RUSSIAN FEDERATION

Interagency Commission of the Russian Federation on Climate Change Problems

FIRST

NATIONAL COMMUNICATION

Moscow 1995

Contents

Foreword

In the Russian Federation the Federal Law on ratification of the UN Framework Convention on Climate Change was signed by the President of the Russian Federation on 4 November 1994, after its adoption by the Federal Assembly of the Russian Federation. The document on ratification was accepted by the Depositarium of the Convention, by the UN Secretary-General, on 28 December 1994.

The main obligations of the Russian Federation, as a country included, in accordance with the Convention, into the joint group of developed countries and countries with economy in transition, are as follows:

- To implement national policy and appropriate measures on mitigation of anthropogenic climate changes by limiting of anthrophogenic greenhouse gases emissions and by increasing of their sinks and reservoirs. All measures on regulation of greenhouse gases emissions and sinks should be implemented so the national anthropogenic emissions of the CO_2 and other greenhouse gases should not exceed in 2000 the level of 1990, as a base year.

- To carry out works on inventory of anthropogenic greenhouse gases emissions and sinks, in accordance with international recommendations and methodology, developed in the frame of cooperation under the Convention.

- To determine regions, environmental and economical objects most vulnerable to climate changes. To develop and to implement measures for adaptation of the economy branches to climate changes.

- To extend scientific research on climate change problems, to develop education activities and to stimulate public attention to these problems.

- To implement broad international cooperation in all problems related with the UN Framework Convention on Climate Change.

- To provide the Conference of the Parties with detailed information about national measures carried out with the purpose to fulfill the Convention and results of these measures.

The First National Communication on the activity under the Convention was compiled under the leadership of the Interagency Commission of the Russian Federation on Climate Change Problems, established by the Government of the Russian Federation. Representatives of various ministries, organizations and scientific institutes of the Russian Federation took part in these works.

The following is the text of the First National Communication of the Russian Federation and its extended summary. The extended summary repeats the general contents of the National Communication in brief form.

Chairman of the Interagency
Commission of the Russian Federation
on Climate Change Problems,

Head of the Russian Federal Service for
Hydrometeorology and Environmental
Monitoring

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September 25, 1995

Extended summary

To prevent dangerous anthropogenic interference with the climate system and its adverse effects the UN Member-States signed in 1992 the UN Framework Convention on Climate Change, which was ratified by the Russian Federation in late 1994.

The necessary measures on fulfilment of all the tasks of the Convention are under development in the Russian Federation. Implementation of a large number of measures are to be carried out in two principal directions:

1. *Development and implementation of the measures on limiting and reduction of anthropogenic greenhouse gases emissions and increasing of their sinks, first and foremost, carbon dioxide.*
2. *Detecting national branches and economic spheres vulnerable to climate changes; developing and establishing of a national system of measures on adaptation of the economy to expected climate changes.*

The results of the activity under the Convention are reflected in the First National Communication of the Russian Federation. Its principal clauses are given in the Extended Summary.

Peculiarities of energy development in the Russian Federation

Many problems in fulfilment of the Convention are related to economic activities in the energy sphere. To provide solution of radical tasks of the fuel and energy complex (FEC) development in new conditions in the Russian Federation, a new federal energy policy is under development. In 1993-1994 the principal clauses of the State Integrated Fuel and Energy Program of the Russian Federation for the period till 2010 ("Energy Strategy of Russia") were developed. The main purposes of this Programme are:

- *Determination of directions and establishment of conditions for most effective use of energy resources and FEC production potential.*
- *Provision of leading role of energy as a significant factor of the enhance of labour productivity and improved standards of life of the population.*
- *Significant reduction of the technogenic loading of the FEC on the environment.*

When determining priorities in a new-energy policy a highest priority in the Energy Strategy is given to the increased efficiency of energy consumption and energy savings. Together with specific elements of the structural, engineering and financial and economic policy such an approach leads to a significant limiting of greenhouse gases emissions.

Inventory of anthropogenic emissions and sinks of greenhouse gases

The methodology how to determine greenhouse gases emissions effecting climate used when preparing the present Communication is much based on the Intergovernmental Panel on Climate Change (IPCC) methodological recommendations. Emissions of principal greenhouse gases effecting climate — CO_2, CH_4 and N_2O were calculated based on the volume of respective activities and IPCC specific emissions coefficients. The activity volume was taken from the state and agency statistics data. In some cases, the available statistic data on emissions were applied. The emissions of greenhouse gases precursors - CO, NO_x and nonmethane hydrocarbons from stationary sources are given based on the state statistics data. The data presented below can be specified later on.

Technogenic emissions of CO_2

Results of the approximate calculation of technogenic emissions of CO_2 based on the fuel and energy balance of the RF and on the data on the cement production are given in Table 1.

Table 1

Technogenic emissions of CO_2 in Russia (1990)

Emission source	Specific emission tC/tce[3]	Fuel consumption,[1] Mtce	CO_2 emission[2] MtC/yr	%
Coal	0.756	278	210	32.3
Oil and gas condensate	0.586	319	187	28.7
Natural and accompanied gas	0.448	531	238	36.5
TOTAL		1128	635	97.5
Cement production		-[4]	11[4]	1.7[4]
Accompanied gas combustion in oil fields	0.448	11	5	0.8
TOTAL :	0.572	1139	651	100

1) including bunker
2) including emissions from the bunker fuel
3) 1tce=0.7toe=29.308GJ
4) including emissions from fuel used for cement production, these emissions were taken into account in previous lines of Table 1

More than 98% of the total emission is connected with fossil fuel, i.e. it refers to category "energy" according to the IPCC classification.

The CO_2 sink and emission in forests and peatlands.

Disturbance of the carbon cycle and the balanced CO_2 exchange between the atmosphere and terrestrial ecosystems can lead both to emission and to uptake of the CO_2 in forests and peatlands. In Russian conditions, where vast areas are under forests (Table 2) and peatlands these fluxes can be especially large. Scientific researches in Russia as well as in other countries indicate that forests of the temperate and north latitudes are, as a whole, sink of the CO_2. The peat accumulation on peatlands could also cause a significant sink of the CO_2.

The Forest Fund lands include two items: forest lands and non-forest lands (grasslands, pastures, etc.). In turn forest lands are separated on really forested lands and other lands (light woody places, etc.).

Table 2

Summary data on the Russian Federation Forest Fund lands as of 1 January 1993.

Total area, thousand ha	1180882
Including forest lands, thousand ha;	886538
of the above area forested lands, thousand ha	**763502**
Stem wood stock, Mm3	80676

The forest fund lands occupy 1181 Mha, including 1110.5 Mha under the Federal Forestry Service (FFS) management. So-called forest lands have 886.5 Mha. Forested *lands cover 763.5 Mha, including 92% under the FFS management. The total stemwood stock is 80.7 Gm^3, including 73.0 Gm^3 on the FFS lands.*

According to the forest accounting data, the total forested area somewhat reduced in 1988 - 1993, that is, first of all, connected with more accurate determination of the area in hardly accessible regions. The change in the age structure of forests is as important as that in their total areas. It is difficult to provide an accurate determination of such changes in Russia, because about half of forests are age mixed. According to estimates, the area of young and middle-age forests somewhat increased, and that of matured and overmatured somewhat decreased.

Works on the CO_2 sink specification are now under progress. They are based on inventory and modelling of the total carbon cycle in the main types of forests in Russia. The current and past relatively small effects of the climate changes are also under consideration. The sink in forests and peatlands is estimated as 200 Mt C/yr, including 160 Mt C/yr in forests and 40 Mt C/yr in peatlands.

Anthropogenic emissions of CH_4

Anthropogenic CH_4 emissions by types of sources are given in Table 3. Emissions produced by natural and accompanied (oil) gas take first place in the total anthropogenic methane emissions in the RF. To calculate the total methane emission in Russia given in this and subsequent Tables a mean value of gas produced emission of 16 M t/yr was taken.

Other gases

Emissions of greenhouse gas precursors from stationary sources are 8.1; 3.0 and 4.1 M t for CO, NO_x (reduced to NO_2) and nonmethane hydrocarbons, respectively.

Total and equivalent greenhouse gases emission.

The anthropogenic emission of principal greenhouse gases and Russian share in the global emission by 1990 is shown in Table 4.

Table 3

Anthropogenic CH_4 emissions in Russia (1990)

Emission source	Emission Mt/yr
Natural and accompanied gas production, transportation and consumption	16
Animal husbandry and animal wastes	4.9
Solid waste disposal	2.4
Coal production	1.9
Oil production and transportation	1.7
Waste waters treatment	no data
Rice production	0.1
Other branches of agriculture	no data
TOTAL	**27**

Table 4

Anthropogenic emission of greenhouse gases in the RF (1990)

Gas	RF Emission/ RF sink, Mt/yr	Global emission, Mt/yr[1)]	The RF share in the global emission, %
CO_2, Mt C	651/200[2)]	6100	10.7
CH_4, Mt CH_4	27	375	7.2
N_2O, Mt N_2O	0.82	8.2	10.0

1) IPCC data
2) Net-emission is 451 MtC/yr if sinks are taken into account

Table 5 shows absolute and relative values of the equivalent emission of three major greenhouse gases: CO_2, CH_4 and N_2O effecting climate change (for 1990). The IPCC 1994 global warming potentials for a 100-year integration interval were used in calculations.

Most important measures in this field which ultimately determine the fossil fuel consumption level are:

1. *Increased efficiency of energy consumption and energy savings in the following branches of the economy: true energy (energy production and transformation); transport; industry; municipal sector and agriculture.*
2. *Measures on the structure policy in the field of energy supply, including: increase of efficiency of the natural gas use and its enhanced share in the domestic consumption; multiply increased use of non-traditional, first renewable resources (solar, wind, geothermal energy, mine methane, biogas, etc.).*
3. *The technological policy aimed at increasing the economic, energy and environmental efficiency at all stages of production, transformation, distribution and use of energy resources, including: development and use of qualitatively new and effective technologies and engineering means in most important branches of the national economy.*
4. *Measures on reasonable price and tax policy which provides energy savings and efficient use of energy carriers.*

Table 5

Equivalent anthropogenic emission of greenhouse gases in the RF (1990)

Gas	Global warming potential	Equivalent emission (CO_2-equivalent)		
		absolute, $MtCO_2$	relative	
CO_2	1.0	2387	1.00	72%
CH_4[1)]	24.5	662	0.28	20%
N_2O	320	262	0.11	8%
TOTAL		**3311**	**1.39**	**100%**

1) with account for direct and indirect greenhouse impact.

Inefficient use of energy resources resulted in Russia in a great nonused energy supply potential. According to “Energy Strategy of Russia” it accounts to 460-540 M t of the coal equivalent or 40-45% of the present energy consumption. One third of the potential whose use is much cheaper than the increased fuel production is concentrated in the FEC, mainly in the electropower and heating supply. The second *third of the potential is in the industry (7-8% in metallurgy, 4-5% in construction material industry), about 20% — in the municipal sector and in agriculture and 10% more in the transport.*

The programme on using the economically based portion of the energy supply potential consists of a complex of high priority measures on the energy supply and the priorities of the subsequent technology innovation. Relative to the extent the measures are realised and their success in the strategy two versions of the energy supply are under consideration — optimistic and probable (Table 6).

The optimistic version foresees the realisation of the entire economically based potential of energy supply by the year 2010. It demands huge investments into energy savings and complete structure reconstruction in the economy and it may turn out to be unrealistic. Therefore the probable version foresees only the realisation of the effective portion of the potential the enterprises benefit when no special stimulation measures are needed.

Measures on limiting CH_4 emissions.

Programmes on reducing methane emission into the atmosphere are under development and pilot application. They foresee:

- *use of the landfill methane for energy purposes;*
- *use of the mine methane for energy purposes.*

Table 6

Energy savings versions (relative to 1992) M tce/year

	2000		2010	
	probable	optimistic	probable	optimistic
Energy resources savings, including those due to	80	180	300	470
- organizational and technical measures	50	80	80	110
- energy saving technologies	30	100	220	360

Source: Energy Strategy of Russia, 1994.

Increased CO_2 uptake by the Russian forests.

Russian forests have a great potential to enhance the CO_2 sink. On can list such potential measures as: increase of the forested area by about 80-100 Mha; changes in the age structure of forests over area above 200 million ha; drainage measures and related increase in condensity of forests; forest fire protection; improved technology of cutting and transportation; prolonged reproduction cycle as a result of replace some deciduous forests by conifers on 120-140 Mha.

In 1989-1993 the forest planting was practically invariable and equal to 490-500 thousand ha/yr. It is around 20% less compared with the previous 5 years (1983-1988) and 40% below that in 1978-1982. Areas under measures for assistance to natural reforestation also did not practically change for the last 5 years: around 900 thousand ha/yr. It is 10% higher than in 1983-1988.

The Federal Forestry Service has already started realisation of the first pilot project in the Saratov oblast, aimed to working out the methodology of carrying out works. The Project has also large environmental importance. The Project is implemented by the FFS jointly with the International Forest Institute (Moscow) and

Oregon State University (USA). The planting on three places (about 500 ha) have been made on abandoned agricultural lands, pastures and burnt-out lands which if not the Project would be sources of the CO_2. Developing of the proposals related with larger Projects in the Vologda oblast and in the Far East is under progress now.

