SUPPLEMENT
to Final Report on Greenhouse Gas Emissions Inventory in Ukraine

Contents

Preface

In accordance with the Workplan the Final Report on Greenhouse Gas Emissions Inventory in Ukraine for 1990 has been prepared by November 30, 1995. Results of studies have been completed by research groups on the base of data for October 30, 1995. However, the groups have been continuing their investigations in some categories, and the results obtained in November and December 1995 are given in the Supplement presented.

Country studies on Ukraine related to GHG emissions in 1991-1994 have been carried out.

Specification of CO_2 emissions estimates in the category "Energy"

In the Final Report, when calculating carbon dioxide emissions from fuel combustion an error has been made. The IPCC Methodology proposes do not consider CO_2 emissions from any type of biomass burning, so as it is supposed that they are considered to be related to natural carbon circlulation on the Earth. In a case when a part of the biomass was obtained for account of carbon stock changes in forests, total CO_2 emission due to this is calculated in the category "Forestry and Land Use Change". In the Energy sector only emissions of other greehnouse gases from biomass burning are considered. In this connection the line "TOTAL" in the Worksheet 1-1 should be removed. Herewith actual carbon dioxide emission, calculated by "top-down" method, makes 669.314 Tg. Values of CO_2 emissions from biomass burning should be equalled zero in each from Minimum Data Tables 1A. Total carbon dioxide emission obtained by "bottom-up" method, makes 668.322 Tg. Given above values differ by 0.15%, that is they coincide practically. It allows to make a conclusion on coherency of statistical data in the Energy Balance of Ukraine and high accuracy of aggregated factors for various types of fuel's combustion.

Specification of CO_2 emissions and uptake estimates in category "Forestry and Land Use Change"

All calculations were made according to the IPCC Methodology, so the content of Sections 3.7 and 4.8 of the Final Report does not need to be altered. Analysis of results of calculations and changes related to specification of estimates are given in Sections 2.1-2.3.

Estimation of CO_2 emissions and uptake from managed forests

To obtain more precise estimates of CO_2 emissions and uptake an additional researches were carried out on natural zones of Ukraine and forest structure.

shows the distribution of forested lands. The distinctions in natural zones, main arboreal species and ages of forest plantations are taken into account.

On stage of specifying of GHG emissions estimates, the detailed analysis of data on biomass increment in forests have been completed, and updated data on CO_2 removal was obtained.

In terms of this work managed forests include all the forests of Ukraine, excluding forest plantations of 1990, forest plantations in settlements and forests in zone of alienation around the Chernobyl Nuclear Power Station (Section 2.3).

Worksheet 5-5 (Sheet A) presents data on natural zones of Ukraine. The necessity to have detailed information for each natural zone caused by significant distinctions in forest forming species composition and their biological productivity for different zones.

To complete Columns À, Â, F of Worksheet 5-5 national statistical data on forestry and reports of enterprises of Ukrainian Ministry of Forestry on volumes and qualitative characteristics of forest managing and harvesting activities were used.

Worksheet 5-5 presents estimates of annual biomass increment in forests for 1990 and carbon accumulation in biomass by natural zones and main forest forming species. Biomass increments were calculated for current forests for forest plantations, which areas have been decreasing constantly ().

Table - Distribution of forested lands in Ukraine (1000 ha)

Natural zone	*Species groups*	*Main species*	*Forested lands*	*Age classes*			
				young growth	*middle aged*	*mature*	*over-mature*
Ukraine	Total		*8,407.9*	*3,942.4*	*3,207.1*	*784.4*	*474.0*
including	evergreen		3,836.8	2,281.2	1,091.8	348.1	115.7
		pine	3,007.7	1,865.6	850.2	234.5	57.4
		spruce	722.9	382.1	209.4	87.8	43.6
		fir	97.4	29.7	29.4	25.2	13.1
	hard deciduous		3,436.1	1,312.6	1,504.3	323.0	296.2
		oak	2,127.6	879.0	981.3	152.8	114.5
		beech	652.4	230.1	248.3	68.9	105.1
	soft		1,135.0	348.6	611.0	113.3	62.1

		birch	435.0	116.3	266.6	40.9	11.2
		aspen	72.3	16.6	22.2	18.2	15.3
Polissya	Total		3,474.3	1,750.9	1,289.0	320.4	114.0
including	evergreen		2,108.9	1,281.2	589.7	193.1	44.9
		pine	2,088.7	1,266.4	586.6	191.5	44.2
		spruce	19.4	14.6	2.6	1.6	0.6
	hard deciduous		554.1	213.6	248.6	53.9	38.0
		oak	462.4	193.9	200.1	40.6	27.8
		beech	0.8	0.2	0.4	0.1	0.1
	soft deciduous		811.3	256.1	450.7	73.4	31.1
		birch	359.3	99.0	218.7	32.9	8.7
		aspen	40.2	7.9	12.1	11.1	9.1

