of production record keeping and sire selection are necessary so that genetically superior animals are used by the artificial insemination centers.
10. Assist private farmers. There is general agreement that independent, privately owned and operated farms are more efficient than state and collective farms.
11. Use of bovine somatotropin. Approximately 12% increased milk production and a 9% decrease in methane output can be immediately achieved by the use of bovine somatotropin.
12. Increase research and education.

6.5 Methane Emissions Assessment

Methane emissions and the analysis of mitigation measures were estimated for the production, transportation, refining and storage of fossil fuel, for solid wastes and wastewater. Emissions from fuel combustion and in agriculture were considered in corresponding categories.

In order to assess fugitive emissions from fuels, production, storage, refining, transportation of fossil fuels and emission factors for three scenarios of the economic development were forecasted.

Fuel production, storage, refining and transportation for the baseline scenario were projected on the basis of National Energy Program of Ukraine and the programs of the development of separate FEC sectors.

While projecting methane emission factors the following matters, caused their considerable future decrease, were taken into account in this category of emission sources.

A considerable share of CH_4 emission is connected with the extremely unsatisfactory exploitation of gas sector, especially in end-use consumers. The reduction of gas losses does not require considerable investment and in the prospective emissions factors are expected to decrease essentially.

Side by side with this, the introduction of up-to-date technologies of oil and gas production should provide the decrease of emission factors to the level of the developed countries.
One of the main tasks, which is put by the Government, is to increase the share of utilized methane on existing mines and to implement preliminary degasation of mine fields, destined for a new construction and reconstruction. This will allow to decrease methane emission factors per ton of produced coal. Hence the emissions in new mines will be considerably lower, than in the old ones.
Methane emission factors in this category are given in Table 6–11, and projections of fuel production, transportation, refining and storage for the baseline scenario - in Table 6–12.

Table 6–11. Methane emission factors trends

Category	1990	1995	2000	2005	2010	2015
Gas production, Gg/billion m^3	25.7	25	20	15	12.5	10
Gas transportation and storage, Gg/billion m^3	18.12	18.12	18	15	12	8
Coal mining and Post-mining activity (new mines), Gg/million t	-	-	12.5	10	9	8.5
Coal mining and Post-mining (old mines), Gg/million t	17	16.9	16	15.5	14.5	13.5
Oil production, Gg/million t	0.1868	0.1868	0.186	0.175	0.17	0.15
Oil refining, Gg/million t	0.04146	0.04146	0.04146	0.04146	0.04146	0.04146
Oil storage, Gg/million t	0.00746	0.00746	0.00746	0.00746	0.00746	0.00746

Table 6–12. Fuel production, transportation, refining, storage and methane emissions trends

	1990	1995	2000	2005	2010	2015
Gas production, billion m^3	28.1	18.2	22	33.55	35.3	35
Gas transportation and storage, billion m^3	149	120	135	125	120	115
Coal mining and Post-mining activity (new mines), million t	0	0	10.155	30.86	44.06	62.66
Coal mining and Post-mining activity (old mines), million t	164.8	83.6	142.045	126.64	125.94	114.84
Oil production, million t	5.3	4.03	4.04	5.7	6.6	6.6
Oil refining, million t	58.1	15.7	47	47	47	49
Oil storage, million t	58.1	15.7	47	47	47	49
Methane emissions, Gg	6227	4044	5273	4653	4107	3356

Methane emissions in this category are projected to considerably decrease and in 2015 total 54% compared to 1990.
In the category "Wastes" municipal solid waste (MSW), municipal and industrial wastewater were taken into account.
To assess methane emissions from MSW the volumes of their generation, processing at waste incineration plants and storage on landfills (see Table 6–13) were forecasted, and to assess emissions from wastewater a number of population and wastewater in industrial sectors were projected.

Table 6–13. Municipal Solid Waste generation, storage and incineration trends, million t

	1990	1995	2000	2005	2010	2015
Annual MSW generation	11	11.8	12.87	14.04	15.31	16.69
MSW landfilled	10.12	11	10.17	9.84	9.61	8.99
MSW incinerated	0.88	0.8	2.7	4.2	5.7	7.7

The implementation of new solid waste treating facilities is the main mitigation measure, allowing to reduce the storage of MSW on landfills and methane emissions, approximately by 530-550 Gg.
The enlarged introduction of technologies (capacity is above 100 thousand of m^3 of wastewater per day) of sediment anaerobic fermentation in methane tanks is planned, that will allow to increase methane recuperation during wastewater refining from 6.24 Gg in 1990 up to 17.5-18.9 Gg in 2015. Methane emissions trends from municipal and industrial wastewater are presented in Table 6–14.