Greenhouse gases emissions scenarios and assessment of the efficiency of measures under development

Proceeding from possible scenarios (optimistic, probable and pessimistic) of the Russian economy development and implementation of any versions of energy savings, there are expected to be realistic minimum and maximum levels of the energy demand given in the Table 7.

Based on that and with allowance for possible versions of fuel and energy complex development one estimated the CO_2 emissions on two scenarios of primary energycarrier consumption in Russia: scenario A (minimum energy demand) and scenario B (maximum energy demand), Table 8.

The estimates demonstrate that in the case these scenarios come true the CO_2 emission in the energy sector of Russia in 2000 and even in 2010 will not exceed the 1990 level.

Table 7

The demand range in energy in the Russian national economy

Energy carriers	1990	1993	1995	2000	2010
Electric power, billion kWhr	1073	937	840-870	850-990	1080-1270
per capita energy consumption, thousand kWhr/capita	7.22	6.42	5.5-6.0	5.8-6.6	7.1-8.3
Thermal energy (centralized), Mt Gcal	2075	1950	1850-1880	1870-1950	1900-2050
Motor fuel, Mt	104	76	74-76	76-80	83-95
Primary energy resources - total, Mt coal equiv.	1257	1093	990-1050	950-1090	1010-1200
per capita consumption, t coal equiv./capita	8.46	7.38	6.7-7.1	6.5-7.3	6.6-7.8

Source: Energy Strategy of Russia, 1994.

Approximately anthrophogenic CO_2 emission in 2000 (in percents of 1990 level) is expected to be: scenario A - 83%, scenario B - 87%.

It is necessary to note, that the expected decrease of the national CO_2 emission associates with the following two major factors:

1. *Deep crisis in the Russian economy in the first half of 1990s leading to reduction in the CO_2 emission (approximately down to 80% of the 1990 level in 1995-1996). The expected not very rapid rise in the production in 1996-2000 will not have significant results on the emission level.*
2. *In 1995-2000 in Russia there is outlined to carry out significant rise of efficiency in energy use and energy savings on the base of application of modern technologies and technical equipment, as well as on the base of new structural policy. These improvements will allow to limit CO_2 emission approximately at the level of 1990 and to meet increasing needs of the country in energy.*
3. *As a result of implementation of broad complex of measures in forestry sector and taking into account impacts of climate factors, it is expected, that in 2000 and in*

2010 CO_2 sinks in Russian forests may increase comparatively with 1993 and these results will create an additional reserve in total reduction of CO_2 emission.

Table 8

Estimations of CO_2 emission, M tC
(value ranges are given for the two scenarios (A and B) for primary energy consumption)

Fuel	1990	1995	2000	2010
Solid Fuel	210	135-138	132-141	156-167
Oil	187	145-147	146-149	150-159
Natural gas	238	238-238	248-262	267-283
Total	**635**	**518-523**	**526-552**	**573-609**

Consequences of climate changes and adaptation measures.

Climate change on the Russian territory could have the following consequences:

- *change in the regional distribution of precipitation, change in the river runoff and soil moisture;*
- *increase in arid area;*
- *changes in natural zone boundaries;*
- *significant change in biosphere and in agriculture productivity;*
- *changes in continental glaciers and reduce of permanent permafrost zone;*
- *sea level rise;*
- *increase in plant productivity due to growth of the CO_2 concentration in the atmosphere.*

These consequences could have serious effect on climate-dependent branches of the economy, first of all, agriculture, forestry and water resources.

The results obtained demonstrate that in the case of the global warming by the IPCC scenarios the cereal productivity in Russia could decrease on the average by 12% but that of fodder crop rise by 5%. If warming and climate aridization processes coincide with the anthropogenic soil degradation then the scenario is realised which supposes a 26% decrease in the average cereal productivity and a 10% decrease in the total productivity of crops. One can expect agriculture crop productivity increase if climate changes in accordance with paleoclimatic scenarios when good soil moisture conditions are supposed in Russia. However, in order to avoid significant losses measures should be taken in all cases to prevent soil degradation and to increase productivity.

The structure of measures proposed on adaptation of the Russian Federation economy includes the following issues:

1. *Development of the Russian economy regulation strategy in conditions of adaptation to the supposed climate changes.*

2. *The state of the economy and its structural reconstruction with account for the supposed climate changes.*

3. *Assessment of the vulnerability and economic consequences for the different branches.*

Scientific and technological programmes, researches and participation in the international co-operation

The co-ordination of all activity under the Convention is realised by the Russian Federation Interagency Commission on climate change issues under the Russian Federation Government. In a wider scope the solutions of all national problems related with the anthropogenic climate change will be included in the Federal Climate Programme "Prevention of Dangerous Climate Changes and their Negative Consequences" being developed.

The following Federal and State scientific and technological programs aimed at reducing anthropogenic emissions and natural resources savings were under implementation in the Russian Federation:

1. *Fuel and energy.*
2. *High-speed environmentally sound transport.*
3. *Environmentally sound energy.*
4. *Resources saving and environmentally sound processes in the metallurgy industry.*
5. *Environmentally sound chemical industry and chemical technology processes.*
6. *Russian forests.*
7. *All-round use and reproduction of wood.*
8. *Most up-to-date bioengineering methods.*
9. *Technologies, equipment and production in the future.*
10. *Processes hold much promise for the agriculture production.*
11. *Processes hold much promise for the agro-industry processing.*
12. *Advanced technologies of the integrated development of Russian fuel and energy resources..*
13. *Global changes in the environment and climate.*
14. *Safety of the population and objects in the national economy taking into account the risk of natural and technogenic catastrophes.*
15. *All-round investigations of oceans and seas, Arctic and Antarctic.*
16. *Ecology of Russia (from 1993 - Environmental safety of Russia).*

The education courses in climatology are in nine universities and institutes.

The general public of the country is providing with recent news about anthropogenic climate change problems from a lot of scientific-technological journals and scientific-popular magazines as well as from mass media.

The Russian side took an active part in the work of the Intergovernmental Negotiation Committee on the Convention and continues to participate in the Convention Side Conference. Head of the Roshydromet, A.I.Bedritsky is vice-chairman of the Side Conference.

Many scientists from the Russian Federation contributed much to the Intergovernmental Panel on Climate Change and its working groups. Academician Yu.Izrael is vice-president of the IPCC. Russian scientists participate in many global programs under the World Meteorological Organisation (WMO). Under the WCP (World Climate Program) Russian specialists are participating in the projects: Climate System Monitoring; Climate Change Detecting. Academician G.S.Golytsin is member of the Joint Scientific Committee of the WMO - International Council of the Scientific Unions under the World Program of Climate Change Investigations.

At the intergovernmental level the following international projects on anthropogenic climate change issues are under implementation:

1. *Climate projects in the framework of the CIS co-operation on the meteorology. Specialists of the Roshydromet take part in the Working Group of the*

Intergovernmental Hydrometeorological Council of the CIS countries "Global and Regional Problems of Climate Change and Ozone".

2. *Russian-American agreement on the co-operation in the field of the environment and natural resources protection. Working Group VIII "The Influence of Environmental Changes on Climate".*
3. *Project "The Russian Federation Climate Change Country Study" under the US Climate Changes Country Studies Program.*

1. Source data

This chapter contains a brief information about environmental conditions at the territory of the Russian Federation and general description of socio-economic situation in the Russian Federation in 1973-1995.

The data given in this chapter were taken from the following publications of the State Committee of the Russian Federation on Statistics (Goskomstat of Russia): “Russia in Figures, 1995”, Moscow 1995; “Russian Statistical Year-Book, 1994”, Moscow 1994; and from hand-book “Forestry Fond of Russia”.

1.1. General information

In accordance with the Constitution of the Russian Federation, 21 republics, 6 lands, 50 oblasts, 10 autonomous districts and two cities of the federal value - Moscow and Sankt-Petersburg are the subjects of the Federation.

The territory of the Russian Federation is 17075,4 thousand km^2 (45% - forests, 4% - waters, 13% - agricultural lands, 19% - reindeer pastures, 19% - other lands).

The square covered by tundra is 2200 thousand km^2. Bogs of all types cover about 1500 thousand km^2, among them bogs with speed of peat accumulation more than 0.5 mm/year cover about 900 thousand km^2.

Data on the population of Russia is presented in Table 1.1 and Picture 1.1. In the base year - 1990, the Russian population was 148.5 million people, according to the census of 01.01.1991. This quantity of the population was used in all the calculations per capita.

Gross Domestic Product (GDP) in the Russian Federation, calculated on results of the international comparison program, is presented in Table 1.2.

Table 1.1

Population of Russia in 1979-1995, million people

Date of census	All population	Including		% of all population	
		urban	rural	urban	rural
17.01.79	137.6	95.4	42.2	69	31
12.01.89	147.4	108.4	39.0	74	26
01.01.90	148.0	109.2	38.8	74	26
01.01.91	148.5	109.8	38.7	74	26
01.01.92	148.7	109.7	39.0	74	26
01.01.93	148.7	108.9	39.8	73	27
01.01.94	148.4	108.5	39.9	73	27
01.01.95	148.3	108.3	40.0	73	27

Source: “Russia in Figures, 1995”, M,1995.

Picture 1.1

Population of the Russian Federation in 1979-1995, million people

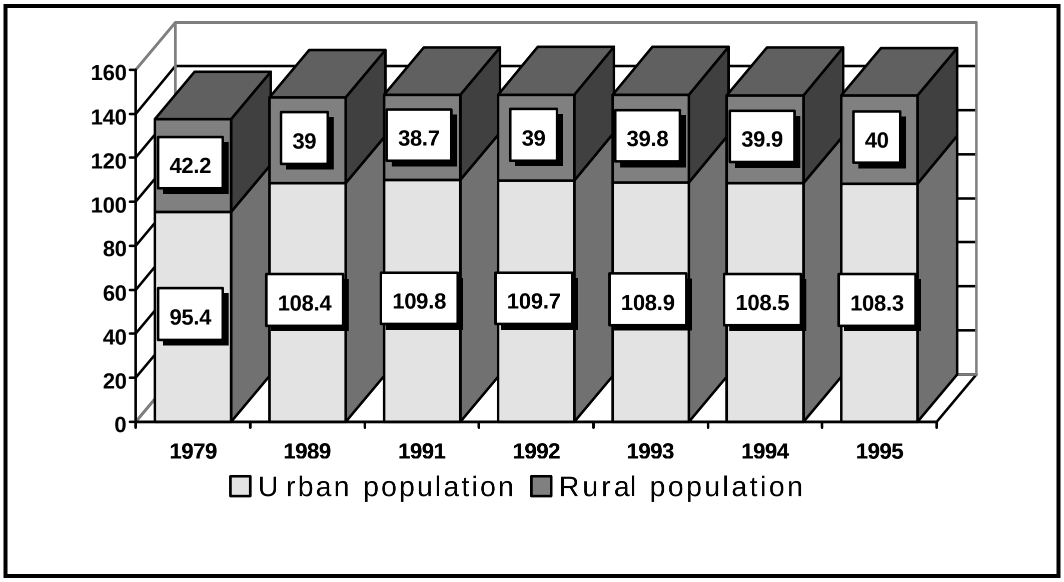


Table 1.2.

Estimation of gross domestic product in Russia, based on results of international comparison program.

	1990	1991	1992	1993
GDP of Russia, in billion U.S. dollars	1268.4	1150.7	956.5	868.3
Ratio between GDP of Russia and GDP of the U.S. (U.S.GDP=100%)	23%	20.3%	16.1%	13.6%
Ratio between GDP of Russia and GDP of the U.S. per capita (U.S. GDP per capita=100%)	38.7%	34.5%	27.6%	23.6%

Source: "Russian Statistical Year-Book, 1994",M, 1994.

1.2. Agriculture and forestry.

As of 01 Jan., 1994 the total area of agriculture lands in Russia was 220.8 Mha including 131.1 Mha of arable lands, 21.8 Mha of grasslands and 63.6 Mha of pastures. In 1993 the cropland area of all cultures (cereal, technical, fodder, potato and vegetables) covered 111.8 Mha.

The largest cropland area of the main cultures (except potato) was registered in 1980. In recent 12 years the total cropland area was reduced by 8.2%, including 18% of cereal, 5% of technical crops and 18% of potato. In the same period fodder crop lands were increased by 10.5%. In 1970-1990 areas of meliorated and drainage places, which were involved in agriculture activity, were increased by 10.8% and covered 12,412 thousand ha.

After 1970 the greatest amount of mineral fertilizers was delivered to agriculture in the year 1987. It was 14,986 thousand t, including 5,930 thousand t of nitric, 5,930 thousand t of phosphate (including phosphate powder) and 3,473 thousand t of potassium fertilizers. In this year 106.7 kg of fertilizers were used per ha of arable lands, including 44.9 of nitric and 35.5 of phosphate fertilizers. Later and especially in 1991, use of the mineral fertilizers and chemical fodder substances was reduced more than by one-half.