Forest-Steppe	Total		2,724.2	1,249.9	1,153.3	225.1	95.9
including	evergreen		797.7	460.7	266.6	60.1	10.3
		pine	588.8	345.3	200.9	36.2	6.4
		spruce	191.5	108.4	61.2	18.8	3.1
		fir	13.7	4.1	3.9	4.9	0.8
	hard deciduous		1,662.9	708.5	751.2	133.2	70.0
		oak	1,179.9	551.6	552.7	49.0	26.4
		beech	201.2	86.3	78.5	25.9	10.5
	soft deciduous		263.6	80.7	135.5	31.8	15.6
		birch	67.0	16.0	40.9	7.6	2.5
		aspen	28.5	8.1	9.4	6.6	4.4
Steppe	Total		878.8	447.4	325.8	57.1	48.5
including	evergreen		272.3	217.5	48.6	3.3	2.9
		pine	272.1	217.4	48.6	3.3	2.8
	hard deciduous		555.9	219.0	257.7	47.0	32.2
		oak beech	299.90.3	107.5	156.90.3	20.9	14.6
	soft deciduous		50.6	10.9	19.5	6.8	13.4
		birch	4.8	0.9	3.7	0.2	
		aspen	2.4	0.6	0.6	0.3	0.9
Carpathian mountains	Total		1,092.5	464.6	362.5	131.2	134.2

including	evergreen		613.6	292.9	178.0	89.9	52.8
		pine	16.9	7.6	6.6	2.1	0.6
		spruce	512.0	259.1	145.6	67.4	39.9
		fir	83.7	25.6	25.5	20.3	12.3
	hard deciduous		471.1	170.8	179.5	40.0	80.8
		oak	46.5	25.8	17.8	2.2	0.7
		beech	416.1	143.1	157.1	36.9	79.0
	soft deciduous		7.8	0.9	5.0	1.3	0.6
		birch	3.8	0.4	3.2	0.2	
		aspen	0.2			0.2	
Crimean mountains	Total		238.1	29.6	76.5	50.6	81.4
including	evergreen		44.3	28.9	8.9	1.7	4.8
		pine	41.2	28.9	7.5	1.4	3.4
	hard deciduous		192.1	0.7	67.3	48.9	75.2
		oak	139.1	0.2	53.8	40.1	45.0
		beech	34.0	0.5	12.0	6.0	15.5
	soft deciduous		1.7		0.3		1.4
		birch	0.1		0.1		
		aspen	1.0		0.1		0.9

Table - Forest plantations in Ukraine

Year	*Total area of forest plantations, 1000 ha*	*including*		
		in state forest fund	*antierosive plantations*	*forest shelterbelts*
1990	57.1	35.4	17.2	4.5
1991	46.9	31.3	12.4	3.2
1992	42.9	28.9	11.7	2.3
1993	40.0	26.8	11.2	2.0

Summary results of calculations of annual carbon uptake increment in biomass of forests managed are presented in .

shows aggregated factors of carbon uptake by forests for different natural zones.

Table - Annual carbon uptake increment in managed forests, (kt)

Plantations	*Total*	*Natural zones*

	in Ukraine	*Polissya*	*Forest-Steppe*	*Steppe*	*Carpatian mountains*	*Crimean mountains*
Total	19,338	7,998	6,358	1,774	2,818	390
including: evergreen	8,759	4,937	1,605	540	1,596	81
pine	6,754	4,892	1,200	539	47	76
spruce	1,744	43	372		1,329	
fir	243		26		217	
other evergreen	18	2	7	1	3	5
Hard deciduous	8,255	1,343	4,258	1,141	1,207	306
oak	5,126	1,124	3,038	620	122	222
beech	1,628	2	508	1	1,063	54
Other hard deciduous	1,501	217	712	520	22	30
Soft deciduous	2,324	1718	495	93	15	3
birch	909	765	127	9	7	1
aspen	131	76	49	4	1	1
other soft deciduous	1,284	877	319	80	7	1

Table - Aggregated factors of carbon uptake, (Mg)

Plantations	*Total in Ukraine*	*Natural zones*				
		Polissya	*Forest Steppe*	*Steppe*	*Carpatian mountains*	*Crimean mountains*
Total in managed forests	2.30	2.30	2.33	2.02	2.58	1.64
Including: Evergreen	2.28	2.34	2.01	1.98	2.60	1.83
pine	2.25	2.34	2.04	1.98	2.78	1.84
spruce	2.41	2.22	1.94	-	2.59	-
fir	2.49	-	1.90	-	2.59	-
other evergreen	2.05	2.50	1.89			1.61
Hard deciduous	2.40	2.42	2.56	2.05	2.56	1.59
oak	2.41	2.43	2.58	2.07	2.62	1.60
beech	2.50	2.50	2.52		2.55	1.59
other hard deciduous	2.29	2.39	2.52	2.03	2.59	1.58
Soft deciduous	2.05	2.12	1.88	1.84	1.92	1.76
birch	2.09	2.13	1.90	1.88	1.84	1.67
aspen	1.82	1.89	1.72	1.67		1.00
other soft deciduous	2.05	2.13	1.90	1.84	1.84	1.67

"-" means that there is only negligible amount of species and data on which does not allow to obtain reliable results.

Worksheet 5-5 (Sheet C) presents estimates of amount of biomass removed from forests at commercial harvests in 1990, for natural zones of Ukraine and main forest forming species. Data on reduction of volume of wood harvested in Ukraine after 1990 are given in

The following literary sources were used for calculation of Biomass Increment (Column B), Carbon Fraction of Dry Matter (Column D) and determination of Biomass Conversion Ratio (Column G):

Factors of conversion of solid wood amount(in cubic meters) into absolutely dry matter (in tones) [2]

Factors of annual increment of roots [3]

Factors of annual increment of branches [3]

Amount of organic matter in leaves (needles) was accounted on base of data on technical biomass [3] with account of weight of absolutely dry matter [11,13]

Factors of conversion of absolutely dry matter into net carbon were calculated on the base of national data on chemical composition of forest biomass [2,8]

Table - Harvests in Ukraine, (1000 m3)

Year	*Total amount of biomass harvested*	*Including*			
		Commercial Harvest	*Cuttings for Forest Clearing*	*Cuttings for Reconstruction of Plantations*	*Other Types of Cuttings*
1990	20,464.5	6,979.4	11,662.8	53.4	1,768.9
1991	16,844.9	6,135.0	9,431.4	37.5	1,241.0
1992	15,472.8	5,894.8	8,137.0	45.6	1,395.4
1993	15,080.9	5,574.0	7,940.6	32.5	1,533.8

Calculations of national Carbon Fraction of Dry Matter (Column N) in total amount of biomass in commercial harvested forests are presented in .