Table 6–14. Methane emissions trends from municipal and industrial wastewater, Gg

	1990	1995	2000	2005	2010	2015
Municipal wastewater	34.46	34.34	31.71	30.85	29.89	28.16
Industrial wastewater	14.07	11.67	14.94	17.44	20.22	22.32
Total	48.53	46.01	46.65	48.29	50.11	50.48

Total methane emissions (Table 6–15) are expected to considerably decrease and on the level of 2015 are 34% lower than the level of 1990.

Table 6–15. Summary of projections of anthropogenic emissions of CH_4,Gg

	1990	1995	2000	2005	2010	2015
Fuel combustion	292	215	233	208	209	200
Fugitive emissions from fuels	6227	4044	5273	4653	4107	3356
Industrial processes: Iron and Steel	333	98	104	104	104	105
Industrial processes: Food	68	71	57	58	57	58
Industrial processes: Construction	5	3	4	5	5	6
Livestock	2240	1700	1764	2001	2077	2154
Rice cultivation	15	11	12	13	16	22
Waste	934	1009	937	909	891	837
Total	10115	7150	8383	7951	7467	6738

Variations of nitrous oxide emissions in optimistic and pessimistic scenarios determine the uncertainty range (Table 6–16). In each scenario of the economic development nitrous oxide emissions are projected to be higher compared to 1990 due to increasing nitric and adipic acids production.

Table 6–16. Nitrous oxide emissions in various scenarios, Gg

Source	1990	1995	2000	2005	2010	2015
Baseline						
Fuel combustion	4.9	3.5	4.0	4.4	4.5	4.8
Industrial processes	23.0	7.1	22.5	25.8	26.0	26.1
Agriculture	10.2	5.1	7.6	8.5	9.4	10.2
Waste	0.13	0.12	0.41	0.63	0.86	1.2
Total	38.23	15.82	34.51	39.33	40.76	42.3
Pessimistic						
Fuel combustion	4.9	3.5	3.9	4.1	4.2	4.4
Industrial processes	23.0	7.1	22.3	24.0	24.2	24.4
Agriculture	10.2	5.1	6.2	7.1	7.9	8.5
Waste	0.13	0.12	0.33	0.48	0.78	1.01
Total	38.23	15.82	32.73	35.68	37.08	38.31
Optimistic						
Fuel combustion	4.9	3.5	4.4	4.9	5.1	5.4
Industrial processes	23.0	7.1	24.1	27.4	27.6	27.7
Agriculture	10.2	5.1	8.0	9.1	10.1	11.1
Waste	0.13	0.12	0.48	0.71	1.01	1.31
Total	38.23	15.82	36.98	42.11	43.81	45.51

6.6 Nitrous oxide emissions assessment

Projections of anthropogenic N_2O emissions from fuel combustion, industrial processes and agriculture were considered in previous subchapters. The IPCC Methodology [6, 18] and waste incineration forecast were used to assess N_2O emissions in the category "Waste".

Summary of projections of anthropogenic emissions of N_2O is presented in the Table 6–17. The increase of relative share of category "Waste" in the total emissions is caused by implementation of new waste incinerated facilities.

Table 6–17. Summary of projections of anthropogenic emissions of N_2O, Gg

	1990	1995	2000	2005	2010	2015
Transport	0.4	0.2	0.2	0.2	0.2	0.2
Other energy sources	4.5	3.3	4.0	4.2	4.3	4.6
Industrial processes	23	7	22.5	25.8	26.0	26.1
Agricultural soils	10.2	5.1	7.6	8.5	9.4	10.2
Waste	0.1	0.1	0.4	0.6	0.9	1.2
Total	38.2	15.7	34.7	39.3	40.8	42.3

Variations of nitrous oxide emissions in optimistic and pessimistic scenarios determine the uncertainty range (Table 6–18). In each scenario of the economic development nitrous oxide emissions are projected to be higher compared to 1990 largely due to increasing nitric and adipic acids production.

Table 6–19. Nitrous oxide emissions in various scenarios, Gg

Source	1990	1995	2000	2005	2010	2015
Baseline						
Fuel combustion	4.9	3.5	4.0	4.4	4.5	4.8
Industrial processes	23.0	7.1	22.5	25.8	26.0	26.1
Agriculture	10.2	5.1	7.6	8.5	9.4	10.2
Waste	0.13	0.12	0.41	0.63	0.86	1.20
Total	38.23	15.82	34.51	39.33	40.76	42.30
Pessimistic						
Fuel combustion	4.9	3.5	3.9	4.1	4.2	4.4
Industrial processes	23.0	7.1	22.3	24.0	24.2	24.4
Agriculture	10.2	5.1	6.2	7.1	7.9	8.5
Waste	0.13	0.12	0.33	0.48	0.78	1.01
Total	38.23	15.82	32.73	35.68	37.08	38.31
Optimistic						
Fuel combustion	4.9	3.5	4.4	4.9	5.1	5.4
Industrial processes	23.0	7.1	24.1	27.4	27.6	27.7
Agriculture	10.2	5.1	8.0	9.1	10.1	11.1
Waste	0.13	0.12	0.48	0.71	1.01	1.31
Total	38.23	15.82	36.98	42.11	43.81	45.51