The Forest Fund lands occupy 1181 Mha, including 1110.5 Mha under the Federal Forestry Service (FFS) management. So called forest lands are 886.5 Mha. Really forested lands cover 763.5 Mha, including 705.8 Mha or 92% under the FFS management. As of 01.01.1993 other forested lands, 57.8 Mha, are under management of different owners, mostly, agriculture collective or state farms; forestry enterprises of the former USSR Ministry of forestry have 9.95 Mha; the RF Ministry of defense manages 3.4 Mha; reserves of the RF Ministry of environment and natural resources contain 6.6 Mha of forests.

The total stemwood stock is estimated as 80 Gm^3, the contribution of coniferous is about 80%. In 1993 real cutting area of all types of cuttings was 1.074 Mha. This is less by 0.34 Mha than that of 1992 and less by 0.74 Mha in comparison with 1990. Formerly, in 1970-1990 cutting areas were decreased from 2.5 to 1.8 Mha. More than 1 Mha of forest lands are covered by fires annually. The areas of forest plantings and measures for assistance to natural reforestation are 500 and 900 thousand ha per year correspondingly.

1.3. Energy resources

Mining of general types of fuel in Russia is shown in Table 1.3 and in Picture 1.2. Natural gas mining in Russia increased during 1970-1990 more than 7 times. In 1994 natural gas mining decreased a little bit in comparison with 1990. Oil mining decreased at the period of 1990-1993 on 32%, coal mining decreased on 23%.

Table 1.3

Mining of general types of fuel in Russia in 1990-1994

Type of fuel	1990	1991	1992	1993	1994
Oil (including gas condensate), M t	516	462	399	354	318
Natural gas, billion m^3	641	643	641	618	607
Coal, Mt	395	353	337	305	271
Fuel peat, Mt	5.2	4.7	7.8	2.5	2.9
Schists, Mt	4.6	4.2	3.8	3.3	3.3

Source: “Russia in Figures, 1995”, M, 1995.

Electric energy production in the Russian Federation is given in Table 1.4 and Picture 1.3.

Table 1.4.

Electric energy production by electric power plants in Russia in 1990-1994, billion kWh

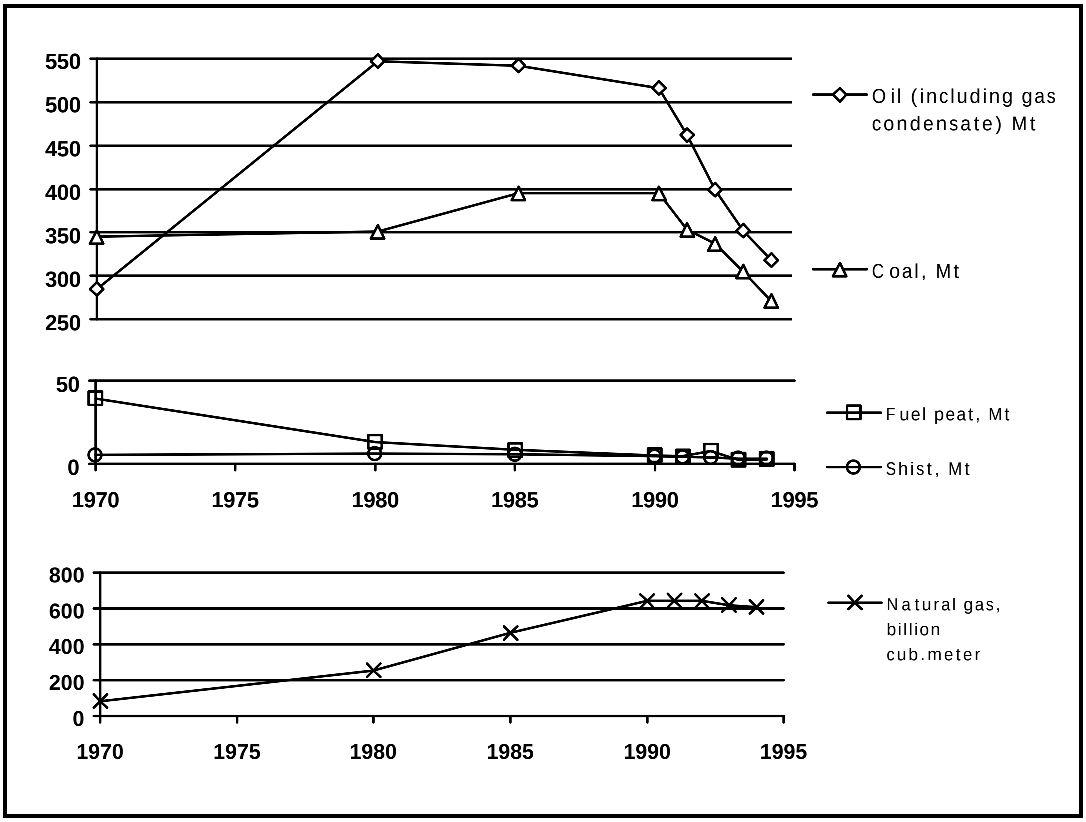
	1990	1991	1992	1993	1994
All electric power plants	1082	1068	1008	957	876
including:					
hydroelectric power plants	167	168	173	175	*
Hydroelectric power plants in % of total electric energy production	15%	16%	17%	18%	*
nuclear power plants	118	120	120	119	*
nuclear power plants in % of total electric energy production	11%	11%	12%	12%	*

* no data.

Sources: “Russia in Figures, 1995”, M, 1995; “Russian Statistical Year-Book, 1994”, M, 1994.

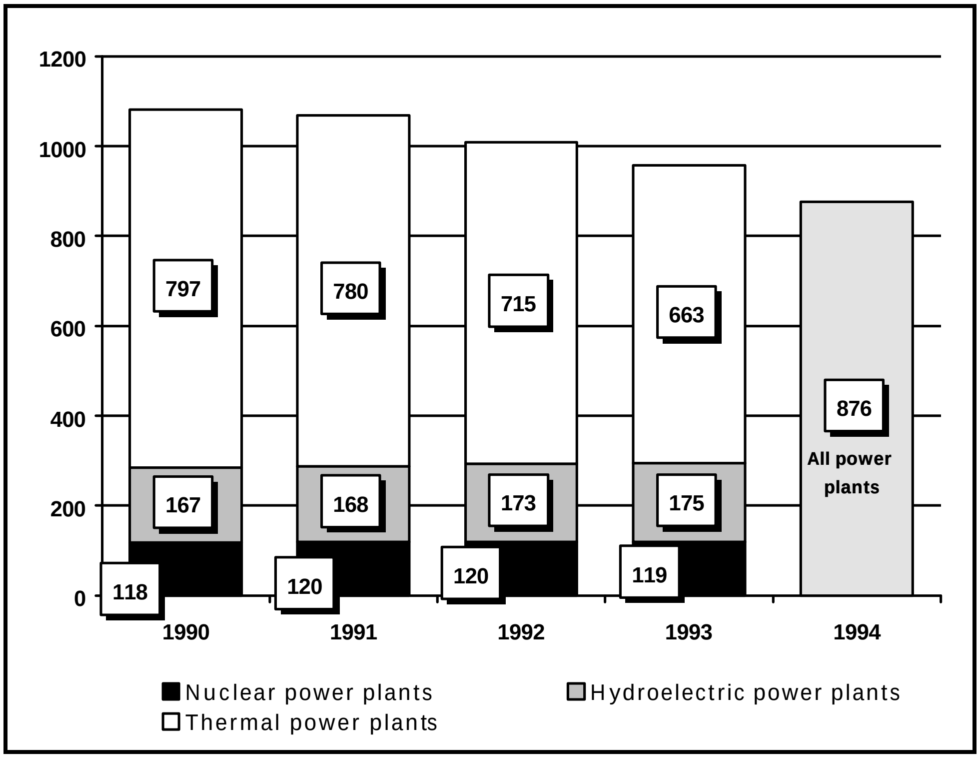
Picture 1.2

Mining of general types of fuel in Russia



Picture 1.3

Electric energy production by types of electric power plants (billion kWh)



The general consumers of electric energy in Russia are industries, including building industry. Share of these industries in electric energy consumption in 1990 was 60 % of the total consumption (Table 1.3).

Electric energy consumption per capita in 1990 was 7284 kWh.

Table 1.3.

Electric energy consumption in the branches of the economy in Russia in 1990 (billion kWh)

Branch of the economy	Electric energy consumption, billion kWh
Electrical energy production	1082.2
Import of electric energy	35.0
Export of electric energy	43.4
Electric energy consumption	1073.8
including: industries and building industry agriculture transport other branches of the economy loss in common use networks	644.7 96.4 103.8 144.7 84.2

1.4. Energy strategy of Russia

Because of general economic crisis in Russia, at the beginning of 1990s the negative transformation took place in the fuel and energy complex (FEC) of the country and in all activities in energy sector, connected with use of different types of energy resources. In this situation, the condition of FEC characterize by a number of factors having negative influence on possibilities to carry out effective state policy on regulation and limiting of technogenic greenhouse gases emissions in energy sector.

Transition to market economy and creation of competition relations in FEC of Russia have close connections with forming of balanced demand and supply prices on energy carriers. The first stage foresee self-financing of FEC branches, than, step by step, movements to appropriate structure of world prices. These measures will lead to developments in energy savings and will help to get over catastrophic lack of investments in FEC, as the most strategically dangerous aspect in the present energy crisis.

To provide all-round and effective solution of the tasks how to get over the crisis in energetic and how to provide further successful development of FEC, a new energy policy is under development in the Russian Federation. At the first stage a Concept of the energy policy of the Russian Federation in new economic conditions was elaborated. Then, in 1993-1994 the principal points of the State Complex Fuel and Energy Program of the Russian Federation ("Energy Strategy of Russia", 1994) were developed.

The main objectives of the energy strategy of Russia are:

- determination of directions and forming of conditions, favorable for most effective use of energy resources and for development of FEC potential abilities aimed to provide rise of leaving level of the people and socio-economic revival in the country in market economy;
- providing of necessary role of energy as one of most important factors in rise of work productivity and as a mean to increase the quality of population life;
- significant decreasing of technogenic loading of FEC to the environment.

For determination of priorities in new energy strategy, the energy strategy gives the highest priority to improvement in energy consumption effectiveness and in energy savings. The energy strategy rise also a goal to reduce radically the use of material, labor and environmental resources for needs of the society, especially in energetic. Together with elements of structural, technological, financial and economic policy such an approach will lead to significant limiting of greenhouse gases emissions.

2. Inventory of anthropogenic emissions and sinks of greenhouse gases

The methodology on determination of GHG emissions, which influence on climate, was used in the development of the Communication on the base of general methodological recommendations of the Intergovernmental Panel on Climate Change (IPCC). The emissions of principal GHG influencing on climate - CO_2, CH_4 and N_2O, were calculated on the base of volumes of appropriate (leading to emissions) activities and specific emission coefficients of the IPCC. Character of activity was determined on the base of state statistics and statistical data of the different agencies. At the same time, in some cases, for example, for determination of the methane emissions from coal mining, available statistical data on emissions were used. Emissions of GHG precursors - CO, NO_x and non-methane hydrocarbons from stationary sources, are given according to the state statistical data.

The emission sources are classified by four general categories, recommended by the IPCC: energy, industry, agriculture and waste. Emissions of all gases, leading to greenhouse effect and climate change, which appear as a result of activities in energy sector (fuel combustion, production, transportation, processing, storage and distribution of primary and secondary energy products, including emissions from the sources of non-combustion nature as, for example, evaporation of liquid fuels or leakages and technological gas emissions) were included into emissions in energy sector. Emissions in technological processes in industry, excluding above-mentioned in energy category, belong to industrial emissions. Agricultural emissions are all anthropogenic emissions in this sector, excluding mentioned in energy category. The same classification was used for emission in waste category.

The general attention was paid to emissions of principal GHG (CO_2 and CH_4). At the same time, in accordance with the IPCC recommendations, available data on N_2O emissions and emissions of other gases - precursors of the principal GHG were also included in the Communication.

Data on emissions given below can be determined more precisely in future, as well as estimations of emission uncertainties will be carried out.

2.1. Technogenic CO_2 emission

At the present moment the appropriate calculations of technogenic CO_2 emission were carried out, on the base of fuel and energy balance of the RF and on the cement production data - as main technology in industry category (Table 2.1). Coefficients of the specific CO_2 emissions, generalized by kinds of fuels, were used in calculations. Bunker fuels were not distinguished in statistics of the total fuel consumption in Russia in 1990 and appropriate CO_2 emission was included into emissions in Table 2.1. Bunker fuel emission will be determined later in separate chapter.

Fuel consumption given in Table 2.1 is in million tons of carbon equivalent (M tce); energy equivalent of carbon equivalent is 7 kcal/t tce or 29.3 GJ/ tce (Data of Ministry of Economy, Ministry of Fuel and Energy, State Committee on Statistics, Ministry of Building Materials, Ministry of Transport were used in calculations).