Table - Calculations of Carbon Fraction of Dry Matter in commercial harvested forests

Cutting types	*Harvest volumes (kt of dry matter)*		
	evergreen	*hard deciduous*	*soft deciduous*
Commercial Harvest	1,428.0	1,255.2	591.4
Cuttings for Forest Clearing	2,212.8	2,758.7	875.5
Cuttings for Reconstruction of Plantations	3.8	16.3	74.0
Other Types of Cuttings	143.6	740.2	70.8
Total by groups of species	3,788.2		6,315.5
Total		*10,103.7*	
Conversion Ratio (Factor of conversion of dry matter into net carbon)	0.49		0.47

Carbon ratio = (3788.2 * 0.49 + 6315.5 * 0.47)/10103.7 = *0.4775*

Obtained in results of calculations on the base of national data, Carbon Fraction of Dry Matter is higher than recommended by the IPCC methodology averaged factor, i.e. 0.45. However this value does not exceed the limits of recommended range (0.43-0.58), and is consistent to real composition of Ukrainian forests.

All results are presented in the Table of minimum data 5D. Estimate of CO_2 removal due to increase of total forested area in Ukraine in 1990, were taken as 72321 Gg.

Estimation of CO_2 emissions from forests fires

Specification of emissions estimates was made with use of averaged statistical data, form Ministry of Forestry of Ukraine on forest fires, for the period of 1986 to 1994. This data is presented in and .

Data on biomass stock in forest floor were obtained on the base of field observations, executed by experts of Ukrainian Research Institute of Forestry and Agroforestry Melioration: for Polissya - [15,16], for Forest-Steppe and other zones [17,18,19,20]. Average weighted data were derived from [21].

Result of analysis of Worksheets 5-1 shows that on the average 4.2 thousand hectares of the territory of Ukraine per year suffer from forest fires, 71% from which are brush fires, which cause negligible damage for forests. So losses from forests fires made 51 Gg of Absolutely Dry Matter and CO_2 emission made 81.8 Gg in 1990.

Table - Lands suffered from forests fires in Ukraine, (1000 ha)

Year	*Forested lands suffered from fires*	*Including areas, suffered from fires:*		*Non-forest areas burned by fires*
		brush fires	*crown fires*	
1994	10,040	6,598	3,442	313
1993	3,178	2,466	712	36
1992	16,101	12,429	3,672	151
1991	1,717	1,052	665	64
1990	2,388	1,366	1,022	46
1989	1,281	905	376	47
1988	767	638	129	46
1987	469	430	39	53
1986	1,307	993	314	96
Total	*3,7248*	*26,877*	*10,371*	*852*
Average annual	4,138	2,986	1,152	95

Table - Damage from forests fires in Ukraine

Year	*Biomass Losses and Damage, m^3*	
	Forest stands	*Stored up Timber*
1994	391,159	840

1992	427,758	241
1991	38,051	201
1990	79,236	673
1989	33,743	137
1988	8,199	23
1987	1,186	27
1986	14,477	272
Total	*1,168,163*	*2,559*
Average annual	129,795	284

Estimation of CO_2 uptake due to abandonment of managed lands in alienation zone of Chernobyl Nuclear Power Plant

Specification of input data allows to assume that due to the Chernobyl disaster, 57 thousand hectares located in zone of alienation(area with radius of 30 kilometers around the Nuclear Power Plant), were abandoned (the Final Report included another value - 110 thousand hectares).

During 1986 - 1994, 3 thousand hectares of this area have been reforested naturally with coniferous (mainly pines) and softwoods (mainly birches and aspens) species, this caused CO_2 removal from the atmosphere. Worksheet 5-4 presents the results of calculations and shows that the CO_2 removal made 396 Gg.

Summary results of CO_2 release and uptake are given in Tables of Minimum data 5À, 5Â, 5Ñ, 5D.

Estimation of uncertainties

Using the procedure of development of uncertainty ranges (given in section 6.4 in the Final Report), the estimates of uncertainties by each CO_2 source and sink were obtained ().

Specification of estimates have led to the decreasing of total uncertainty in the category “Forestry and Land Use Change”.

Table - Uncertainties range in estimates of the CO_2 emissions and uptake in category “Forestry and Land Use Change”

Category	*Uptakes (-) or emissions(+) of ÑÎ$_2$, (Gg)*			*Accuracy,*
	accepted estimate	*minimal limit*	*maximal limit*	*%*
Forests fires	+81.8	+75.9	+82.5	-7.2 +0.9
Abandoned lands	-420.6	-419.5	-421.7	-0.3 +0.3
Managed forests	-72,321.3	-70,999.6	-74,020.9	-1.2 +2.4
Harvesting	+20,683.7	+16,429.4	+25134.5	-25.9 +21.5
Net uptake (-) or emission (+)	-51,976.4	-54,913.8	-49,225.6	+5.7 -5.3

Estimation of N_2O emissions in category “Agriculture”

Additional researches allowed to estimate N_2O emissions of nitrogen applied in fertilizers for all crop types in Ukraine for 1990 and 1993.

Input data on applied nitrogen fertilizers were taken from statistical data of Ministry of Agriculture of Ukraine. According to these in 1990 1784.36 thousand tones of different fertilizers with content of nitrogen, in 1993 - 996.19 thousand tones.