6.7 Differences between Estimates in the Mitigation Measures Analysis and Inventory

Estimates for direct GHG emissions are slightly different from the National Inventory reported in Chapter 4 of this report. The difference between the assessments of indirect greenhouse gases is more essential.
The largest difference is due to updating of recent Guidelines from the Intergovernmental Panel on Climate Change. Other differences not reflected in Chapter 4 include updates in sources list (non-energy emissions in food sector, metallurgy, chemistry and construction), and improvements in fossil fuel emission coefficients.
Because of these differences, the 1990 Inventory values reported in Chapter 4 cannot be compared to projections of future Ukrainian emissions presented in this chapter to estimate changes in emission levels over time. However, each chapter is internally consistent.

6.8 Summary of GHG Emissions Projections

In the future direct GHG emissions are projected to be lower than the emissions of 1990 in any scenario of the economic development, despite the essential growth of GDP in a baseline and especially in optimistic scenarios of the economic development of Ukraine. This is supposed to be achieved by the whole set of measures for GHG emissions decrease and the increase of CO_2 uptakes in the Forestry.
In the baseline scenario it is projected to implement mitigation measures with overall potential of 100 000 Gg CE and therefore emissions at the level of 2015 will be 45889 Gg CE less than in 1990.
GHG emissions and removals trends are given in Table 6–20 for the baseline scenario.

Table 6–20. Total GHG emissions/removals in the baseline scenario

	1990	1995	2000	2005	2010	2015
Direct GHG emissions						
CO_2, Gg	711447	425299	530042	569149	598016	634352
CO_2, Gg CE	194031	115991	144557	155222	163095	173005
CH_4, Gg	10115	7150	8383	7951	7467	6738
N_2O, Gg	38.2	15.7	34.7	39.3	40.8	42.3
Total, Gg CE	255192	158268	195503	204082	209310	215172
Total, % compared to 1990	100	62.02	76.61	79.97	82.02	84.32
CO_2 uptakes in forestry						
CO_2 uptakes, Gg	-51976	-64886	-66643	-68548	-70702	-72784
CO_2 uptakes, Gg CE	-14175	-17696	-18175	-18695	-19282	-19850

Net						
CO_2, Gg	659471	360413	463399	500601	527314	561568
Total, Gg CE	241017	140572	177328	185387	190028	195322
CO_2, % compared to 1990	100	58.32	73.57	76.92	78.84	81.04

In optimistic scenario of the economic development, the net GHG emission levels in 2015 will total above 220 Tg CE, that is approximately 10.7% lower than in 1990.
In pessimistic scenario net GHG emissions on the level of 2015 will total above 180 Tg CE or about 73% from the level of 1990.
A very wide range of change of indices, characterizing the future economic development and expected emission levels is connected with a very high grade of uncertainty of future development of Ukrainian economy (Table 6–21).

Table 6–22. Ranges of fuel consumption and GHG emissions in 2015

	Pessimistic scenario	*Optimistic scenario*	*Range*	*Average deviation, %*
Fuel, PJ	7596.4	9787.2	2190.8	12.8
Direct GHG Emissions, Tg CE	195.2	245.4	50. 2	11.5
Sinks in Forestry, Tg CE	-19.9	-23.9	-4.0	9.1
Net GHG Emissions, Tg CE	175.3	221.5	46.2	11.6

6.9 References

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7. VULNERABILITY AND ADAPTATION ASSESSMENT IN UKRAINE

It is a matter of common knowledge that climate conditions have influenced human life and activity from the mankind's early days. It is evident that understanding of climate change system and its interaction with human activities can result in more efficient economic and social decision.

Given the country's unstable economy and critical ecological problems, the consequences of climate change in Ukraine could be serious. The results of scientific research during the last few years show that climate change in Ukraine has significant impacts on agriculture, forestry, water and coastal resources.