Table 2.1

Technogenic CO_2 emission in Russia (1990)

Source of emission	Specific emission, tC/tce.	Fuel consumption, M tce	CO_2 emission	
			M tC/yr	%
Coal	0.756	278	210	32.3
Oil and gas condensate	0.586	319	187	28.7
Natural and accompanied gas	0.448	531	238	36.5
TOTAL	0.563	1128	635	97.5
Cement production	—	—	11[1)]	1.7[1)]
Accompanied gas combustion in oil fields	0.448	11	5	0.8
TOTAL	**0.572**	**1139**	**651**	**100**

1) excluding emissions from fuel used for cement production; these emissions were taken into account in previous lines of Table 2.1.

As it was shown in Table 2.1, more then 98% of the total emissions are due of fossil fuel production and consumption, e.g. these emissions belong to energy category, in accordance with the IPCC classification.

Table 2.2

Distribution of the technogenic CO_2 emission by types of sources (1990)

Type of source	CO_2 emission	
	M tC/yr	%
Fossil fuel	640	98.3
Industrial production	11	1.7
TOTAL	**651**	**100.0**

Distribution of CO_2 emissions by end-use fuels types calculated on the base of fuel balance of Russia, is presented in Table 2.3.

Population of the Russian Federation at the beginning of 1990 was of 148.041 million people, according to the statistical data of the State Committee on Statistics. The CO_2 emission per capita (total and classified by different types of sources) is given in Table 2.4.

Table 2.3

The distribution of the CO_2 emissions according to specific features of the fossil fuel consumption in Russia

Fuel	CO_2 emission, %			
	Direct transformation to electric and heating energy	Use as a fuel after processing	Needs in industrial and technological processes, and other needs [1)]	Total
Coal	58.5	21.2	20.3	100.0
Oil and gas condensate	0.5	99.4	0.1	100.0
Natural and accompanied gas [2)]	64.4	1.0	34.6	100.0

1) including direct use as a fuel in industry and other branches of the economy.

2) excluding accompanied gas combustion in oil fields, given in Table 2.1

Table 2.4

Technogenic CO_2 emission per capita in Russia as of 1990

Source of emission	Emission, tC per capita in year
Coal	1.42
Oil and gas condensate	1.26
Natural and accompanied gas	1.61
Cement production	0.07
Accompanied gas combustion in oil fields	0.03
TOTAL	**4.39**

2.2. The CO_2 sink and emission in forests and peatlands.

Disturbance of the carbon cycle and the balanced CO_2 exchange between the atmosphere and terrestrial ecosystems can lead both to emission and to uptake of the CO_2. In Russian conditions, where vast areas are under forests and peatlands these fluxes can be especially large. Scientific researches in Russia as well as in other countries indicate that forests of temperate and boreal latitudes are, as a whole, sink of the CO_2.

2.2.1. Forests

Increase or decrease in the carbon stock of forest ecosystems can be caused by several reasons:

- changes in land-use and forested areas;
- changes in age and species structure of forests caused by cuttings, plantings or natural reforestation on cutting areas and burnt out places (young fast growing forests are the CO_2 sink, but overmature forests are source);
- influence of climate changes and other external factors (insects, air pollution, recreation activity, etc.) on forest growth and decomposition of organic matter.

The methodologies of the CO_2 sink/emission inventory and particularly the IPCC methodology mean several consequent steps. The first step is determination of different forest type areas and calculation of stem wood stock. The correspondent data were obtained by the Federal Forestry Service (FFS) in the last state accounting of the Forest Fund as of 01.01.1993 (Tables 2.5, 2.6 and 2.7).

The summary of the Forest Fund land accounting is presented in Table 2.5. These lands include two items: forest lands and non-forest lands (grasslands, pastures, etc.). In turn forest lands are separated on really forested lands and other lands (light woody places, ravines, etc.).

Table 2.5

Summary data on the Russian Federation Forest Fund lands as of 1 January 1993.

Total area, thousand ha	1180882
Including forest lands, thousand ha;	886538
of the above area forested lands, thousand ha	**763502**
Stem wood stock, Mm^3	80676

The forest fund lands occupy 1181 Mha, including 1110.5 Mha under the FFS management. So-called forest lands are 886.5 Mha. Forested lands cover 763.5 Mha, including 705.8 Mha or 92% under the FFS management. Other forested lands, 57.8 Mha, are under management of different owners, mostly, agriculture collective or state farms (30 Mha); forestry enterprises of the former USSR Ministry of forestry (9.95 Mha); the RF Ministry of defense (3.4 Mha); reserves of the RF Ministry of environment and natural resources contain 6.6 Mha of forests.

The total stem wood stock is estimated as 80.7 Gm^3, the contribution of coniferous species is about 80%. The total stock on the FFS lands is 73.0 Gm^3. Mature and overmature forests contain more than one-half of the stock.

The distribution of forests by natural-climate zones and subzones (Table 2.6) has a great importance for determination of the total carbon stock in ecosystems as well as for estimation of forest reaction on climate changes. The taiga forests have dominant position. Moreover the Middle and South taiga forests cover about 40 and 20% of the total forested area of the country.

The age structure of forests is an another important issue. Young fast growing forests are sink, but overmature forests are the CO_2 source. Consequently the age distribution or, actually, disturbance of this distribution from balanced is a key point which determines the CO_2 exchange with the atmosphere. In Russia about one-half of forests is age mixed. In addition the total area of the past forest plantings is relatively small. These circumstances significantly decrease the accuracy of data on age structure (Table 2.7).

Table 2.6

The distribution of the FFS managed forests by natural zones/subzones as of 1 January 1993, thousand ha.

Natural zone/subzone	Total
Space taiga, forest-tundra	117866.8
North taiga	60697.9
Middle taiga	287962.0
North taiga	146098.4
North mixed forests	21879.5
South mixed forests	16233.2
Deciduous	26114.2
Forests of forest-steppe and steppe	28937.2
TOTAL	**705789.2**

Table 2.7

The distribution of the FFS forested lands by age and species groups

	Area, thousand ha	Stem wood stock Mm^3
Forested lands	**705789**	**73028**
Coniferous		
young	88512	2776
near-mature	48234	7394
mature and overmature	259132	34156
total	507708	57677
Hard-wood deciduous		
young	2022	84
near-mature	1850	229
mature and overmature	9131	1041
total	17287	1860
Soft-wood deciduous		
young	24442	511
near-mature	12092	1732
mature and overmature	39270	6339
total	113211	12104

Before planning of forestry mitigation measures it is important to collect information about so-called forestry groups of forests. There are 3 groups which are characterized by different types of forest management. The first group contains forests which have a great environmental protection importance, high sanitary or recreation importance as well as forests with high scientific, historical or socio-cultural significance. They cover 122 Mha (17.2% of the total FFS managed forests). The second group is composed by forests of high populated regions, which are characterized by environmental protection importance and limited in use to timber harvesting (7.2%). All other forests are collected in the third group. These forests are mostly in high forested regions, they have forestry importance and cover 533 Mha (75.5%).

The situation on forest accounting and related problems were considered in recent publications prepared by the FFS jointly with the International Institute of Applied System Analysis. According to these works, on the average forestry settlement was carried out on 37 Mha annually. It means one time in 10-12 or 15-20 years in every forestry enterprise. The materials of the last forestry settlement and additional data on changes in Forest Fund (cuttings, fires, forest deceases, etc.) are basic information for the state forest accounting which was made every 5 years. In low populated Siberia and Far East regions, where there is practically no industrial timber harvesting, forest accounting was carried out one time in 30-35 years. Moreover, in some regions the accounting was done one time at all and, usually, by remote methods. These circumstances do not allow us to calculate the CO_2 fluxes by direct subtraction of data obtained in the last and in the previous forest accounting (by 01.01.1993 and 01.01.1988 correspondingly). According to forest accounting data, the total forested area was reduced insignificantly in 5 years, from 771.1 to 763.5 Mha. The analysis of space distribution of the decrease indicates that changes are connected with, first of all, far Siberia and Far East regions. Probably this decrease is more precise determination of the same forested areas and transfer of a part of lands to light woody land category. It is impossible also to make determine conclusion about changes in age structure. Qualitatively it is possible to say that areas of young and middle-age forests were increased, but areas of mature and overmature forests were decreased.

The total stem wood stock is estimated by the year 1993 as 80.7 Gm^3, that is about 1 Gm^3 less than estimation by the year 1988. The stock in the mature and overmature forests was decreased by 3.5 Gm^3. On the other hand, the stock in the young, middle-age and near-mature forests, which are active sink of the CO_2, was increased by 2.5 Gm^3.

The estimations of the International Forest Institute (Moscow) show that the total phytomass on forested area contains 36 GtC. The estimations of the total carbon content in forest ecosystems of the different natural zones were carried out in the Institute of Global Climate and Ecology jointly with the State Hydrological Institute: total carbon content in mortmass (litter, dry stems, died roots, etc.) has 16.5 GtC, soil humus is about 200 GtC, phytomass as a whole has 33 GtC.

The simplest way to estimate the CO_2 sink in forest, described in the correspondent IPCC Guidelines, is use of data on total increment of aboveground wood (Mm^3/yr) and subtraction of wood harvested or burnt out.

However in Russian conditions the calculation of the CO_2 sinks/emissions in forests has several principal difficulties.

- In our latitudes the main part of the carbon is just in soil humus. Litter and dry stems are also important from this point of view. So the exclusion of the decay processes related with these carbon reservoirs is possible but in the first draft estimation only.
- The main part of forests are not involved practically in timber harvesting now. It means that difference: “increment minus cutting” have to be replaced by “increment minus natural mortality and decay”. About one-half of the Russian forests are age mixed that is an additional difficulty in determination of increment. On the other hand, the age distribution of these forests is not close to naturally balanced so it is not reasonable to exclude their from calculations.
- Emission of the CO_2 and moreover other GHG in and after fires can be estimated now only as order of magnitude.
- Taking into account of current very modest climate changes, particularly, warming and increase in the atmospheric CO_2 concentration is especially actual just for Russia because of temperature is an important growth limiting factor for the main part of the taiga forest.

According to the Handbook “Forest Fund of Russia (as of 01.01.1993)”, the increment of stem wood is estimated as 822 Mm^3/yr. (this is so-called potential increment which does not take into account the losses caused by cuttings, fires and natural mortality). One can use available data on wood (dry biomass) density, well known data on carbon content in woody biomass and calculate this increment in the carbon terms as 200-220 MtC/yr. After that it is possible to take into account available average values of the factors connecting the total carbon stock in phytomass of forest ecosystems and the carbon in stem wood. As a result one can estimate the total increment (which does not take into account the losses caused by cuttings, fires and natural mortality) as 350-450 MtC/yr.

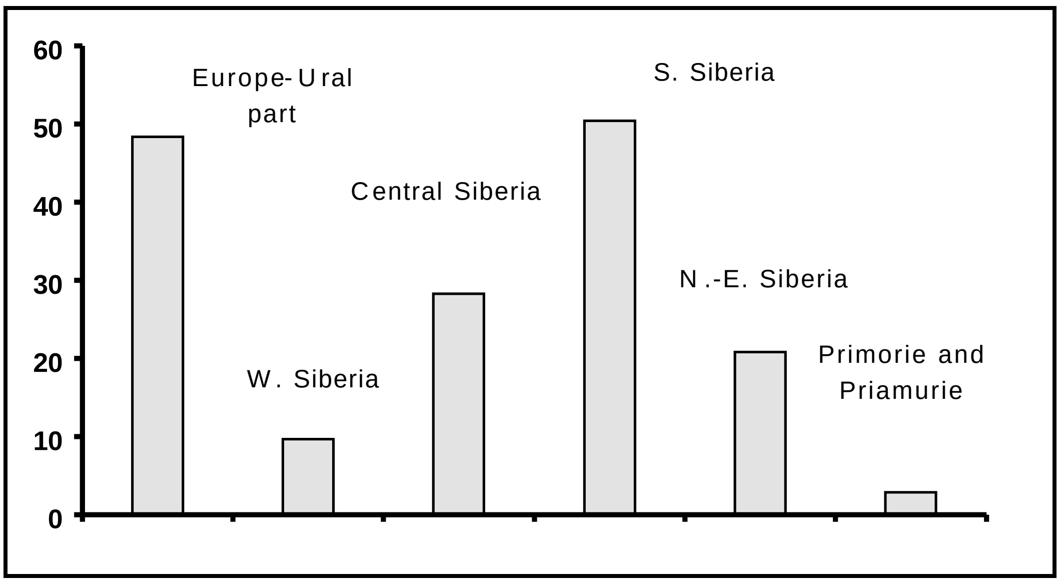
In 1993, according to the FFS data, really the main condensed cuttings covered 1.1 Mha, volume of harvested timber was about 200 Mm^3. In the carbon terms this value is about 50 MtC/yr. Additionally approximately the same amount (including roots) was left on cutting areas and was involved in gradual decay (the CO_2 emission).

Estimating the forest fire effect it is necessary to keep in mind that fires are an integral element of a natural cycle in boreal forests. An additional emission is connected only with “additional” anthropogenic fires.

