Initial National Communication of Azerbaijan Republic on Climate Change

PHASE 2

Capacity Improvement Activities on Climate Change in the Priority Sectors of Economy of Azerbaijan

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FOREWORD

Initial National Communication of Azerbaijan Republic under UNFCCC on Climate Change has been developed in 1998 through 1999 and on May 23, 2000 it was submitted to the UNFCCC Secretariat. Moreover during the Sixth Session of the Conference of Parties (Hague, November 12-24, 2000) presentation of this document was made and the published versions of a Communication in Russian and English languages were disseminated among the participants of that meeting. That document served as the first stage of climate change studies in Azerbaijan and helped with solution of the following objectives:

- Preparation of the Greenhouse Gases Emission and Sinks inventory covering the period of 1990 through 1994;
- Development of emission forecasts and mitigation activities;
- Assessment of vulnerability and climate change impacts and adaptation activities.

This work is the continuation and constituent part of the Initial National Communications. Current document is aimed at solution of the following tasks:

- Identification of technology needs for capacity improvement in the priority sectors of Azerbaijan economy; study of technology acquisition and introduction opportunities; assessment and preparation of projects
- Capacity development for participation at the Systematical Observations Network
- Implementation of additional researches of vulnerability and adaptation of fish resources and desertification processes to climate change.

Researches in these fields are very important in all terms. In order to achieve the goals imposed by Kyoto Protocol Mechanisms and Articles 2, 4 and 5 of a Convention it is necessary to organize fast and wide-scale transfer and application of technologies and know-how, which serve for mitigation of GHG emissions consequences [2,3].

Study of existing literature and documents of the Conference of Parties and supplementary organs of a Convention shows that climate change issues is full of uncertainties and disputes. However one point is evident - technological innovation is the key to prevent the negative impacts of climate change.

In future the economic policies of all states – especially those with economies in transition – must develop upon the technological progress [4,5].

In order to achieve the goals, which were pointed out above, national experts of Azerbaijan – with financial support of GEF and UNDP – implemented the second phase of a project – "Climate Change Enabling Activities. Phase II: Capacity Improvement Activities in the Priority Sectors".

Implementation of the project involved many qualified experts from different ministries and agencies and NGO's of Azerbaijan.

Researches in the field of technology needs assessment and development of projects for priority sectors were implemented by the following experts:

- O. Mahmudov (Radiation Studies Department of the Academy of Sciences), M. Mehtiyev and G. Suleymanov (State Hydrometeorological Committee), T. Kangarly (Ministry of Economy), E. Atakishiyev (JSC "Azenergy"), G. Agayev (Private JSC "Azerigas"), A. Sadikhov (SOCAR), I. Mamedov (Municipal Power of Baku), B. Askerov (Municipal Power of Sumgait), N. Nazarov (State Company "Azerchemistry"), I. Khalilov (Railways Administration).

Works on systematical observations capacity assessment were conducted by S. Khalilov and F. Bairamov (State Hydrometeorological Committee). Adaptation of fish resources to climate change was assessed by T. Osmanov (State Hydrometeorological Committee), and K. Ragimov (Institute of Geography of Academy of Sciences) assessed the adaptation of desertification processes.

Technical works were performed by the specialists of National Center on Climate Change of the State Hydrometeorological Committee – I. Kangarly, M. Kazimova, A. Mansimova, S. Mustafayev and P. Rustamova.

Within the whole course of project implementation national experts visited many regions of Azerbaijan and collected the relevant information. There were held four workshops attended by all of the interested national agencies and organizations. Numerous scientific and informational articles were published in the newspapers and TV and radio interviews were organized.

Project administrators are also thankful to many other experts, which contributed to the project development. We are also grateful to the municipal powers and Azerbaijani businessmen, who assisted the development of current document.

1. Identification/submission of technology needs.

1.1. Criterions of technology needs identification.

Under current economic circumstances of Azerbaijan the identification of technology needs is very important task in terms of prevention of the dangerous consequences of climate change. This is mainly explained by the necessity to efficiently use the natural resources of our country.