7.1 Climate change scenarios

To assess vulnerability of Ukrainian natural resources and economic sectors General Circulation Models (GCMs) outputs submitted by National Center for Atmospheric Research (NCAR) were used. There were considered the following models: the Goddard Institute for Space Studies (GISS) model, the Geophysical Fluid Dynamics Laboratory (GFDL) model, the Canadian Climate Center Model (CCCM), the United Kingdom Meteorological Office (UKMO) model [1]. These outputs are related to equilibrium conditions, that is they describe climate conditions at effective doubling of CO_2 in the atmosphere. Transient simulation represent climate conditions more realistically. These scenarios are run by assuming a steady increase in CO_2 concentrations (by 1% per year). In such conditions there is a possibility to trace climate system inertia, that is a natural lag of its reaction behind a change of greenhouse gases concentration in the atmosphere. Considering the above, an attempt was made to use GFDL and Max-Plank Institute in Hamburg (MPI) models outputs for transient condition.

Since no one of the considered models reflects regional climate features, the approach including the following steps was used to create climate change scenarios for Ukraine:

- interpolation of models outputs obtained for grid boxes into grid points, that is meteorological stations sites;
- evaluation of differences between temperatures under $2xCO_2$ and $1xCO_2$ conditions for each grid point and their addition to actual temperatures;
- assessment of ratios of precipitation under $2xCO_2$ and $1xCO_2$ conditions for each grid point and their multiplication by actual precipitation [2].

7.2 Water Resources Sector

Dnieper is the main water thoroughfare of Ukraine. At present, management of water resources of Dnieper basin as a main basin in Ukraine is implemented through numerous ponds and water reservoirs, located at its inflows and within river-bed, as well as through network of canals through which Dnieper water is fed to draught regions of Ukraine.

Observance of interests of all water consumers and rational use of water resources is stipulated by the Regulations of Operation for Dnieper Cascade Water Reservoirs (RODCWR) (Ministry for Water Management of Ukraine, 1981, Kyiv), as well as by Interagency Commission on Establishment of Water Reservoirs Operating Regimes.

In dependence on state of water reservoir filling, schedules of operating foresee 4 zones.

1st zone — zone of full provision. All consumers are provided with water without restrictions.

2nd zone — zone of economic consumption. All water consumers are provided with water in accordance with norms. Restrictions of auxiliary needs are introduced.

3d zone — zone of strict water saving, when water reservoirs are being drawn down below navigation drawdown level not more that 1 m. Restriction for irrigation systems and for auxiliary needs of industry are introduced. River transportation is put into navigation duty with draught that does not exceed 2.6 m. Ecological passing may be curtailed to 300 m^3/s for short periods. Upon that everyday inspection of water quality is established.

4th zone — zone of all consumers' restriction. To provide for needs of inhabitants, limits and schedules for strict water supply are established.

Analysis of existing policy of water resource management gives all reasons to assume that under all considered scenarios of future climate change existing RODCWR may be used, since these Regulations were elaborated for various states of Dnieper water content [3,6]. With that, needs of various sectors of the national economy are arranged to be met together, and the Interagency Commission may promptly correct operating regime of water reservoir in each particular case.

In cases of extreme water level lowering the following measures could be considered as adaptation ones:

- an increase of reservoirs usable storage, that is elevation of normal afflux horizons and lowering of drawdown level;
- construction of Dnieper-Bug hydro-junction in the Dnieper mouth.

However, the measures above are rather expensive, and there will be need in water use restriction when water level is low.

Decrease of power production by Cascade of Dnieper HPPs will lead to the necessity of searching alternative ways to cover peak loads in the power system.

Adaptation measures of river transportation to insufficient provision of necessary navigable depths in Dnieper for the most ‘unfavorable’ climate change scenario may be as follows:

- 1st version - transferring all passengers and load traffics to railway transport. This way, however, is not beneficial, since it is rather expensive and, besides, it ‘paralyses’ tremendous capital investments into navigation, harbors and distorts seriously infrastructure formed to date.
- 2nd version - renewal of navigation on account of creation of necessary navigable depths (3.2-3.9 m). In this case, bottom-deepening works are necessary to be carried out. Overall cost of works to be fulfilled for guaranteed navigation will be $140-160 million.

For ‘unfavorable’ climate change scenario, when water content of Dnieper may be insufficient to meet demands for irrigation, it may be advised to reduce areas of irrigated land and, consequently, change structure of crop areas in favor of drought-resistant crops.

Under climate change scenarios leading to decreased Dnieper water content, quality deterioration of surface waters may become possible. Therefore, bearing in mind present high level of Dnieper water contamination, it is recommended to use in the nearest future underground waters of deep water horizons to meet demands for drinking water.

7.3 Coastal Resources Sector

Erosion of coast of the Black and Azov Seas causes serious social problems in coastal regions due to destruction of housings, numerous resort bases, sanatorium, mud hospitals, industrial enterprises and arable lands.

Table 7–1 presents data on land losses under different scenarios of sea level rise.