The works to determine the CO_2 sink, which take into account all above-listed processes are now under progress in the FFS and the Roshydromet. These works are based on inventory and modeling of the full carbon cycle in the main types of forests in Russia. Some preliminary results are presented on Figure 2.1. The total sink in forests is estimated as 160 MtC/yr.

Figure 2.1

The distribution of the total carbon sink by natural-climate regions, MtC/yr.



2.2.2. Peatlands

The investigations which were carried out in the State Hydrological Institute allowed to calculate the CO_2 sink caused by peat accumulation. A volume of peat use as fuel or raw material is far less now than peat accumulation (the CO_2 emission related with peat use was taken into account above in emission inventory in energy and industry).

These calculation are based on the recently corrected data on areas of the different types of peatlands and data on rates of the carbon accumulation. The total peatland area is 154 Mha, including about 90 Mha of bogs with accumulation rate higher 0.5 mm/yr. The rate is varied from 0.15 to 1.5 mm/yr. In majority of cases volume density of a peat is 0.14 g/cm^3 and the carbon content of a dry biomass is 57 %. The specific carbon accumulation rate can vary from 0.12 to 0.70-0.80 gC/(m^2·yr), on the average value is 0.30 gC/(m^2·yr).

In this way the total carbon sink in peatlands is estimated as 40 MtC/yr.

2.3. Anthropogenic CH_4 emission

Anthropogenic CH_4 emission by types of sources, given in Table 2.8, was obtained partly by generalization of statistical data and published data on results of the methane emission research by branches of the economy and; partly by calculations on the base of state statistics and statistical data of ministries and agencies, as well as on the base of estimations of results of activities leading to emission, for example, on the base of annual volume of solid waste disposal (Calculations were carried out in the Institute of Global Climate and Ecology of the Roshydromet and Russian Academy of Sciences using data of Ministry of Fuel and Energy, State Committee on Statistics, Ministry of Agriculture and Provision, as well as coefficients of specific emission, recommended by the IPCC).

Table 2.8

Anthropogenic CH_4 emission in Russia (1990)

Source of emission	Emission, Mt/yr
Mining, transportation and consumption of natural and accompanied gas	16
Livestocks and livestock waste	4.9
Solid waste disposal (landfills)	2.4
Coal mining	1.9
Oil mining and transportation	1.7
Waste water refining	no data
Rice production	0.1
Other kinds of agricultural production	no data
TOTAL	**27**

It is necessary to mention individually the emission associated with natural and accompanied gas in oil fields. This type of emission takes the first place in total anthrophogenic methane emission in Russia, and its uncertainty is high.

For calculations of the total methane emission, presented in Table 2.8 and in the following tables, a mean value of 16 M t/yr was used. Uncertainties for other types of the methane sources, given in Table 2.8, provide much less contribution into uncertainty of the total emission.

Absolute and relative distribution of emissions by categories of sources, recommended by the IPCC, is presented in Table 2.9; the methane emission per capita - in Table 2.10.

Table 2.9

The distribution of anthropogenic CH_4 emission by types of sources (1990)

Type of source	CH_4 emission	
	M t/ year	%
Energy	19.6	73
Agriculture	5.0	18
Processing and disposal of industrial and other waste	2.4	9
TOTAL	**27.0**	**100**

Table 2.10

The anthropogenic CH_4 emission per capita

Source of emission	Emission, t per capita in year
Mining, transportation and consumption of natural gas	0.12
Live-stocks and live-stock waste	0.03
Solid waste disposal	0.016
Coal mining	0.013
Oil mining and transportation	0.011
Waste water refining	no data
Rice production	0.0007
Other kinds of agricultural production	no data
TOTAL	**0.18**

2.4. Other gases

Emissions of GHG precursors from stationary sources, according to data of the Goskomstat of Russia, are given in Table 2.11.

Table 2.11

Non-principal greenhouse gases emissions in Russia (1990)

Gas	Emission, M t/yr.
CO	8.1
NOx (reduced to NO_2)	3.0
Non-methane hydrocarbons	4.1

2.5. Total and equivalent greenhouse gases emission

Anthropogenic emission of the principal GHG and share of Russia in the global emission in 1990 is shown in Table 2.12.

Table 2.13 contains absolute and relative values for 1990 of equivalent emission of three principal GHG: CO_2, CH_4 and N_2O, leading to climate change. The global warming potentials of the IPCC 1994 were used in calculations of 100-year range of integration.

General contribution (72%) to equivalent emission is provided by CO_2.

Table 2.12

Anthropogenic greenhouse gases emission in the Russian Federation (1990)

Gas	Emissions of RF/ sinks of RF, M t/yr	Global emission, M t/yr [1)]	Share of RF in global emission, %
CO_2, M t C	651/200[2)]	6100	10.7
CH_4, M t CH_4	27	375	7.2
N_2O, M t N_2O	0.82	8.2	10.0

1) IPCC data
2) net-emission is 451 MtC/yr, if sinks are taken into account

Table 2.13

The equivalent anthropogenic greenhouse gases emission in the Russian Federation (1990)

Gas	Global warming potential	Equivalent emission (CO_2 equivalent)		
		Absolute M t CO_2	Fixed on CO_2 emission	Contribution to total emission
CO_2	1,0	2387	1.00	72 %
CH_4 1)	24,5	662	0.28	20 %
N_2O	320,0	262	0.11	8 %
TOTAL		**3311**	**1.39**	**100 %**

1) including direct and indirect greenhouse impact

The average values of the equivalent GHG emission per capita are presented in Table 2.14.

Table 2.14

The equivalent anthropogenic greenhouse gases emission per capita in the Russian Federation (1990)

Gas	Equivalent emission, t CO_2/capita in the year
CO_2	16.1
CH_4 1)	4.5
N_2O	1.8
TOTAL	**23.1**

1) including direct and indirect greenhouse impact

In 1990-1994 in the Russian Federation emissions of above-mentioned greenhouse gases decreased due fall in industrial and agricultural production. At the same time, according to estimations available, decrease of emissions set aside from the fall of production. This situation is due of increase in energy capacity in the national economy and, therefore, in fossil fuel consumption per unit of issued production. Other reasons are conditioned by more specific factors, for example, by continued production of significant quantity of fossil fuels for export from the Russian Federation or by increasing of the amount of cars.

3. Policy and measures on regulation of anthropogenic greenhouse gases emissions and sinks

3.1. General

According to the items 2a and 2b, Article 4 of the Convention, policy and measures, aimed to reduce greenhouse gases emissions and to improve quality of their sinks, are under development in the Russian Federation. The general attention in anthropogenic GHG sinks is devoted to practical measures aimed to control and to limit technogenic GHG emissions in energy sector in the country, first of all in utilization of fossil fuels and products of their processing in all the branches of the economy:

- energy (energy production and transformation);
- transport sector;
- industry;
- municipal sector;
- agriculture;
- other branches of the economy.

The main part of these measures follow the policy and principles, contain in developed State All-Round Fuel and Energy Program of the Russian Federation for the period to 2010 (Energy Strategy of Russia).

Concerning regulations of GHG sinks on the territory of the country, the general attention was paid in the First National Communication to improvements of quality and increasing of the carbon dioxide sinks by forests of the Russian Federation.

In all cases, policy and measures, aimed to fulfill the obligations under the Convention, are connected with or are a part of the general state economic policy and state energy policy. Two principles are of most importance in planning and implementation of measures in regulation of GHG emissions and sinks:

- Principle of economic and ecological effectiveness of planning and implemented measures (minimum resulting expenditures with maximum economic, ecological and climatic effects).
- Principle of comprehensive and all-round consideration of possible impacts of implemented measures to economic and social systems (with special attention to possible negative effects of measures to be implemented).

The coordination of the development and control in implementation phase of the measures on regulation of anthropogenic GHG emissions and sinks are provided by the Interagency Commission of the Russian Federation on Climate Change Problems, established by the Russian Government in 1994.

3.2. Regulation of CO_2 emission in energy use of fossil fuels in the branches of the economy

The policy and measures on limiting of technogenic CO_2 emission in energy sector of the country is based on Energy Strategy of Russia, developed in 1993-1994. The highest priority in energy policy the Energy Strategy determine as improvements in effectiveness of energy consumption and energy savings.

It is important to emphasize that such an approach, together with concrete elements of structural, technological, financial and economic policy, will lead simultaneously to significant limiting of greenhouse gases emissions to the atmosphere.

3.2.1. Complex of measures to increase effectiveness of energy sphere and to limit CO_2 emission

Limiting of the level of national CO_2 emission according to new energy policy is caused by, first of all, implementation of a number of measures, considered to be of high priority for solution of socio-economic and ecological tasks in development and modernization of energy supply in the country. The implementation of these tasks is based on the principle of sustainable socio-economic development, effective use of modern achievements in scientific and technological progress and transition to new economic conditions.

The most important measures in this area and activities, which will finally determine the level of fossil fuel consumption and, therefore, the level of CO_2 emission on the territory of the country, are the following:

1. Improvements in energy consumption effectiveness and in energy savings in all branches of the economy.

2. Measures in structural policy concerning energy supply for the period of the next 10-15 years:

- efficiency improvements in consumption of natural gas and rise of natural gas share in domestic consumption of fossil fuels;
- priority of deep processing and all-round utilization of hydrocarbon raw materials in the branches of the economy;
- improvements in quality of coal products by increasing of volumes of their deep dressing and preparation;
- intensification of local energy resources utilization (hydroenergetics, peat, local fossil fuel deposits, etc.);
- significant rise in non-traditional energy resources utilization, first of all, use of renewable energy resources (helio, wind, geothermal energy, mining methane, biogas, etc.)
- improvements in safety and reliability of energy blocks in nuclear power plants.

3. Technical policy, aimed to improvements in economic, energy and ecological effectiveness at all stages of mining, transformation, distribution and utilization of energy resources:

- improvements in ecological and accidental safety of energy resources and energy infrastructure;
- decentralization of energy supply system and limiting of distance between energy sources and users;
- development and use of principal new and effective technologies and technical equipment in mining, transportation and utilization of fossil fuel raw materials on the territory of the Russian Federation in the most important branches of the economy:

- energy (energy production and transformation);
- transport sector;
- industrial branches of the economy;
- other branches of the economy.

4. Measures in expedient policy in prices and taxes, which will provide with energy savings and economically effective use of energy resources in new economic conditions.

Time for implementation and results of above-mentioned measures in efficiency improvements in energy sector are in dependence on achievements in global measures aimed to get over the economic crisis in the country and to provide further sustainable development. The Energy Strategy foresees scenarios of the energy demand and energy consumption in the branches of the economy. Three possible scenarios of socio-economic development in the country were considered for the period to 2010 (optimistic, probable and pessimistic). Scenarios of resulting consumption of energy resources will depend on the measures in energy savings and in efficiency of energy consumption.

3.2.2. Energy savings and improvements in energy consumption effectiveness in the branches of the economy

Non-effective use of energy resources creates a large potential in energy savings (460-540 Mtce), which was not used in Russia and which reached 40-45% of the current energy consumption (Table 3.1). One third of this potential, which use is much cheaper than to increase mining of fuels, concentrates in FEC, mainly in electroenergy and heating supply. The second third of this potential is concentrated in industries (including 7-8% - in metallurgy, 4-5% - in building materials industry), about 20% - in municipal sector and in agriculture, 10% - in transport sector. Utilization of this potential has the highest priority in the energy policy, because each percent in savings of energy resources provide 0.35-0.4% rise of the national income.

Table 3.1

Potential in energy resources savings in Russia

	Natural gas, billion m^3	Oil products, M t	Coal, coke, M t	Electric energy, Billion tce	Heating energy, M Gcal	Total, M tce
Fuel and energy complex	45-60	15-17	33-39	38-46	160-180	150-180
Oil mining	5-10					6-12
Coal mining				8-10		2.5-3.5
Transportation of energy raw materials	8-9		7-8	30-36	150-170	52-59
Electric energy and heating systems	32-42	10-12	26-31			80-97
Oil processing		4.5-5			9-10	8-9
Municipal sector	10	0.6-0.8	21-23	65-70	120-145	75-83
Agriculture	1.4-1.5	14-15	1.5-1.7	8-10	4	27-29
Transport		29-34				42-50
Industry	34-42	6-7	12-14	220-265	167-205	158-190
General measures in industrial branches	10-13	0.5		150-185	75-100	73-92
Metallurgy	12-15	2	10-11	20-24	5-6	34-39
Machine-building industry	-(3-4)	0.5		55-60		15-16
Building materials industry	10-11.5	1.7-2	2-2.5	-(8.5-10)	40-45	20-23
Chemical and oil-chemical industry	5-6			4-5	12-15	9-10
Timber-processing industry	0.3-0.7	1-2			35-40	8-10
Total	**100-110**	**65-75**	**70-80**	**330-390**	**450-540**	**460-540**

Source: Energy Strategy of Russia, 1994

The program, how to use economically expedient part in energy savings potential, contains a system of primary measures in energy savings and priorities in further modernization of technologies. An effective policy in prices consider to be a tool for these purposes. In addition, special measures will be necessary in economic stimulation of energy savings, as well as system of administrative (establishment of standards in energy consumption, system of penalties, etc.) and organizational (establishment of funds on energy savings, stimulation of companies realizing measures in energy savings, etc.) measures will also be desirable.