There are no overall data on types of fertilizers, applied in land use in Ukraine, so an averaged factor of nitrogen content in fertilizers was used.

The list of main types of fertilizers and nitrogen content in them are given in [22].

Table - Nitrogen fertilizers applied in Ukraine

Nitrogen fertiliser	*Chemical formula*	*Nitrogen content,%*
Ammonium sulphate	$(NH_4)_2SO_4$	20.5 - 21.0
Liquid nitrogen fertilizers	-	82.3
Liquid ammonia	NH_4OH	20.0
Sodium saltpeter	$NaNO_3$	15.5 - 16.0
Ammonia saltpeter	NH_4NO_3	34.0 - 35.0
Carbamide	$CO(NH_2)_2$	46.0

An averaged factor of nitrogen content in fertilizers is taken as 36.51%. So the content of nitrogen in fertilizers in 1990 made 651.47 thousand tones and in 1993, 363.71 thousand tones.

Estimate of N_2O emissions is determined through the estimation of nitrogen content in nitrous oxide, using factor of nitrogen emission 0.01, recommended by the IPCC Methodology.

[N_2Î emission] = [Nitrogen content] * [Nitrogen emission factor]*[44]/[28]

As a result of computation estimates of N_2Î emission from applied nitrogen fertilizers in Ukraine in 1990 were taken as 10.24 Gg, in 1993 - 5.72 Gg.

Estimating uncertainties of the obtained results were made within a large uncertainty range in determination of averaged factor of nitrogen content. Maximum and minimum values of nitrogen content in a

presents the uncertainty ranges for $N_2\hat{I}$ emission from applied nitrogen fertilizers in Ukraine in 1990.

Table - Uncertainties ranges in $N_2\hat{I}$ estimates

Category	*Accepted estimate*	*Minimal limit*	*Maximal limit*
Nitrogen content ratio, (%)	36.51	20.0	82.3
$N_2\hat{I}$ emissoin, (Gg)	10.23	5.61	23.08
Accuracy		-45%	126%

The results have confirmed the conclusion of the Final Report that significant uncertainties remained in estimates of $N_2\hat{I}$ emissions for each category.

It should be noted that nitrogen fertilizers' consumption has reduced greatly for 1993 (about by 50%). It was connected with general economical difficulties, such as deficiency of means to purchase new fertilizers.

Updated $N_2\hat{I}$ emissions estimates were added to summary tables in Part 5 of the Final Report. Table 5-25 and Figure 5-18 were replaced with and

Table - N_2O emission in Ukraine

Category	*N_2O emission, Gg*	*%*
Energy	6.71	26.82
Nitric acid production	6.61	26.42
Forests fires	1.34	5.35
Waste incineration	0.13	0.52
Nitric fertilizers	10.23	40.89
Total	*25.02*	*100.00*

Figure - N_2O emission in Ukraine

General conclusion of results of estimating emissions with account of new estimates in categories "Forestry and Land Use Change" and "Agriculture"

Specification of CO_2 emissions and uptake does not have much influence on the content of Section 5.5 of the Final Report. Quantitative

changes are presented in , which replaced Table 5-20 from the Final Report.

Table - CO_2 Emissions and uptake in category "Forestry and Land usage"

Activities	*Ñ Î $_2$ emissions and uptakes, Gg*
Forests fires	+81.8
Land abandoning	-420.6
Managed forests	-72,321.3
Harvests	+20,683.7
Net uptake (-) or emission (+)	-51,976.4

shows data on forest density at optimistic prognosis and their current values for regions of Ukraine.

It is obvious that regions with highest level of pollutants emissions (Donetskaya, Zaporozhskaya, Dnepropetrovskaya regions and others) have the most lower levels of forest density and require special efforts on reforestation activity.

Table - Area of forested lands in administrative regions of Ukraine, %

Region	*Real*	*Optimal*
Vinnitskaya	11.5	16
Volinskaya	30.4	37
Dnepropetrovskaya	3.6	8
Donetskaya	4.8	12
Zhitomirskaya	31.3	37
Zakarpatskaya	50.0	55
Zaporozhskaya	1.3	5
Ivano-Frankovskaya	40.7	49
Kievskaya	19.4	23
Kirivogradskaya	4.5	11
Luganskaya	8.8	16
Lvovskaya	28.0	30
Nikolaevskaya	1.9	7
Odesskaya	4.1	9
Poltavskaya	7.5	15
Rovenskaya	36.2	40
Sumskaya	16.3	21
Ternopolskaya	12.9	20
Kharkovskaya	10.7	15
Khersonskaya	3.1	8
Khmelnitskaya	11.9	17
Cherkasskaya	13.8	16
Chernovitskaya	28.8	33

Republic of Crimea	10.1	19

Specification of total estimate of CO_2 uptake in category “Forestry and Land Use Change” is required to change Table 5-23 and Figure 5-16 in the Final Report so as it is shown in .

Tables and figures in Section 5.11 in the Final Report were changed accordingly: Table 5-31 was replaced with ; Table 5-32 with ;Figure 5-23 with ;Figure 5-24 with .