Table 7–1. Land losses under various sea level rise scenarios

Coastal zone	*2050*		*2100*	
	22 cm	*46 cm*	*66 cm*	*115 cm*
Prychernomorje (Black Sea side)				
Erosion	780	1110	1340	2360
Flooding	-	270	410	1600
Firths				
Erosion	365	585	660	1580
Flooding	-	900	1750	4800
Pryazovje (Azov Sea side)				
Erosion	1400	1800	2300	3500
Flooding	-	-	30	100
Crimea				
Erosion	1350	1730	2100	2800
Flooding	-	110	3800	12500
TOTAL				
Erosion	3895	5225	6400	9840
Flooding	-	2270	5990	19000

The most ‘favorable’ scenario is that of sea level rise for 22 cm by 2050. Under this scenario, coastal zone, experiencing erosion intensification, nevertheless will almost retain existing form. Firths, deltas, interspersions, spits will not disappear.

To decrease losses from coast erosion to the minimum, it is necessary to conduct coast-reinforcing works, stipulated by the General Plan of anti-slump and coast-reinforcing measures. Such works for Odessa region are to be performed along 32-km of shoreline (costing about $11 million), for Nikolayev region — 11-km of shoreline ($33 million), for Crimea — 141-km of shoreline ($550 million). At Azov coastal line, 170 km of eroded cliffs need to be protected, that will cost not less than $250 million. Delivery of considerable volumes of sand to the coastal areas should be considered as an addition to coast fortification measures. Taking into account this measure, expenses for regions will amount: Odessa - $211 million, Nikolayev - $93 million, Kherson - $39 million, Crimea - $872 million. Total expenses will make $1208 million. With that, existing coast protection constructions (under conditions of their integrity) in regions of Odessa, Crimea will be sufficient measure to protect coasts under 22-cm sea level rise scenario by 2050. If the sea level rise will be pertained up to 2100, level elevation over present one will be 41 cm, which will already need additional expenses for modernization of coast protection, and implementation of new measures in certain cases.

The most ‘unfavorable’ scenario predicts sea level rise for 115 cm by 2100. Taking into account dynamics of sea level rise, elevation rate by 2050 may approach value of 10 mm per year. At any case, large-scale measures for

protection of coastal resources will be needed by 2050 and, especially and for sure, by 2100. Otherwise, deltas of Dnieper, Danube and Dniester will degrade, 9840 hectares of land fund will be destroyed and 19,000 hectares of low-lying sections of the coastlines will be flooded; many health resort villages will be destroyed completely, spits and interspersions will be disintegrated, all firths of Prychernomorje and Azov Sea will become salinized; thousands hectares of arable lands will be salinized, slumps in Prychernomorje and in Crimea will be activated.
All that needs special study to elaborate National Program for Coast Protection. At present, it is obvious that the whole coastal zone needs protection — from active cliffs to meadows. The latter, likely, ought to be fenced from the sea by artificial dams. It is quite clear that coast protection measures will require considerable investments.
Thus, to ensure an effective adaptation, the following steps will be necessary to take:

- To take as a basis the General Plan of anti-slump and coast-reinforcing measures with additions concerning fortification of free beaches by transferring of large volumes of beach-forming materials to coastal zone. This plan has no alternative for scenario of sea level rise for 22 cm by 2050.
- To develop National Program on Coast Protection Measures that would include two main parts: a) scientific substantiation of trend and intensity of erosion processes within coastal zone of the Black and Azov Seas; and b) specific plan of measures up to 2050, proceeding from 46-cm scenario by 2050 and 115-cm one by 2100.
- To create models of probable soil salinization of low-lying sections of coastal zone under various scenarios of sea level rise.

7.4 Forest Resources Sector

Public opinion in Ukraine for the recent years is slowly transforming to the understanding of the fact that importance of forests as raw materials in Ukraine is lagging behind that of their environment-forming functions essentially. At the same time, legislation base of Ukraine is changing towards substitution of priorities in forestry. So, Forest Code of Ukraine, adopted in 1994 [4], states that "forests in Ukraine are major means to preserve favorable for human life conditions of environment. They have restricted operational meaning and perform not so much raw materials supply, as environment-forming and environment-protective functions: water-protective, sanitary-hygienic, recreation, aesthetic, educational and others".
To assess integrally the impact of global climate changes on forestry, simulation model of functional response of forestry to change of indices of forestry conditions in Ukraine was elaborated. This model allows to combine use of statistical data on forestry conditions with experts' assessments of significance and interaction of primary functions of forests [5].
Comparison of aftereffects of various climate change scenarios realization for forestry have showed that the most unfavorable changes will take place according to GFDL scenario, and the most favorable ones — according to GISS one (Figure 7-1).