Depending on completeness in realization of these measures and their success and on the base of three scenarios in development of energy (optimistic, probable, pessimistic), two variants in energy savings (optimistic and probable) are considered in the Strategy (Table 3.2). Optimistic scenario foresees realization to 2010 of all economically expedient potential in energy savings. This scenario requires large investments in energy savings and total reconstruction of the economy. This goal might be unreal. That is why the probable scenario foresees only undoubted part of the potential, which will be beneficial for utilities and will not require special stimulation measures.

Table 3.2

Variants of the energy savings (relatively to 1992), M tce/yr

	2000		2010	
	probable	optimistic	probable	optimistic
Energy resources savings,	80	180	300	470
including due to: organizational and technical measures	50	80	80	110
technologies providing energy savings	30	100	220	360

Source: Energy Strategy of Russia, 1994

3.2.3. Improvements in the structure of energy

The Energy Strategy considers to be necessary to avoid in short-period perspective the building of new large energy objects, which will require large investments. The general attention will be paid to the radical reconstruction of existing energy objects, as well as to modern technologies. For the period of coming 4-6 years it is expected:

- to prevent decreasing of gas mining, to recover in 1996-1997 its pre-crisis level and after that to increase gas mining;
- to pull up in 1996-1997 the fall in oil and gas condensate mining on the level of 270-300 Mt/year;
- to pull up the fall in coal mining on the level of 250-270 Mt/year;
- to increase significantly energy and economic effectiveness of electric energy by reconstruction and replacement of old and worn-out equipment and by combine production of electric energy and heat;
- to keep electric energy production on nuclear power plants;
- to stimulate interest of users in renewable, including non-traditional energy sources.

At the next stage (up to 2010) the structure of FEC will be improved on the base of situation in the domestic and external markets of energy resources. Necessary and maximum scenarios of FEC development, reflecting such tasks, are given in Table 3.3.

Necessary development of FEC is determined so, that energy requirements in Russia will be guaranteed with low energy consumption (maximum energy savings) and with moderate export of energy resources. Maximal development of FEC will be required if favorable conditions for extended export of energy resources will exist in conditions of high energy consumption (e.g. in conditions of probable volumes of energy savings and economic development).

Typical peculiarity of the scenarios on energy resources production is a significant rise to 2000-2010 of the natural gas share in the structure of mining and production of primary energy resources (from 40% in 1990 to 54% in 2000). This situation will allow to increase share of natural gas in the structure of fossil fuels consumption at the territory of the country and, therefore, it will allow to reduce specific CO_2 emission per unit of energy used.

Table 3.3

The scenarios of the production of primary energy resources

	1990	1993	1995		2000		2010	
			neces-sary	max	neces-sary	max	neces-sary	max
Energy resources production * total M tce, including:	1855	1526	1380	1440	1410	1600	1550	1820
Oil and gas condensate, M t	515	355	280	300	270	310	280	350
Natural and accompanied gas, Billion m^3	640	618	615	630	660	740	740	860
Coal, M t, M tce	396 257	306 196	260 166	270 172	250 160	290 185	300 190	340 210
Hydroenergy, billion kWh	167	174	161	162	165	170	180	190
Nuclear energy, billion kWh	118	119	115	120	120	125	125	160
Non-traditional energy resources, M tce	1	1	2	3	4	6	10	17

Source: Energy Strategy of Russia, 1994
* - including export

3.3. Measures to limit CH_4 emission

Programs on limiting of the methane emission to the atmosphere are currently at the stage of development and pilot implementation:

- use of landfill methane for energy purposes;
- use of coal-associated methane for energy purposes.

3.4. Measures to limit NO_x and CO emissions

The special works are implemented in the fuel and energy complex under the Program titled “Ecologically Sound Energy”. These works should decrease significantly NO_x and CO emissions at large thermal power plants.

3.5. The enhance of the CO_2 sink in forests of the Russian Federation.

The information about potential measures to increase the CO_2 sink in forests is collected here as well as data on tree planting and assistance to natural reforestation, which are basic materials for development of real measures and concrete projects. In addition the summary data about the first project which is under realization now and two planned projects are presented.

Potential measures were considered on all suitable lands and without any corrections related with real possibility to implement these measures.

According to Federal Forestry Service, potentially it is possible to increase forested area by 80-100 Mha. The average quality class of a forest which may be planted on this area will be 4 and lower (there is 5 grade classification of tree quality, the first is the best), forest condensity (the ratio between observed number of trees per ha and maximum possible number) could be approximately 0.7, probable species will be mostly larch. One can estimate that these forests at 70 years old can have about 110 m^3 of steam wood per ha and related potential sink will be 13 $GtCO_2$ or 160-180 $MtCO_2$/yr (40—50 MtC/yr).

The change in the age structure of forests could give the same large sink. There are above 200 Mha of the overmature forests in the Asian part of the country where natural mortality is more than increment. The harvesting of these forests has very low intensity and can not provide with shift of age distribution to young forests. Large-scale cuttings with immediate reforestation on 200 Mha (by 2 Mha/yr in 100 years) could result in sequestration of about 34 $GtCO_2$ (or 80-100 MtC/yr).

One more potential measure is increase in forest condensity. In Russia 28% of forests have condensity lower 0.5. An excess in precipitation is the main barrier for increase in condensity and quality class on 40% of all forested areas. Drainage measures could increase the stock of stem wood upto 130 m^3/ha or by 16 $GtCO_2$. Under implementation of these measures in 60-80 years the annual sink will be 200-250 $MtCO_2$/yr (50-60 MtC/yr).

One can list also such potential measures as: forest fire protection; improved technology of cutting and transportation; prolonged reproduction cycle as a result of replace some deciduous forests by coniferous on 120-140 Mha.

In this way, Russian forests have a great potential to enhance the CO_2 sink. Real implementation of the measures listed above requires huge expenses and careful consideration of projects.

Developing of concrete measures (on a modest area but with maximum efficiency) requires, first of all, data on current situation with reforestation.

The summary data on forest planting are presented on Figure 3.1 and in Table 3.4. In 1988-1993 these areas were practically invariable and equal to 490-500 thousand ha/yr. Forest plantations were totally created on 2474 thousand ha in these 5 years. It is around 20% less compared with the previous 5 years (1983-1988) and 40% below that in 1978-1982.

Data on measures for assistance to natural reforestation (mostly preservation of young trees on cutting areas) are also presented on Figure 3.1 and in Table 3.4. These areas did not practically change for the last 5 years: around 900 thousand ha/yr, totally 4515 thousand ha in 5 years. It is necessary to notice that it is 10% higher than in 1983-1988.

Data presented above will be used in future in developing of concrete measures to enhance the CO_2 sink in the Russian forests.

Table 3.4

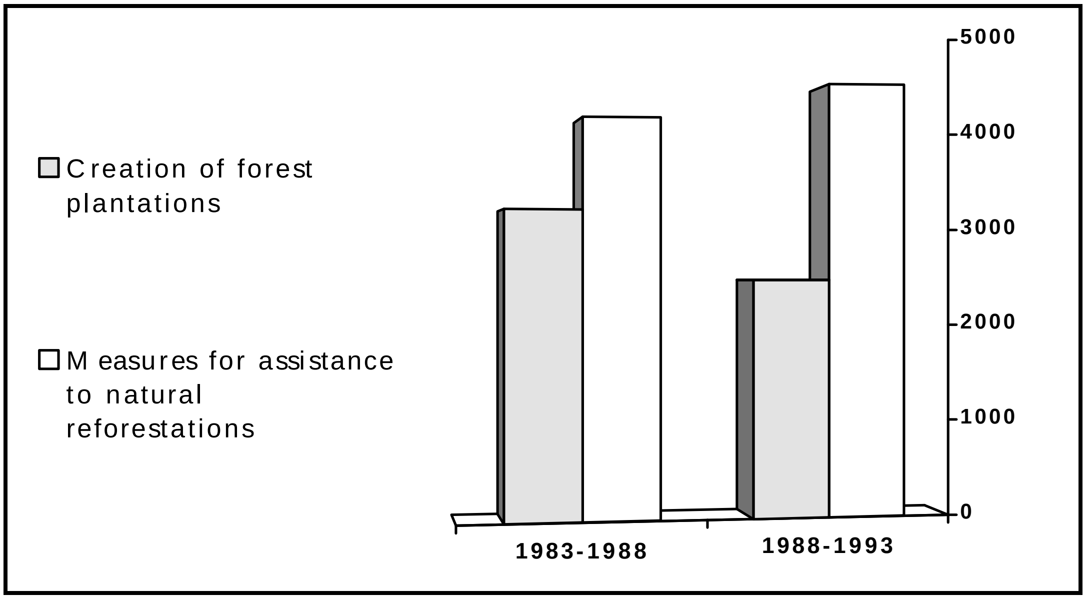
The creation of forest plantations and areas of measures for assistance to natural reforestation in 1993, thousand ha.

Economic region	Forest plantations	Measures for assistance to natural reforestation
North	87.6	229.4
North-West	25.3	4.0
Central	57.8	22.8
Volga-Vyatka	44.4	46.0

Central-Chernozem	6.1	0.8
Volga	27.9	3.8
North Caucas	8.9	1.9
Ural	94.8	117.9
West Siberia	50.7	135.4
East Siberia	63.4	184.2
Far East	28.3	158.7
TOTAL	**495.2**	**903.6**

Figure 3.1

The areas of reforestation measures in recent 5 years periods, thousand ha in 5 years



The FFS has already started realization of the first pilot project in the Saratov oblast, aimed to working out the methodology of carrying out works. Developing of the corresponded measures in the Vologda oblast and in the Far East is under progress now.

The Saratov project includes forest planting on area 500 ha on abandoned agriculture lands, pastures and burnt out places which if not the Project would be source of the CO_2. It is suggested that about 30 thousand tC will be sequestrated on planting area in 40-60 years. The Project has large environmental and recreation importance.

The larger project in the Vologda oblast is in the process of preparation. This region is characterized by taiga forest and relatively stable economic situation. Plantings are planned on abandoned agriculture lands. The diversification of economy in the oblast; organization of the National Park and promotion of tourism activity are also the goals of the Project. In the Far East even more large-scale project is considered in the region with intensive export cuttings and unique flora and fauna. The creation of additional employment and protection of unique vegetation and animals are the goals of the Project as well as reforestation and the carbon sequestration.

4. Greenhouse gases emissions scenarios and estimation of effectiveness of the measures planned

4.1. Technogenic CO_2 emission scenarios for fossil fuels use in the national economy.

The following CO_2 emission scenarios for the period to 2000 and to 2010 were based on macroeconomic estimations of possible development of the socio-economic situation in Russia, developed in the frame of the Energy Strategy of Russia, 1994, and on appropriate scenarios of energy resources consumption in all the branches of the economy.

Table 4.1 shows three possible scenarios of economical development in Russia (optimistic, probable and pessimistic). Optimistic scenario foresees successful implementation of the plans of the Government in financial stabilization of the economy, in reduction of production fall and its getting over in 1996 with further fast reconstruction of the economy to 2000 and with following sustainable rise of the economy to 3.5-4% annually. This scenario foresees principal changes in socio-economic structure, implementation of intensive policy in energy savings with high prices for natural resources and energy raw materials (appropriate to the level of world prices). The pre-crisis level of life conditions of people will be recovered in 2000-2002, according to this scenario, and will reach present life level in the countries of the European Union in 2010.

Probable scenario foresees to get over economic fall in 1997-1998, to get reconstruction of the economy at the pre-crisis level after seven-eight years with further rise to 3-3.5% annually. This scenario is also oriented to active policy in energy savings, but will be less effective, than optimistic scenario, particularly because of more moderate policy in prices and lesser possibilities in investments for structural changes in the economy. The pre-crisis level of life conditions of the population will be recovered 3-4 years later, than in optimistic scenario, and its further rise will be significantly less.

Pessimistic scenario imitates continuation of the economic crisis practically up to 2000 and much more time for recovering of life level of the population.

Combination of these scenarios in economic development and in variants of energy savings shows a large spectrum of possible variants in energy consumption (see Table 3.2). In case of use of realistic combination of these scenarios, it is possible to receive minimum and maximum levels for perspective requirements in energy (Table 4.2).

Table 4.1

Scenarios of economic development in Russia

	1990	1995	2000	2010
Optimistic				
GDP*, %	100	55	85	124
Fund of consumption, %	100	66	95	136
Probable				
GDP %	100	51	68	102
Fund of consumption, %	100	61	78	114
Pessimistic				
GDP*, %	100	46	45	72
Fund of consumption, %	100	55	53	83

*GDP - gross domestic product.
Source: Energy Strategy of Russia, 1994.