Figure - $\tilde{N}\hat{I}_2$ emissions and uptake in Ukraine, (Tg)

Figure - Carbon balance

Table - Generalization of estimates of Greenhouse Gas emission

Gas/Source	*CO_2 emission (molecular), Tg*	*Carbon emission (equivalent), Tg*
CO_2		
Fuel combustion	668.36	182.28
Industrial processes	31.78	8.67
Total emission	700.14	190.95
Forests (sinks)	-51.98	-14.18
Total (balance)	**648.16**	**176.77**
CH_4		
Agriculture	2.25	13.5
Coal Mining	2.78	16.68
Oil and gas production and transporation	3.44	20.64
Fuel combustion	0.06	0.36
Waste	0.93	5.58
Total emission	9.46	56.76
N_2O		
Fuel combustion	0.0067	0.49
Nitric acid production	0.0062	0.46
Nitrogen fertilizers	0.0102	0.75
Forests fires	0.0013	0.10
Waste inceneration	0.0001	0.01
Total emission	0.0245	1.81
Total		**235.34**

Table - Carbon balance

Greenhouse Gas ratio	*Carbon emission, Tg*	*%*
CO_2	176.77	75.11
CH_4	56.76	24.12
N_2O	1.81	0.77
Total	**235.34**	**100.00**

Figure - Generalization of results in activitiy categories (Carbon emission, Tg)

Estimation of GHG emissions in Ukraine in 1990-1994

General approach

During the process of development of Ukrainian GHG Emissions Inventory in 1990 methodologies of emissions estimating in categories of human activities recommended by the IPCC Guidelines have been elaborated.

Solving the problems at the following stages within the Project "Country Study on Climate Change in Ukraine", requested to estimate the dynamic of changes in GHG emissions in the first half of 90's.

Additional researches carried out by working groups allowed to calculate changes in GHG emissions for each category.

The lack (shortage) of reliable statistical data on a number of indexes increased accuracy of estimates for 1991-1994, but did not affect qualitative assessment of current emissions.

Estimation of CO_2 emission from fuels combustion

CO_2 emissions were estimated for 1991-1994, and statistical data on a number of fuel types for 1991 are absent. In such a case estimates were derived from data for 1990 and 1992.

Total energy resources consumption for the period considered in Ukraine become more than 1.6 times less. CO_2 emissions become 1.8 less.

Data on fuels consumption are given in . Fuel types included in the table, correspond to those used in national statistics lists [22,23,24,25].

Table - Fuels consumption in 1991 -1994 in Ukraine

Fuel	Consumption, PJ			
	1991	*1992*	*1993*	*1994*
Jet kerosene	1.15	0.72	0.52	0.2
Gasoline	357.44	299.88	209.26	181.48
Kerosene	46.27	26.63	9.45	8.004
Diesel oil	525.42	456.72	368.15	320.35
Household fuel	59.99	45.12	18.15	8.97
Furnace fuel oil	868.18	629.74	502.95	287.07
Marine residual oil	10.93	5.56	30.5	36.67

Gas turbine fuel	9.49	5.32	1.068	0.828
Natural fuel gas	3,518.71	3,354.32	3,033.55	2,605.89
Shale fuel gas	0.3	0.0018	0.008	0.108
Coke-oven gas	212.97	175.81	133.97	110.73
Blast-furnace gas	992.97	986.71	767.04	588.72
Dry gas	65.81	47.74	31.68	28.65
Liquefied gas	17.36	33.68	30.82	26.26
Coal and processing products ïå	1,058.9	1,478.7	1,454.63	1,170.96
Dry metallurgical coke	432.1	413.05	381.66	277.28
Dry coke bean (coke breeze)	4.83	0.89	2.66	2.82
Coke trifle	35.55	38.56	34.08	33.44
Oil and gas condensate	0.66	0.46	0.72	0.82

and present results of calculated changes in CO_2 emissions from fuels consumption in Ukraine.

A drastic decrease of CO_2 emissions in Ukraine in first half of 90's are connected with general reduction of production. Implementation of measures on resource saving, energy conservation and refining processes did not take place and did not affect GHG emissions.

Figure - Total fuel consumption in Ukraine, PJ

Figure - $\tilde{N}\hat{I}_2$ emission changes from fuel combustion in Ukraine, Tg

Estimation of CH_4 emission from coal mining

Information presented in the Final Report shows that coal mining process is the main source of CH_4 emission in category "Energy".

Coal mining has been reducing during the period of 1990 -1994, it became 1.7 times less. Coal consumption for burning during this period decreased by 11%.

and and and present calculated CH_4 emission from coal mining in Ukraine.

Table - Coal mining volume in Ukraine, millions tonnes

Activity	*1990*	*1991*	*1992*	*1993*	*1994*
Underground mines	155.50	130.50	129.20	111.3	91.90
Surface mines	9.28	5.40	4.40	3.14	2.15
Total	*164.78*	*135.90*	*133.60*	*114.44*	*94.05*

Figure - Coal mining volume in Ukraine, millions tonnes

Table - CH_4 emission from coal mining in Ukraine, Gg

Activiry	*1990*	*1991*	*1992*	*1993*	*1994*
Underground mines	2,567.80	2,185.87	2,164.10	1,864.27	1,539.32
Post-mining	208.37	173.87	173.13	149.14	123.15
Surface mines	7.46	4.34	3.54	2.52	1.73
Post-mining	1.24	0.72	0.59	0.42	0.29
Total	*2,784.87*	*2,364.80*	*2,341.36*	*2,016.35*	*1,664.49*

The decrease of CH_4 emission from coal mining in Ukraine is caused by reduction of production volumes, not by measures on

Scientific group did not manage to obtain reliable data on CH_4 emission from oil and gas production for inventory years. Total estimate of CH_4 emissions were taken unchanged (estimate for 1990), because volumes of gas transportation in Ukraine (it gives the greatest contribution in the emissions) have been changed negligibly.

Figure - CH_4 emission from coal mining in Ukraine, (Gg)

Estimation of CO_2 emissions in category "Industrial processes"

According to the methodologies, described in Sections 2.4 and 3.5 in the Final Report, estimates of $ÑÎ_2$ emissions in Ukraine for 1991-1994 were calculated for the following industrial processes:

Cement production
Lime production and consumption
Limestone production and consumption
Soda ash production and consumption
$Ñ Î_2$ production and consumption

- present input data on volumes of production and estimates of $Ñ Î_2$ emissions.