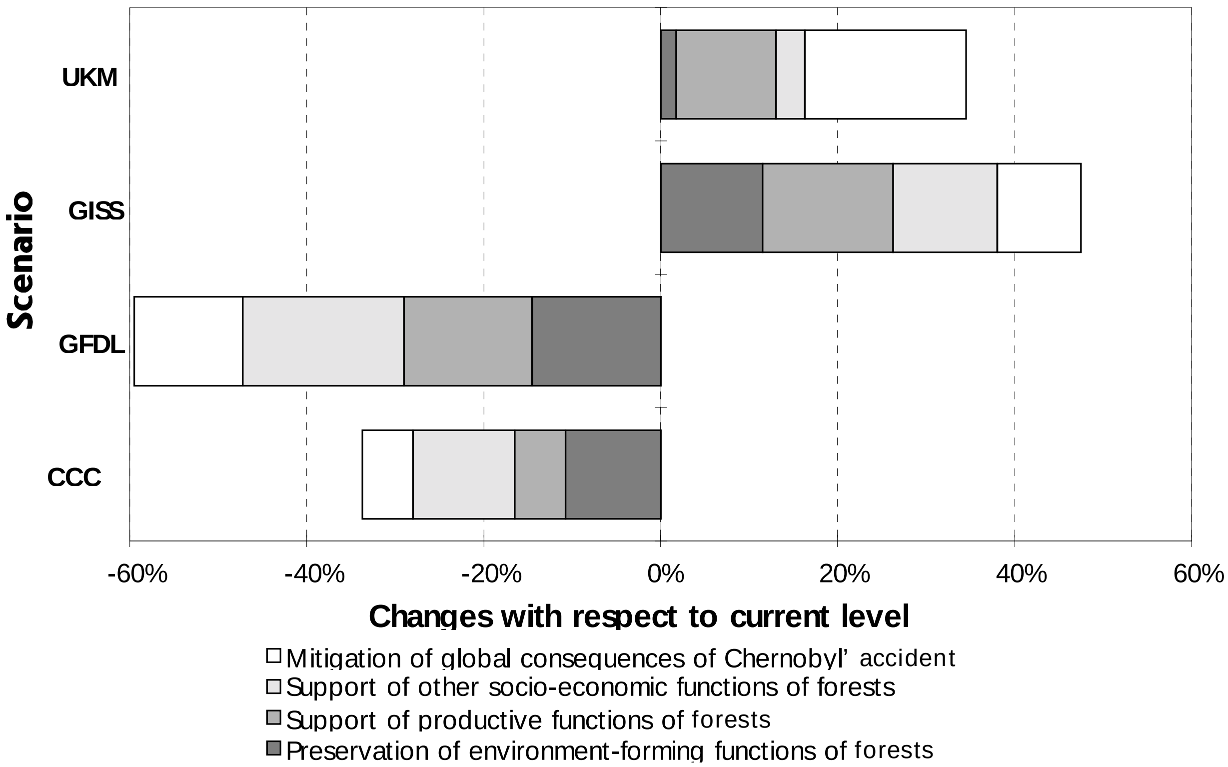

Figure 7-1. Comparative analysis of functional response of the forestry sector for equilibrium conditions under discussed scenarios

The most vulnerable forest functions under CCCM scenario are those providing recreation, preservation of biodiversity of ecosystems and social protection of the population (that one involved into timber industry), which will be reduced for 62%, 60% and 56%, respectively, as compared with current conditions. The least vulnerable forest functions under implementation of CCCM scenario are: possibility of transfer of agricultural lands to forest use within contaminated zones (this possibility may be improved for more than 40% as compared with current conditions); as well as those providing supply of timber industry and contribution to global carbon circulation (these will be shortened for 11% and 15%, respectively, as compared with current conditions).

The most vulnerable forest functions under GFDL scenario are those preventing migration of radionuclides and providing social protection of the population, which will be shortened for 87% and 80%, respectively, as compared with current conditions. The least vulnerable forest functions under GFDL scenario are those providing water and soil protection, as well as contribution of forests into global carbon circulation, which will be shortened for 31%, 44% and 47%, respectively.

According to GISS scenario certain recession of forest functions that provide recreation and preservation of biodiversity of ecosystems that could be shortened for 11% and 13%, respectively.

In general, forecast for UKMO scenario is similar to that for GISS one with exception of the fact that social protection of population, involved into timber industry, is expected to be reduced by 10% under UKMO scenario.

Consideration of potential ways of forestry adaptation to climate changes shows that main directions are following: reduction of significance of the most vulnerable forestry functions for the society (exogenous approach), and introduction of measures to mitigate damages that may be inflicted to the forests directly (endogenous approach). For adaptation strategies development the combined approach is most effective one.