Table 4.2

Range of energy requirements in the economy of Russia

Energy sources	1990	1995	2000	2010
Electricity, billion kWh	1073	840-870	850-990	1080-1270
Energy consumption per capita, thousand kWh per capita	7.22	5.5-6.0	5.8-6.6	7.1-8.3
Heating energy (centralized), M Gcal	2075	1850-1880	1870-1950	1900-2050
Motor fuel, M t	104	74-76	76-80	83-95
Primary energy resources, M tce	1257	990-1050	950-1090	1010-1200
Energy consumption per capita, tce per capita	8.46	6.7-7.1	6.5-7.3	6.6-7.8

Source: Energy Strategy of Russia, 1994.

All energy consumption scenarios foresee primary providing with energy of the branches and activities, associated with the most necessary requirements of the people in comfortable houses, nutrition, transport and information services, including utilization of high quality energy raw materials for these purposes.

In general, the policy of energy consumption re-orientation to population needs will lead to rise of these needs in the total consumption of primary energy resources in Russia from 24-28% at present time to 28-29% in 2000 and to 30-32% in 2010.

Perspective requirements in energy may be provided by use of different combinations of primary energy resources. Taking into account technical and economic variants in development of the fuel and energy complex, contain in the Energy Strategy in Russia, planning volumes of energy raw materials export and existing specific features in consumption of different kinds of fuels, two principal scenarios of consumption of the primary energy resources were calculated. One scenario (Scenario A) reflects minimal level of requirements in energy, the second (Scenario B) - maximum level of these requirements (Table 4.3).

Table 4.3

Scenarios of fossil fuels consumption in the Russian Federation in 1990 - 2010, M tce
Range of values between Scenario A (minimal requirements in energy) and Scenario B (maximal requirements in energy) are presented in the Table

Source of energy	1990	1995	2000	2010
Solid fuel	278	179-183	174-187	206-221
Oil	319	248-251	249-255	256-272
Natural gas	531	532	553-585	596-631
Total	**1128**	**959-966**	**976-1027**	**1058-1124**

Source: Energy Strategy of Russia, 1994.

Table 4.3 contains scenarios of consumption of fossil fuels and products of their processing (solid fuel, oil and oil products, natural gas), which allow to estimate CO_2 emission in energy sector in Russia in 2000 and 2010. Estimations of CO_2 emission were carried out using available emission factors (Table 4.4).

Table 4.4

CO_2 emission factors (IPCC/OECD, 1994)

Fuel	CO_2 emission factors		
	kgC/GJ	tC/toe*	tC/tce**
Solid	25,8	1,08	0,756
Oil	20,0	0,837	0,586
Natural gas	15,3	0,641	0,448

* 1 t of oil equivalent = 41,868 GJ

**1 t of carbon equivalent (tce) = 0,7 t of oil equivalent (toe) = 29,308 GJ

Estimations of CO_2 emission for two scenarios of fossil fuels and their products consumption are given in Table 4.5.

Table 4.5

Estimations of the anthropogenic CO_2 emission. Range of values between two (A and B) primary energy consumption scenarios, million t C

Fuel	1990	1995	2000	2010
Solid	210	135-138	132-141	156-167
Oil	187	145-147	146-149	150-159
Natural gas	238	238-238	248-262	267-283
Total	**635** **100 %**	**518-523** **81.6-82.4 %**	**526-552** **83-87 %**	**573-609** **90-96 %**

Source: Calculations on the base of forecasts in primary energy rescues consumption, see Energy Strategy of Russia, 1994

4.2. Estimations of the effects of possible measures in limiting of CO_2 emission

Analysis of two scenarios developed for technogenic CO_2 emission shows, that in two most realistic versions of the development of energy (see range between Scenario A, minimal, and Scenario B, maximal) the anthropogenic CO_2 emission in energy sector in Russia will not exceed in 2000 the level of 1990.

The average anthropogenic CO_2 emission in 2000 will be (in percents of 1990 level): Scenario A - 83%, Scenario B - 87%.

It is necessary to note, that the expected decrease of the national CO_2 emission associates with the following two major factors:

1. Deep crisis in the Russian economy in the first half of 1990s leading to reduction of the CO_2 emission (in 1995-1996 the level can be approximately 80% of 1990). In 1996-2000 the expected modest rise in the production will not have significant influence on the emission level.
2. It is planned to achieve in 1995-2000 in Russia significant rise of energy efficiency and energy savings on the base of modern technologies and technical equipment, as well as on the base of new structural policy. These improvements will allow to limit CO_2 emission approximately on the level of 1990 under increasing needs of the country in energy.
3. As a result of implementation of broad complex of measures in forestry sector and taking into account impacts of climate factors, it is expected, that in 2000 and 2010 the CO_2 sinks in Russian forests may increase up to 30% and 70% comparatively with 1993 and these results will create an additional reserve in total reduction of the CO_2 emission.

4.3. The methane fluxes in permafrost zone

There is the following behavior of tundra soils now: they are the methane source in wet periods and sink in dry periods. Speaking about reaction of tundra on climate change one can see that there are different prognoses but, as a whole, it is possible to conclude that if a decrease in precipitation in summer period, tundra will be the methane sink. On the other hand, there are some mechanisms for stabilization of soil moisture and temperature which compensate this effect. In this way, if climate changes do not stimulate any succession changes in tundra ecosystems, on the average the methane fluxes could be approximately the same.

The methane production and oxidation by microorganisms strongly depend on soil temperature and moisture. It means that in short-time scale the methane flux can be significantly influenced by alteration of climate parameters.

The increase in the methane emission caused by melting is suggested in the permafrost zone.

5. Consequences of climate changes and adaptation measures

5.1. Consequences of climate change on the Russian territory.

Climate change on the Russian territory caused by increase in the CO_2 and other GHG could have the following consequences:

- change in amount of precipitation and soil moisture;
- change in natural zone boundaries. In Russia the greatest shift in vegetation zone boundaries will be in high latitudes;
- increase in crop productivity. For example, the doubling of the CO_2 concentration in the atmosphere could cause increase of present crop productivity by about 30%;
- significant change in biosphere;
- change in the river runoff and water regime of upper soil layer on significant part of territory;
- change in agriculture potential of regions;
- change in continental glaciers and decrease of permanent permafrost zone (for example, in West Siberia and Yakutiya in the beginning of the next century one can wait already for some decrease in area of permanent permafrost);
- sea level rise which will cause higher hydravlic stress on coastal constructions and buildings.

These and other consequences (the related materials were used in preparation of, inter alia, the IPCC Report) could have serious effect on climate-dependent branches of the economy.

5.1.1. Forestry

The analysis of ecological and climatological properties of the main forest species allows to compose mostly qualitative prognosis of possible reactions connected with climate change.

On the North forest boundary Siberian and Daurian larch are pathfinder species. On the other hand, their light dependence is barrier for keeping of area, where climate and soil conditions are suitable for other species. Therefore in climate change larch could be replaced by fir and even pine on a part of area (especially in the South regions).

Speaking about fir one can suggest that global warming itself could not influence on its natural extension and reforestation. However amount of precipitation may be important here. The climate change forecasted will influence negatively on fir in the South taiga and Mixed forests zones. Probable climate change will have less significance for burch than for fir.

It is possible to conclude that on the Russian territory will be no catastrophic falling in living conditions of the main forestry species. Global climate changes could lead changes in competition relations between the species. In this way, changes probably would appear in the natural reforestation processes in the boreal forest zone. One should wait for the greatest changes in Forest-tundra and North taiga.

There are some data on quantitative values of the parameters characterized reply of forests on climate change. In North and Middle taiga influence of warming and prolongation of the vegetation period causes increase in the growth rate. Under warming with the increase in the average summer temperature by 1^0C, the growth rate is 12-15% more. However, in South taiga zone this effect is 3-4 times less than on the North. The correspondent warming reply of the Mixed forests is about 3–8 %. In contrary, in the forest-steppe zone warming can cause a little decrease in the growth rate.

According to available data, the influence of the CO_2 concentration is estimated as 0.75-1.5% increase in the growth rate under the 10% increase of the concentration. The increase in amount of precipitation by 6% could cause the growth rate decrease by 0.5-1.5% in taiga forests and increase in deciduous forests by 4-5%. One also could wail for 10-15% increase in the annual rate of organic matter decay under the influence of 1^0C warming and correspondent prolongation of the positive temperature period.

5.1.2. Agriculture

Under the IPCC climate change scenarios a significant fall in Russian agriculture productivity is possible. It was shown that 30% decrease in the cereal production of the main Russian agriculture regions and 10% decrease of the total crop productivity are possible if warming and aridisation processes go simultaneously with growing soil degradation.

On the other hand, under the present climate conditions 20% growth of the CO_2 concentration could compensate cereal production losses connected with humus losses by the same 20%. Consequently, anthropogenic carbon dioxide fertilization could play a most important role in solution of food problems.

Table 5.1 contains the detail estimate of the global greenhouse effect influence on the Russian agriculture. It takes into account all significant factors: changes in climate parameters, soil fertility, growth of the CO_2 concentration and trophospheric O_3.

The atmospheric CO_2 fertilization is the powerful factor which theoretically could compensate negative influence of climate aridization waited for. Nevertheless, the total indicators of changes in crop productivity show that the CO_2 forcing effect can be significantly reduced by ozone.

According to data of Table 5.1, calculations with invariable present fertility level, the IPCC warming scenarios and the direct influence of CO_2 and O_3 result in decrease in cereal productivity on the average by 12%. Under the same suggestions fodder crops productivity is increased by 5%. One can notice that this invariable present fertility level is reachable but a most difficult task in Russia.

According to another fertility level scenario, warming and aridisation processes will go simultaneously with anthropogenic soil degradation. In this case fall of the average cereal productivity by 26% and 10% decrease of the crop productivity are forecaseted.

Table 5.1

The prognosis of agriculture productivity in Russia by 2030 for two levels of soil fertility and under 30% increase in CO_2 and O_3 concentrations.

Region	Cereal		Fodder crops	
	Fertility level			
	decrease by 80%	present level	decrease by 80%	present level
North and North-West	-6	-0	+6	+12
Central	-19	-7	+2	+8
Volga-Vyatka	-24	-9	-5	+5
Central-Chernozem	-21	-6	-8	+1
Volga				
North	-30	-16	-14	+7
South	-30	-17	-16	+12
North Caucas	-27	-19	-28	-10
Ural	-25	-10	-11	+8
West Siberia				
South	-26	-11	-1	+4
South-East	-33	-15	-8	+5
East Siberia				
South	-32	-18	-2	+8
Far East	-26	-13	-8	+1
TOTAL	**-26**	**-12**	**-10**	**+5**

So large reduce of the cereal productivity in present-day steppe zone (especially in dry steppe regions) will cause non-profitability of cereal production and this branch of agriculture will require a full transformation. It is necessary to keep in mind that in this way probability of strong droughts will be significantly higher. It means that and agriculture, as a whole, will be more non-stable in this zone than now. The calculations show that frequency of large-scale bad harvest years will be 1.5-2 times more even with preservation of soil fertility level.

It is necessary to consider also other possibilies of adaptation measures in agriculture and, first of all, optimization of land-use. In warming and aridisation the zone of marketable agriculture should be shifted up to the North. A part of drought resistant and heat-loving plants should be increased. Large-scale implementation of new water saving technologies, new distribution of meliorated and drainage lands and other possible measures should be realized. The efficiency estimation of these adaptation measures and correspondent investments require deep inter-sectorial investigations. It is difficult to overestimate an importance of such works.

5.1.3. Permafrost regions

Permafrost covers about 10 Mha in Russia that is 58% of the total territory of the country. According to the IPCC prognosis, increase in annual temperature by 2^0C will cause shift of the south permafrost boundary up to the North by 250-350 km. This shift and decomposition of permafrost will influence on, first of all, human settlements with all their infrastructure, roads, airports, energy objects (oil and gas pipelines, power stations, etc.). Probably, these processes have started already. For example, an excess of air temperature (in comparison with normal values) initiated the process of exfoliating and slipping down of soil layers in the Russian Arctic Yamal peninsula in 1989.

5.1.4. Sea level rise

Sea level rise with related influence on coastal regions is one of the most important consequences of possible climate change. Russia has faced with such problems. There is Caspian Sea level rise due to different reasons including change in climate and precipitation regime in Volga River basin. Since 1978 the permanent rise was observed and as of 1995 it is equal to 2.5 m.

According to the Russian Federation Committee on Water Management, 320 thousand ha of value lands were flooded and excluded from use in recent 16 years in the Caspian Sea region. There was large damage of coastal towns, ports, roads, thousands people were replaced. The total direct losses were 4.3 billion rubles (in prices of the year 1991).

5.2. Adaptation measures.

Effects in biosphere caused by climate changes mostly result in significant social and economic consequences. The main climate-ecological effects and their socio-economic consequences are collected in Table 5.2.

The special role among these effects is connected with changes in GHG emissions and sinks when we have the both climate change and environmental pollution. Such changes have deep social consequences, they influence on national strategy to reduce net GHG emission and possibility of energy development.