Table - $ÑÎ_2$ emissions from cement production in Ukraine

Annual estimates	*1990*	*1991*	*1992*	*1993*	*1994*
Cement productoin, (millions t)	22.70	21.70	20.10	15.00	10.70
Clinker productoin, (millions t)	17.46	17.25	15.68	11.67	8.29
$Ñ Î_2$ emissions, Gg	8,745.3	8,643.2	7,855.0	5,847.0	4,155.0

Table - CO_2 emissions from production and consumption of lime in Ukraine

Annual estimates	*1990*	*1991*	*1992*	*1993*
Lime production, (1000 tonnes)	8,677.0	7,648.0	7,484.0	5,924.0
including: construction lime, (1000 tonnes)	2,005.0	1,928.0	2,107.0	1,245.0
technological lime, (1000 tonnes)	6,672.0	5,720.0	5,377.0	4,679.0
CO_2 generation, (Gg)	6,811.5	6,004.0	5,875.0	4,650.0
CO_2 consumption, (Gg)	2,280.0	2,062.0	2,088.0	3,788.0
Total CO_2 emission, (Gg)	*4,531.5*	*3,942.0*	*3,787.0*	*3,133.0*

Table - CO_2 emissions from limestone production and consumption in Ukraine

Annual estimates	*1990*	*1991*	*1992*	*1993*
Iron production, (10^6 t)	44.9	36.6	35.4	26.9
Steel production, (10^6 t)	52.6	45.0	41.8	32.4
Glass production, (10^6 m^2)	64.8	64.2	56.7	46.4
Limestone production, (10^6 t)	64.4	62.4	59.2	45.2
Consumption of limestome as flux, (10^6 t)	18.7	15.5	14.8	11.3
Consumption of dolomite as flux, (10^6 t)	6.8	5.6	5.4	4.1
Consumption in glass production, (10^6 t)	0.12	0.12	0.10	0.08
Total CO_2 emission, (Gg)	*10,967.96*	*9,052.50*	*8,678.83*	*6,625.05*

Table - CO_2 emission from soda ash production and consumption in Ukraine

Annual estimates	*1990*	*1991*	*1992*	*1993*
Soda production, (1000 t)	1,119.5	1,065.0	1,091.0	775.0
Soda export, (1000 t)	235.1	275.8	252.1	187.9
Soda import, (1000 t)	1.8	2.7	3.3	2.3
Internal soda consumption, (1000 t)	886.2	827.9	842.2	589.4

CO_2 emission from soda production, (Gg)	619.6	589.5	603.9	428.9
CO_2 emission from soda consumption, (Gg)	367.8	343.6	349.5	244.6
Total CO_2 emission, (Gg)	*987.4*	*933.1*	*953.4*	*673.5*

Table - $\tilde{N}\hat{I}_2$ emission from carbon dioxide production and consumption in Ukraine

Annual estimates	*1990*	*1991*	*1992*	*1993*
Sinthetic ammonia production, (1000 t)	5,149.6	4,838.1	5,449.7	2,537.6
Carbamide production, (1000 t)	1,503.0	1,420.0	1,255.0	1,096.0
$\tilde{N}\hat{I}_2$ generation, (Gg)	7,646.0	7,177.0	8,187.0	3,776.0
$\tilde{N}\hat{I}_2$ consumption, (Gg)	1,102.0	1,042.0	920.5	804.0
Total $\tilde{N}\hat{I}_2$ emissoin, (Gg)	*,6544.0*	*6,135.0*	*7,266.5*	*2,972.0*

present total estimates of $\tilde{N}\hat{I}_2$ emission in category “Industrial Processes”.

Figure - $\tilde{N}\hat{I}_2$ emission, Tg

Decrease of $\tilde{N}\hat{I}_2$ emission in the category “Industrial Processes”, is caused by reduction of production volumes and its consumption in the Ukraine.

Estimation of CH_4 emissions in category “Domestic Livestock”

Estimates of $\tilde{N}\acute{I}_4$ emission in Domestic Livestock in Ukraine for 1991-1993 were obtained accordingly with methodologies, given in Sections 3.5 and 4.6 in the Final Report.

presents input data on the number of animals and the results of estimation of $\tilde{N}\acute{I}_4$ emissions. shows total values of emissions in Domestic Livestock.

Decrease of number of animals in Domestic Livestock has led to reduction of $\tilde{N}\acute{I}_4$ emission. No measures on $\tilde{N}\acute{I}_4$ use and utilization were applied.

Table - $\tilde{N}\acute{I}_4$ emission from Domestic Livestock in Ukraine

Annual estimates	*1990*	*1991*	*1992*	*1993*
Dairy Cattle, (1000	8,851	8,378	8,263	8,057

Non-Dairy Cattle, (1000 heads)	17,787	16,245	15,465	14,400
Sheep, (1000 heads)	8,879	7,896	7,259	6,647
Goats, (1000 heads)	343	523	570	590
Horses, (1000 heads)	754	738	724	754
Swine, (1000 heads)	20,088	19,427	17,839	16,175
Poultry, (1000 heads)	255,120	246,899	234,439	233,148
$ÑÍ_4$ emission from enteric fermentation, (Gg/year)	1,702.63	1,663.14	1,605.54	1,524.94
$ÑÍ_4$ emission from manure, (Gg/year)	536.40	523.89	499.63	470.24
Total $ÑÍ_4$ emission, (Gg/year)	*2,239.03*	*2,187.03*	*2,105.17*	*1,995.18*

Figure - $ÑÍ_4$ emissions from Domestic Livestock in Ukraine

Total$ÑÍ_4$ emission, Gg/year

$ÑÍ_4$ emission from enteric fermentation, Gg/year

$ÑÍ_4$ emission from manure, Gg/year

Estimation of CO_2 uptake by managed forests

In accordance with the methodology, described in Sections 3.7 and 4.8 in the Final Report and also in Part 1 of the Supplement presented, the estimates of $ÑÎ_2$ release and uptake in the category “Forestry and Land Use Change” were calculated.