For adaptation period of forest ecosystems to climate changes according to the most 'favorable' scenario, two following strategies will be the most efficient.

Strategy 1. Reduction of significance of forest functions for protection of atmosphere and provision of favorable conditions for agriculture and other sectors of the economy in conjunction with endogenous measures on compensation of changes in stocks, area, increment, biomass, age structure and diversity of wood species composition of forests; accessibility of forests for population recreation purposes; fire control in forests, contaminated with radionuclides; preservation of historically formed forest types, fundamental types of forest-forming species, protective forest stands and shelter-belt forest stands.

Strategy 2. Reduction of significance of forest functions on wood production, atmosphere protection and provision of favorable conditions for agriculture and other sectors of the economy in conjunction with endogenous measures on compensation of changes in area, age structure and diversity of wood species composition of forests.

From general point of view, the first strategy may be characterized as endogenous one with exogenous compensation of detriment, for which reduction by endogenous methods is of low efficiency. The second strategy may be characterized as exogenous one with endogenous compensation of detriment of the most vulnerable indices of forest conditions.

For forest ecosystems adaptation period to climate change, envisaged by the most 'unfavorable' scenario, the strategies given below will be the most effective ones.

Strategy 1. Reduction of significance of forest functions on protection of soils and atmosphere, wood production, provision of favorable conditions for agriculture and other sectors of the economy, as well as prevention of erosive migration of radionuclides in conjunction with endogenous measures on compensation of changes in area covered with forest and maintenance of age structure of forests.

Strategy 2. Reduction of significance of forest functions on provision of favorable conditions for agriculture and other sectors of the economy, as well as prevention of erosive migration of radionuclides in conjunction with endogenous measures on compensation of changes in area, biomass and age structure of forests.

The first strategy may be characterized as based on endogenous approach with compensation of detriment by forest-growing methods, since adaptation to this detriment with endogenous methods is of low efficiency. The second strategy could be characterized as the most exogenous one with endogenous compensation of detriment of the most vulnerable indices of forest conditions.

For all adaptation strategies, the implementation of following measures is necessary:

FOREST-GROWING

- enhancement of measures on forest protection against pests and diseases;
- implementation of resistant wood species which provide the best productivity under climate conditions being formed;

SCIENTIFIC

- development of methods of monitoring and forecasting of forest conditions;
- development of methods of information support of decision-making process for forestry;
- development of methodology of forest protection against pests and diseases;
- extension of researches on selection and introduction of new species;

POLICY

- elaboration of legislation on criteria of forestry;

- rise of responsibility level of forest users and objects for forestry integrity;
- provision of financial privileges for those who use forests in accordance with socially stipulated criteria;

FINANCIAL

- creation of insurance and reserve funds to compensate expenses, related to works on maintenance of sanitary conditions of forests, for relevant organizations.

7.5 Agricultural Sector

Winter wheat is the main crop in Ukraine. Its share in total crop production makes 50% [7]. Zone of assured winter wheat cultivation in climate change conditions will, likely, move in the direction of northern latitudes, on the territories of western Polyssia and right-bank Forest-steppe. According to preliminary assessments, its share in grain-crops structure could decrease and make 20-25%. At the same time will be formed favorable conditions for enlarging area under other crops: barley, oat, corn, legumes (to 20%) as well as for areas under green fodder, for perennials sowings. Such a situation will forward the forming of intensive dairy cattle production zone on western Polyssia and right-bank Forest-Steppe; and meat livestock production - steppe regions of Ukraine.

It should be noted, that about 5.1-5.3 mln tons of grain are to be set apart for the population nutrition. So, hard grain production demand will grow.

Thus, potential climate change will impact agricultural production greatly. At the same time the sector's readiness to implement adaptation measures to meet expected climate change is rather low. One of important factors, affecting agriculture, is the reform of ownership relations in agriculture.

Shift in agro-technical cultivation of winter wheat, including scarifying, sowing terms, depth of sowing, seed material amount, predecessors rotation, chemical processing of the soil, agricultural implements does not provide for sufficient crop production level and reduction of its prime cost. Positive effect, that is, production growth is possible to obtain only under increased amount of chemical fertilizers applied.

According to CCCM scenario the steppe crop yield in and its quality could be raised by 10-20% compared to indices obtained under changed meteorological conditions only. For that the amount of chemical fertilizers (nitrogenous, phosphoric, potassium) applied should be increased. As result expected, stalk's productivity and grain mass in an ear will grow due to forming more grains in an ear, furthermore the grain quality will improve. It should be noted also, that the main yield increment (by 7-15%) is gained on account of increased amount of nitric fertilizers.