Estimation of possible social-economic consequences of climate changes should include all aspects of relations between natural ecosystems and people. Particularly, possibility of ecosystems to provide human population with food is determined (directly or non-directly) by the following their abilities:

- to support and regulate the main living processes;
- to create production consumed by human population (water, food, construction materials, fuel, medicines, etc.);
- to create determine landscape structures (human settlements, agriculture, resorts and recreation territories).

Table 5.2

Ecological-climatic effects and their consequences

Ecological-climatic effects	Socio-ecologocal consequences	
Change in natural climate zone boundaries	Change in agriculture structure.	Changes in agriculture productivity, areas covered by different crops, livestock pastures and arid lands.
	Change in forestry structure.	Changes in forestry productivity, areas covered by different tree species.
	Change in land-use and human activity caused by permafrost melting.	Decrease in permafrost area. Damages in human settlements. Damage of roads and transport structure, oil and gas pipelines.
Sea level rise	Influence on human settlements and transport.	Growth in coastal territories flooded. Change in spawning-ground state. Damage of human settlements. Damage of roads and transport structure.
	Changes in marine ecosystems	Change in marine ecosystem state.
Change in environment	Increase in hard ultraviolet radiation.	Growth in sickness rate, increase in prevalence of eye disease. Change in productivity of natural ecosystems, forestry and agriculture.
	Increase in environment pollution caused by worse air mixing conditions and strengthening of photochemical reactions.	Increase in areas with overloading of pollution standards. Growth in sickness rate, worsening of health and living conditions. Decrease in productivity of natural ecosystems, forestry and agriculture.

Developing of adaptation measures connected with human settlements, correspondent infrastructure and economy in permafrost zone has a great practical importance in Russia.

At last it is necessary to highlight actuality of vulnerability estimations for coastal regions influenced by sea level rise and related developing of adaptation measures.

Currently recommendations for adaptation to climate changes are developed under the State Scientific and Technological Program “Global changes of environment and climate”. There is intensive preparing of the special Federal Program “Prevention of dangerous climate changes and their negative consequences” which includes climate change adaptation subprogram.

The structure of the possible measures is presented in Table 5.3

Table 5.3

Structure of measures

Field of activity	Measures
Health protection	Estimation and prediction of climate changes consequences related with health of Russian people. Development of proposals to adequate reaction on these consequences.
Economy	Development of conception of the Russian economy regulation in adaptation of government and private sectors to climate changes (according to: administrative structure: republics, regions, oblasts; natural-climatic zones, including permafrost regions; branches of economy). Economy conditions and their structural changes with taking into account of climate changes suggested. Estimation of vulnerability and economic climate changes consequences (losses and benefits) for branches of the Russian economy.
Agriculture	Estimation and prediction of climate changes consequences in agriculture. Development of proposals for technology implementation. Estimation of influence on soil properties. Influence of climate changes on distribution of insects related with agriculture. Estimation of direct influence of the atmospheric CO_2 and other GHG. Investigations of regional consequences.
Environment protection	Economic estimation and development of legislative aspects of climate change adaptation.
Water management	Estimation and prediction of climate change consequences related with numerical parameters of water resources (according to administrative units, natural-climatic zones, large water basins). Estimation of vulnerability of water resources to climate changes.

Table 5.3 (continue)

Field of activity	Measures
Monitoring of climate changes and their consequences	Realization of climate changes monitoring in global and regional scale on permanent base. Estimation and prediction of climate changes tendencies. All-round estimation of climate change consequences and their influence on climate system as a whole.
Forestry	Estimation and prediction of vulnerability of forests to climate change. Development of proposals to adaptation of forests to climate changes. Estimation of economic climate change consequences for forestry and forests.
Transportation	Estimation and prediction of climate change consequences related with transportation (ice and hydrological regime, state of permafrost).
Construction	Estimation and prediction of climate change consequences related with buildings and constructions in permafrost zone and regions flooded.

6. Investigation of climate system and systematic observations

6.1. Climate changes observed.

In characterizing of the XX century climate it is necessary to notice, first of all, two facts. Firstly, according to observations, so-called global warming was detected. Secondly, there is increase in GHG concentrations (first of all, carbon dioxide) which, according to theoretical investigations, can be reason of warming of the atmospheric surface layer. However quantitative characteristics of the global warming noticed in the above and especially details of space distribution are known only approximately and prognoses are significantly a matter of convention.

Air temperature. Over the North Hemisphere in 1891-1993 the positive linear trend of the average annual air temperature of was 0.35^0C per hundred years. In 1990 warming arose up to record value, in recent years the trend is somewhat smaller, probably due to volcanic activity.

In the last century in Russia a general tendency of the surface air temperature was characterized by slight positive linear trend in all seasons except autumn.

The 1961-1990 three decade period was more warm than the previous, 1931-1960, in the Eurasia (especially in winter and spring), South America, North Africa and Australia. The opposite situation is in the North regions of the Eurasia, North and Central America. On the Russian territory there was warming in winter and spring in the South Siberia while in the North regions some cooling was detected in autumn and winter. The last decade was the most warm over the Earth as well as in Russia.

Atmospheric precipitation. On global scale in the XX century there was no detected unidirectional trend in the atmospheric precipitation over the continents. In the last 30-40 years over the North Hemisphere continents precipitation increased in non-tropical latitudes and decreased in subtropical latitudes. In Russia interannual alterations of the annual and seasonal precipitation also had not valuable trends in 1891-1993 over almost all territory. One can highlight the 1960s when increase in the annual precipitation in the Asian part of Russia as well as in the country as a whole was changed by decrease, which is especially detectable in summer. On the European part the annual precipitation were mostly in growing in the last 40 years. The last decade in Russia as a whole was the second from the most dry decades of the hundred years record (first of all, in the Asian part).

Currently regional peculiarities of climate changes have not been sufficiently explored. Additionally it is necessary to extend list of climate monitoring parameters (wind, air humidity, state of surface and etc.). These issues are subject of the future development of climate monitoring methods.

6.2. Climate changes expected.

Climate changes coming can be discussed mostly by climate models, which investigate vulnerability of climate system to change of boundary conditions, and by paleoclimate analogies.

Anthropogenic climate signal, connected with growth of GHG concentrations and change in atmospheric aerosol, is estimated by modern models. The event of the global warming can be considered as registered but its value and space distribution are characterized by high uncertainty.

There is determine opinion of the modern scientific literature that the increase of the atmospheric CO_2 concentration will cause 1^0C warming of the North Hemisphere air surface layer temperature by the year 2000 and that in the next century doubling of the CO_2 concentration will be reason of 3.5^0C warming. The most up-to-date models and new GHG and aerosol scenarios give us more modest warming estimations. All models indicate that near the poles changes will be higher than near the equator; warming over continents will be faster than over oceans. However, the prognoses of the regional-scale models are very uncertain and sometimes are in contrary between each other. So regional prognoses can not be considered as reliable. It is very important to develop methods for detecting of anthropogenic climate signal and assessment of quantitative characteristics.

The prognoses of changes in the average air temperature of the North Hemisphere and the Russian territory in 1993-2010 caused by anthropogenic influences is presented in Table 6.1.

The new CO_2 scenarios published by WMO were used in this prognosis. According to different scenarios, the CO_2 concentration expected by 2010 are from 382 to 392 ppm (the CO_2 concentration was 353 ppm in 1993). Obviously this prognosis does not exclude possibility to face some years or periods with high enormous climate conditions.

Table 6.1

Prognoses of antrophogenic change in the average air temperature from 1993 to 2010.

CO_2 concentration, ppm	North Hemisphere ^0C	Russian territory ^0C
382	0.35	0.80
392	0.47	0.82

6.3. Research of terrestrial ecosystems

Systematic forest accounting and related observations are carrying out over all Russian territory. The All-Russian Scientific and Information Center of Forest Resources of the Federal Forestry Service is lead organization in this field. Detail forest accountings were made every 5 years (1993, 1988, 1983,...). Data on bog areas and peat accumulation were collected in several decades in the State Hydrological Institute of the Roshydromet. Systematic research of influence of climate factors on the terrestrial ecosystems are under progress in the Institute of Global Climate and Ecology of the Roshydromet. These research include analysis of collected data, developing of models and also some experimental works. Investigations connected with influence of warming on tundra and methane emission to the atmosphere are carrying out in the Institute of Atmospheric Physics of the Russian Academy of Science

6.4. Scientific and technological programs

The following Federal and State scientific and technological programs aimed at reducing anthropogenic emissions and natural resources savings were under implementation in the Russian Federation:

1. Fuel and energy.
2. High-speed environmentally sound transport.
3. Environmentally sound energy.
4. Resources saving and environmentally sound processes in the metallurgy industry.
5. Environmentally sound chemical industry and chemical technology processes.
6. Russian forests.
7. All-round use and reproduction of wood.
8. Most up-to-date bioengineering methods.
9. Technologies, equipment and production in the future.
10. Processes hold much promise for the agriculture production.

11. Processes hold much promise for the agro-industry processing.
12. Advanced technologies of the integrated development of Russian fuel and energy resources..
13. Global changes in the environment and climate.
14. Safety of the population and objects in the national economy taking into account the risk of natural and technogenic catastrophes.
15. All-round investigations of oceans and seas, Arctic and Antarctic.
16. Ecology of Russia (from 1993 - Environmental safety of Russia).

6.5. Organization of climate change monitoring.

In accordance with World Meteorological Program, analysis of observed climate changed is under progress in framework of projects related with climate system monitoring and climate change detecting.

The goal of the climate monitoring is detecting of climate anomalies, deviations of monthly averaged, seasonal and annual meteorological parameters from the normal values. Usually values averaged over 20 - 30 years are considered as normal. It means that the goal is also determination of trends of these normal values (or characteristics of climate in the different three decade or other long-time periods) and assessment of a part of the climate changes connected with anthropogenic impacts.

The Roshydromet is responsible for climate change monitoring in the Russian Federation. Since 1985 bulletin “Data on climate monitoring” was issued. The bulletin which contains data on air temperature (the Earth), atmospheric precipitation (the continents of the North Hemisphere) and also data on the atmospheric circulation in middle troposphere (the North Hemisphere), cloud cover (the Earth), temperature of the World Ocean surface (the North Hemisphere). A part of data are transferred to WMO for publication. All estimations are referred to the Earth, the Hemispheres, the continents and oceans, large States, and regions of the Russian Federation.

7. Education and public awareness.

The Russian Federation pays a great attention to education of specialists in climatology. There is education courses related with the different issues of climatology in the following universities:

Sankt-Peterburg Hydrometeorology Institute - meteorology and climate.

Sankt-Peterburg University - climatology and ecological issues

Moscow University - climatology and climate theory. There are courses: general climatology; climates of the Earth; climates of the Russia and neighbor countries; theory of climate; applied climatology.

Kazan University - climatology and renewable energy resources.

Perm' University - climatology and water resources.

Tomsk University - medical climatology.

Saratov University - general climatology.

Irkutsk University - regional climatology.

Far East University - regional climatology.

The general public of the country is providing with recent news about anthropogenic climate change problems from the following sources:

- popular-scientific magazine “Nature”, “Chemistry and Life” and etc., scientific and technological journals “Meteorology and Hydrology” (translated in English and distributed in a lot of countries), “Izvestiya (News) of the Russian Academy of Science, geographical issue” and others.
- Scientific and technological literature published by the Hydrometeorology and other publishing houses.

8. International cooperation and participation in joint implementation of the convention.

The Russian Federation takes an active part in international cooperation related with anthropogenic climate changes.

The Russian side took an active part in the work of the Intergovernmental Negotiation Committee on the Convention and continues to participate in the Convention Side Conference. Head of the Roshydromet, A.I.Bedritsky is vice-chairman of the Side Conference.

Many scientists from the Russian Federation contributed much to the Intergovernmental Panel on Climate Change and its working groups. Academician Yu.Izrael is vice-president of the IPCC. Russian scientists participate in many global programs under the World Meteorological Organization (WMO). Under the WCP (World Climate Program) Russian specialists are participating in the projects: Climate System Monitoring; Climate Change Detecting. Academician G.S.Golytsin is member of the Joint Scientific Committee of the WMO - International Council of the Scientific Unions under the World Program of Climate Change Investigations.

Russian scientists and specialists take part in programs and projects under the World Program on Climate Investigations realized by WMO: Global Experiment on Energy and Water Cycle (GEWEX). Experiment on Modeling of the Global Climate System; Tropical Ocean Global Atmosphere Investigation Program (TOGA), World Global Ocean Circulation Experiment (WOGE)., Climate Variability and Predictability Experiment (CLIVAR); Arctic Climate System Investigation Experiment (ACSYS).

At the intergovernmental level the following international projects on anthropogenic climate change issues are under implementation:

1. Climate projects in the framework of the CIS co-operation on the meteorology. Specialists of the Roshydromet take part in the Working Group of the Intergovernmental Hydrometeorological Council of the CIS countries “Global and Regional Problems of Climate Change and Ozone”.
2. Russian-American agreement on the co-operation in the field of the environment and natural resources protection. Working Group VIII “The Influence of Environmental Changes on Climate”.
3. Project “The Russian Federation Climate Change Country Study” under the US Climate Changes Country Studies Program.