Estimates of $ÑÎ_2$ uptake due to abandonment of managed lands in the alienation zone were obtained as a means of yearly values and considered unchanged for 1990-1993.

The following data were used for calculations of dynamic changes in $ÑÎ_2$ emissions and uptake in forests managed:

Area of forest plantations in Ukraine ()
Harvesting in Ukraine ()
Suffered from forest fires lands (and)
presents total balance estimates of $ÑÎ_2$ uptake in forestry of the Ukraine in 1990-1993.

Table - $ÑÎ_2$ emission in forestry, (Gg)

Annual estimates	*1990*		*1991*		*1992*		*1993*	

Managed forests	-19,724	-72,321	-19,700	-72,234	-19,691	-72,201	-19,684	-72,176
Harvests	5,641	20,684	4,548	16,676	4,178	15,318	4,072	14,930
Abandonment of forested lands	-115	-421	-115	-421	-115	-421	-115	-421
Forest fires	22	82	16	58	148	541	29	107
Balance	-14,176	-51,976	-15,251	-55,921	-15,480	-56,763	-15,698	-57,560

Reduction of harvest volumes in managed forests has led to increase of CO_2 uptake; the area of reforested lands has not been growing during the inventory years.

Estimation of CH_4 emissions from municipal solid waste and wastewater

According to the methodologies given in Sections 3.8 and 4.9 in the Final Report, estimates of CH_4 emissions from landfills were calculated for the period from 1991 up to 1994.

shows input data and estimates of CH_4 emissions from landfills.

Table - CH_4 emission from Municipal Solid Waste

Annual estimates	*1990*	*1991*	*1992*	*1993*	*1994*
Annual volume of MSW in landfills, (Gg)	10,416.50	10,477.00	10,269.00	10,174.50	9,963.60
CH_4 emission, (Gg)	911.44	916.74	898.54	890.27	871.81

CH_4 emissions from Wastewater were estimated accordingly with Sections 3.9 and 4.10 methodologies. shows input data and estimates of CH_4 emissions from Municipal and Industrial Wastewater in Ukraine for 1990-1994.

Table - CH_4 emission from wastewater treatment

Annual estimates	*1990*	*1991*	*1992*	*1993*	*1994*
Total Municipal Wastewater, (10^6 m^3)	3,684	3,889	4,013	3,955	3,815
Treated Wastewater outlflow, (10^6 m^3)	3,597	3,757	3,886	3,813	3,652
Recuperation of CH_4, (Gg)	6.3	6.3	6.3	6.3	6.3

CH_4 emission from Municipal Wastewater, (Gg)	34.46	33.65	33.65	33.24	33.24
CH_4 emission (wastewater from Iron and Steel Production), (GG)	1.08	0.98	0.93	0.95	0.60
CH_4 emission (wastewater from Non-Ferrows Production), (Gg)	0.02	0.03	0.03	0.01	0.02
CH_4 emission (wastewater from Fertilizer Production),(Gg)	1.94	1.23	1.28	0.98	0.80
CH_4 emission (wastewater from Food and Beverages Production), (Gg)	5.08	3.30	2.10	1.60	1.09
CH_4 emission (wastewater from Pulp and Paper Production), (Gg)	1.04	0.68	0.30	0.30	0.25
CH_4 emission (wastewater from Petroleum Refinery/Petrochemicals), (Gg)	0.41	0.19	0.22	0.11	0.10
CH_4 emission (wastewater from Textiles),(Gg)	0.94	0.98	0.62	0.39	0.30
CH_4 emission (wastewater from other production), (Gg)	3.60	5.13	5.43	4.94	4.59
Total CH_4 emission, (Gg)	*48.57*	*46.17*	*44.55*	*42.52*	*40.99*

The trend of decreasing CH_4 emissions from wastewater treatment is connected with reduction of production in Ukraine.

present total estimates of CH_4 emissions in category “Waste”.

Figure - CH_4 emission in category "Waste"

Total CH_4 emission, Gg

CH_4 emission from MSW, Gg

CH_4 emission from wastewater, Gg

Conclusion

Generalization of results was carried out according to approaches given in Sections 5.7-5.11 in the Final Report.

Total estimates of CO_2 emissions by inventory years in Ukraine are presented in . Accuracy of estimates are taken accordingly with the results of calculations presented in Part 5 of the Final Report.

Table - CO_2 emission in Ukraine in 1990-1993

Annual estimates	*1990*	*1991*	*1992*	*1993*
Fuel consumption	668	534	530	469
Industrial processes	32	29	29	19
Forestry	-52	-56	-57	-58
Total	*648*	*507*	*502*	*430*

Decrease of total CO_2 emission is connected with reduction of industrial production volumes in Ukraine.

presents total estimates of CH_4 emissions in Ukraine by years under consideration. Accuracy of estimates taken accordingly with the results of calculations, presented in Part 5 of the Final Report.

Table - $ÑÍ_4$ emission in Ukraine in 1990-1993, (Mg)

Annual estimates	*1990*	*1991*	*1992*	*1993*
Energy	6.28	5.81	5.79	5.47
Agriculture	2.25	2.19	2.11	2.00
Waste	0.93	0.96	0.94	0.93
Total	*9.46*	*8.96*	*8.84*	*8.40*

Decrease of total $ÑÍ_4$ emission caused by the reduction of volumes of coal mining and number of animals in Livestock.

present emissions estimates converted into carbon equivalent.