Under climate conditions projected by UKMO scenario, the winter wheat yield could be raised up by applying increased dosage of chemical fertilizers, in the main, those nitric. In such a case nitric fertilizers applied will cause the crop yield growth by 300-600 kg/ha (1-6%).

Thus, crops' adaptation options rise under optimal applying of complex chemical fertilizers, while domestic crops and up-to-date cultivation technologies are used. However, increased applying of complex chemical fertilizers will lead to rise of prime cost of 100 kg of winter wheat by $20-30, according to preliminary assessments, if compare to current level [8].

To maintain a stable level of crop production and reduce its prime cost under climate changed in Ukraine, new domestic crops with high adaptation abilities are to be created.

The basic principles of the state regulation in agriculture in Ukraine have just started being formed. Foremost it relates to the creation of legislation for the land reform, development of economically well-grounded measures on optimum structure of arable land forming, implementation of national inventory and land monitoring, privatization program in agriculture.

Since climate changes could affect the structure of Ukrainian agriculture greatly, a National Program of Agriculture Development in Ukraine is to be developed. Such program should include set of political, economic and technical measures, that will enable to mitigate climate change impact on formed geographical, social and economic conditions of agricultural production. An adaptation policy realization in Ukraine may start with the acceleration of the land reform in Ukraine.

One of premises of successful adaptation policy is increase of the genetic potential of domestic agricultural crops and animal breeds, that requires implementation of appropriate research programs.

Educational programs for experts in agriculture, particularly agronomists, specialists on plants protection, agronomists-chemists, veterinary surgeons should be amended.

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8. RESEARCH AND PUBLIC EDUCATION

Key to successfully mitigating and adapting to climate change is a better understanding of the global climate system and the deleterious impacts human activities have on it. Besides requiring further study of the magnitude, timing, and regional and local impacts of climate change, acquiring this understanding also involves substantial additional research on and dissemination of information to enable society to better prevent or - as some change is unavoidable - to accommodate climate change. In short, it calls for programs in both research and public education.

Ukrainian Country Study in the frames of US Country Studies Program Support for Climate Change Studies was the first large-scale program in such direction. This program is nationally integrated effort that seeks to expand knowledge of this processes that affect climate change and to develop integrated models to predict these effects.

Ukraine also participates in USA program to offer financial and technical support to qualified countries for the development of national climate change action plans. The support for national plans will help countries prepare to meet their obligations under the UNFCCC and will also help them to conduct in-depth assessments of opportunities to promote technology transfer.

Ultimately, of course, the public is the true arbiter of national response strategies and policies. Thus, the public must have a solid understanding of global change science, particularly the consequences of policy options. To promote this understanding, Ukrainian Country Study Team direct efforts to general education, communication, and dissemination of climate change information.

The publication of four volumes on Country Study in Ukraine is envisaged. For the past period the work over the first volume, reflecting the results of the inventory on GHG emissions in Ukraine, was finished.

9. THE FUTURE

Ukraine is currently examining the question of its future participation in the intergovernmental activities relating to the UN Framework Convention on Climate Change.

Participation in U.S. Initiative on Joint Implementation (USIJI), which is a pilot program to reduce net GHG emissions and establish an empirical basis and framework for approaches to joint implementation, is envisaged.

The UN Framework Convention on Climate Change commits Parties to the Convention to develop national programs, plans and measures to respond to climate change. One of the key responses that countries can make is to prepare a national action plan and to adopt measures to mitigate of climate change by reducing GHG emissions and enhancing sinks of greenhouse gases.

The further researches are necessary because uncertainties in meeting commitments to future levels of greenhouse gas emissions and sequestration arise from several sources:

- The actual impact of measures may differ from their projected effects - some measures not currently scored at all may yield significant reductions, while some measures may yield lower-than-expected returns because they are not fully funded or are not fully effective for other reasons.
- Future legislative and administrative options that address environmental, energy, agricultural, and forest concerns could significantly increase or decrease net greenhouse gas emissions.
- Changes in the scientific understanding of the relative global warming potentials of different gases could change the estimates of the effectiveness of the measures in terms of carbon-equivalent emissions.
- Improvements in the understanding and management of agricultural and forest soil carbon as they relate to the domestic carbon sink could change the net emissions baseline and the effectiveness of measures.

Financial resources for Ukraine to conduct the in-depth climate change research are limited. Therefore, it is necessary to get additional funds for conducting the technology assessments for mitigation and adaptation measures, and for promoting the diffusion of technologies.

The National Action Plan is not a one-policy development exercise, but it rather begins a process of continual improvement in energy, environmental, and economic policy. In developing future steps, Ukraine will continue to seek out opportunities for emission reduction that provide for economic growth and job creation.