As was mentioned by IPCC, the technologies serving for climate change impacts mitigation and adaptation to climate change must be an Environmentally Sound Technology (EST) and support the sustainable development. While identifying the technology needs of a certain country not only the assessment of specific technology types is necessary, but it is also significant to consider the entire systems, which include such aspects as know-how, production procedures, goods and services, organization and management. Thus the concept "technology" covers not only the physical appearance but also all of the procedures concerning production and usage of a technology in its' physical terms.

Manufacturing and introduction of new technologies must base upon the national economic development priorities. Achievement of social and economic growth is the basic objective of economic policies pursued by the states with transition economies. However methods of how to achieve and support economic growth must conform to environmental standards and priorities.

Following criterions are applied while selecting the climate relevant EST's:

- Economic sectors, which are important in terms of reduction of GHG emissions;
- Share of the selected sector in the structure of GDP;
- Assessment of existing technologies;
- Interaction with the other technologies;
- Permanency of GHG emissions reduction;
- Quantitative reduction of GHG emissions obtained once the technologies change;
- Environmental, political and socio-economic importance of technologies;
- Further improvement opportunities.

Whether it was the identification of technology needs, or selection of corresponding climatic or environmentally sound technologies, or development and realization of the projects leading to reduction of emissions – all of these activities were implemented by stages and based upon the outcomes of the Phase I studies [1] (Fig. 1).

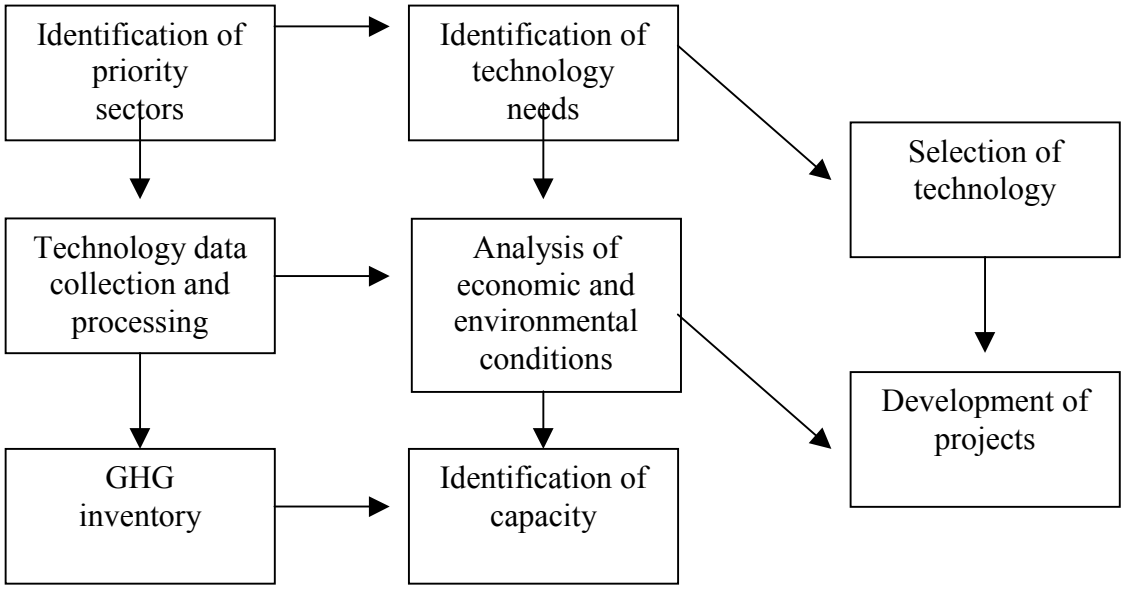

Fig. 1. Scheme of technology needs assessment.

1.2. Identification of priority economic sectors for technology needs assessment.

National technology needs cover the broad spectrum from GHG emissions reduction technologies to adaptation technologies. While the national economy of Azerbaijan is on its' way of transition, the technologies for fuel and energy industry (to include the production and distribution of fuel), communal and residence sectors and clean energy (solar and wind and geothermal power and etc.) production sector are the priority ones.

Priority adaptation technologies include the ones, which save the water and soil resources, promote the sustainable development of forests, reserve and develop the fish reserves and support the national food security.