Figure - Carbom emission (equivalent) in Ukraine in 1990-1993

Total

From $ÑÎ_2$

From $ÑÍ_4$

The decrease of total estimate of carbon emission is undoubtedly connected with general reduction of production volumes and industrial production consumption in Ukraine. The level of production has been decreasing during 1994-1995, this trend allows to assume that GHG emissions will be reducing in future.

According to forecasts of Ukrainian and foreign economists the short period of economy stabilization (1996) will be followed by increase of industrial production. It is expedient that modernization of industrial equipment should be carried out in accordance with obtained estimates of GHG emissions, that energy saving and not disturbing ecology balance technologies should be used.

References

1. Forestry Encyclopedia, Vol.1,2. Moscow: ”Soviet Encyclopedia”, 1985- Vol.1 - p. 563, Vol.2 - p. 631.

2. Baranov I. A. Technology of Production of Woody Mass and Cellulose - Moscow: Timber Industry, 1961 - p. 224.

3. Normative and Reference Materials for Taxation for Forestry of Ukraine and Moldova.- Kiev: Harvest, 1987 - p. 560.

4. Rodin L.E., N.I.Bazilevich. Dynamics of Organic Matter and Biological Circulation of the Main Types of Vegetation of the World.- Moscow-Leningrad: Science, 1965 - p. 256.

5. Artsybashev E.S. Forest Fires and Struggle Against Them. - Moscow: Timber Industry, 1974 - p.152.

6. Curbatsky N.P. Methodology and Tactics of Forest Fires Extinguishing. - Moscow: Goslesbumizdat, 1962 - p.156.

7. Curbatsky N.P., G.A. Ivanova. Danger from Forest Fires in Pine Forests of Forest-Steppe and Ways of Their Reduction. - Krasnojyarsk, 1987 - p. 112.

8. Levin E.D., S.M. Repyah. Woody Biomass.- Moscow: Timber Industry, 1984 - p. 120.

9. Molchanov A.A. Biomass Productivity in Forests of Different Zones. - Moscow: Science, 1971 - 276 ñ.

10. Postoilake G.G. Forest Aboveground Biomass in Circulation of Matter. - Kishinyov: Shteentsa, 1976 - p. 180.

11. Semechkina M.G. Structure of Phytomass of Pine Forests. - Novosibirsk: Science, 1978 - p. 168.

12. Smirnov V.V. Biomass in Some Forest Phytocenoces of Plain Part of SSSR.. - Moscow: Science, 1971 - p. 264.

13. Usol’tsev V.A. Modeling of the Structure and Dynamics of Forest Stands Phytomass. - Krasnojyarsk, 1985 - p. 192.

14. Forestry of Ukrainian SSR (for 01.01.88.),1989 - Kiev: - p. 247.

15. Mostepanyuk V.A. Regulating the Soils Nutrition of Pine Forest Plantations in Subors of Polissya of Ukrainian SSR. Thesis of Candidate of Agriculture Sciencies,1986 - p. 228.

16. Savushchik N.P. productivity of Pine Forests in Polissya of Ukrainian SSR in connection with soils conditions. Thesis of Candidate of Agriculture Sciences, 1989 - p. 156.

17. Vypirajlo O.V. Ecological Features of Forest Plantations in Conditions of Chronic Pollution by Waste. Thesis of Candidate of Agriculture Sciences, 1994 -p. 162.

18. Shudrya J.V. Recreative Loading Influence on the Main Components of Oak Plantations in Western Forest Steppe. Thesis of Candidate of Agriculture Sciences, 1985 - p. 185.

19. Bondaruk G.V. Influence of Recreation on Conditions of Pine Forests in Left-Bank Forest Steppe of Ukrainian SSR and Creating in Them Favorable for Recreation Environment. Thesis of Candidate of

20. Bondar V.I. Influence of Recreation on Deciduous Plantations in Southern Left-Bank Forest Steppe of Ukrainian SSR and Their Vulnerabilities. Thesis of Candidate of Agriculture Sciences, 1982 - p. 261.

21. Gensiruk S.A., S.V. Shevchenko, V.S. Bondar. Complex Forestry Mapping of Ukraine and Moldova.- Kiev: Naukova Dumka, 1981 - p. 360.

22. Gorodniy N.M. Agrochemistry. - Kiev: High School (Vyshcha Shcola), 1990 - p. 267.

23. Report on residues, incomes and consumption of fuels for 1991, Ministry of Statistics of Ukraine, Form 4 - MTP, Kiev,1992.

24. Report on residues, incomes and consumption of fuels for 1992, Ministry of Statistics of Ukraine, Form 4 - MTP, Kiev,1993.

25. Report on residues, incomes and consumption of fuels for 1993, Ministry of Statistics of Ukraine, Form 4 - MTP, Kiev,1994.

26. Report on residues, incomes and consumption of fuels for 1994, Ministry of Statistics of Ukraine, Form 4 - MTP, Kiev,1995.

27. Economy of Ukrainian SSR in 1990. 1991. Report of national Committee on Statistics of Ukrainian SSR for 1990. Kiev. Ukraine.

28. Economy of Ukrainian SSR in 1991. 1992. Report of national Committee on Statistics of Ukrainian SSR for 1991. Kiev. Ukraine.

29. Economy of Ukraine in 1992. 1993. Report of national Committee on Statistics of Ukraine for 1992. Kiev. Ukraine

APPLICATIONS