Technology needs for the priority sectors were assessed at the basis of a) GHG emission inventories for the period of 1990 through 1994 [1], b) data on the structure of GDP of 1990 through 1998 and c) information on energy efficiency of different countries [7,8,9]. There were developed the following criterions:

1. CO_2 emissions and methane are the criterions used in the GHG inventory (1990-1994) and applied to identification of technology needs for the priority sectors. Analysis demonstrated that 80-90% of CO_2 emissions emanates from the "Energy" category. Priority sectors of this category are defined as follows:
   - Energy production and fuel refining – 38.4%
   - Industry – 18.0%
   - Transport – 10.2%
   - Commercial and residential sectors – 26.2%
2. The share of a sector in GDP structure is a criterion used for determining the priority sectors. Analysis showed that in 1999 the share of industry in the GDP has made up 23%, while the fuel and energy complex is a priority industrial sector and makes up 68.3%, of which:
   - Fuel industry – 51.7%
   - Electrical energy – 16.6%
3. Comparison of specific energy intensity of existing and new technologies of a country with the global average. Two basic criterions will be applied under this method, that is
   - Comparison of specific energy intensity by the economic indicators (see Table 1);
   - Comparison of specific energy intensity of existing technologies with the standards applied to these technologies or modern ones.

Economic development is closely related to the specific energy intensity. Under the market economy, energy intensity level of the production considerably impacts the product's price and competitiveness. Prices go up due to the high energy intensity. This factor reduces product's demand and stalls the production development. As a result of fact reduction of tax basis and public welfare occurs and foreign exporters of goods get an extra opportunity to gain revenues.

In the year of 1997 the specific energy intensity (i. e. the energy consumed per the unit of GDP) of the national industrial production by 8.5 times exceeded the global average and by 12.9 times went beyond the European average (see Table 1).

Natural gas and liquid oil products are the main primary energy types in Azerbaijan. Within the course of last few years the structure of fuel consumption in the energy production sectors of a country has changed. In 1990, the shares of consumed fuel oil and gas has made up 33% and 67% respectively. Now these indices changed and the share of consumed fuel oil became 80%. Therefore it is logical that the CO_2 emissions level increased accordingly.

Criterions, which were pointed out before, were used for identification of the priority sectors and sources of technology needs assessment (see Table 2).

Table 1. Energy intensity indicators of the various countries as of 1997.

Regions / states	Population (mlns.)	GDP ($ blns.)	FEC Mt	Emission $MtCO_2$	FEC/capita toe/capita	FEC/GDP Toe/$	CO_2/FEC tCO_2/toe	tCO_2/ capita	$kgCO_2$/ capita
Global	5681.19	25269.78	9584.56	22853.41	1.69	0.38	2.38	4.02	0.90
EU	1093.88	20022.45	5067.52	12235.02	4.63	0.25	2.41	11.18	0.61
Asia	1713.02	1383.74	982.25	1907.96	0.57	0.71	1.94	1.11	1.38
Azerbaijan	7.60	3.71	11.99	32.09	1.58	3.23	2.68	4.22	8.64
Azerbaijan (1990)	7.13	8.28	17.13	44.70	2.40	2.07	2.61	6.27	5.40
Armenia	3.76	1.88	1.80	3.08	0.48	0.96	1.70	0.82	1.63
Georgia	5.43	3.92	2.30	4.59	0.42	0.59	2.00	0.85	1.17
Russia	147.31	349.89	501.98	1456.24	4.02	1.69	2.46	9.89	4.16
Ukraine	50.70	65.23	150.06	375.59	2.96	2.30	2.50	7.41	5.76
Turkey	63.75	203.05	71.27	187.49	1.12	0.35	2.63	2.94	0.92
USA	266.79	6629.50	2162.19	5470.49	8.10	0.33	2.53	20.50	0.83
Germany	82.05	1833.12	347.27	883.99	4.23	0.19	2.55	10.77	0.48

Table 2. Priority sectors for te4chnology needs.

Category	Sector	Sources
1. Energy production	1. Energy production and refining of fuel	1. Energy production 2. Energy transmission and distribution 3. Production, refining, storage and transportation of oil and gas 4. Flaring of gas
	2. Industry	1. Ferric and non-ferric metallurgy 2. Building materials production
	3. Transport	1. Auto-transport 2. Railways
	4. Commercial and residential sector	1. Usage of electrical energy and heat
2. Industry	1. Metallurgy 2. Ore-free mineral products 3. Chemical industry	1. Ferric and non-ferric metallurgy 2. Building materials production 3. Chemical industry
3. Agriculture and silviculture	1. Stock-raising 2. Plant-growing 3. Silviculture	1. Manure 2. Plant-growing wastes 3. Wood biomass
4. Wastes		1. Solid wastes 2. Communal sewage
5. Alternative energy sources		1. Solar 2. Wind 3. Biomass 4. Geothermal

1.3. Main trends of the project development for the priority sectors.

Analysis of data by the economic sectors showed that the Republic of Azerbaijan has many priority sectors, which are currently in need of technological modernization. Meanwhile the energy intensity relevant sectors are considered the most important in these terms (see Table 2).

Low energy efficiency of economy still remains to be the basic reason for problems occurred in the national fuel and energy complex. Power consuming intersectoral structure of industrial production and technological imperfectness of the main production funds' manufacturing capacity are the main sources of such a condition. Energy intensity of many technologies considerably exceeds that of developed countries.

Lack of accounting and control over the use of fuel and energy carriers as well as the stagnation of production facilities negatively influence upon the energy efficiency.

Limited use of energy saving technologies, accounting equipment and alternative energy sources comes from the poor solvency, insufficient database and structure of a technology market. Lack of financial means and difficulty to obtain the credits with appropriate terms are also the case.

Considerable energy intensity is explained by increasing number of out-dated production reserves, worn out technologies and lack of specialists qualified in the field of energy efficiency. Public are not informed on effective methods of how to provide the efficient use of power.

Assessment of the energy efficiency mobilization activities showed that once we maintain the 1990 level of energy intensity for all of the sectors of economy, then we can achieve 13-fold increase of GDP per capita.

Changes, experienced by our economy for the last few years, also reflect on energy intensity of its' different branches. Day by day the production volumes increase and the structure of production changes. Public demand for electrical power and heat goes up and energy intensity of the service sector increases. The more the public welfare improves the more demand for energy becomes.

Currently there are prepared several alternative scenarios of our country's further social and economic development, which include the specified purpose programs on industrial, agrarian, regional and social and environmental development.

Solution of these strategic tasks with the secure power supply and high rates of economic reforms and further development of investment process given enables the realization of immediate projects providing for introduction of new climate relevant technologies leading to reduction of GHG emissions (see Table 3).

Table 3. Priority sectors for technology needs assessment.

Sectors	Activities
Electrical energy production	Replacement of fossil heavy oil products with natural gas Introduction of new technologies at the basis of steam gas turbines on TPP's Increase of the share of hydro-energy production and alternative energy sources
Oil and gas production	Collection and utilization of accompanying gas while the oil production Transition to less energy intensive oil production technologies Introduction of new technologies in oil refineries Introduction of energy saving technologies in the gas sector
Transport	Application of modern transport facilities Reconstruction of railway transport
Commercial and residential sectors	Installation of control and measuring equipment while the energy and natural gas distribution Municipal heating and hot water supply Transition to modern lighting equipment
Agriculture and forestry	Use of agricultural biomass and manure for energy production Plantation of new forests with the view to produce renewable energy
Wastes management	Processing of solid organic wastes Collection of methane from sewage cleaning machines.

2. Capacity development for identification of technology needs, acquisition and introduction of technologies, assessment and development of projects.

2.1. Current condition of existing technologies.

Study of GHG inventory data, assessment of climate change mitigation activities and relevant capacity as well as assessment of technology needs for all of the economic sectors of Azerbaijan [1] show that application of out-dated and energy intensive technologies serves as the main reason of large GHG emissions. Information on national economic sectors' energy intensity was presented in Azerbaijan's Initial National Communication on Climate Change.

Electrical energy industry of Azerbaijan is now suffering from the shortage of natural gas, for which furnace fuel oil is being used for electrical power production. Despite recent introduction of a range of modern supply systems the technical and economic indicators of that sector stay very poor. In the year of 1998 the efficiency of fuel consumption by Thermal Power Plants (TPP) has reduced by 19% as compared to the baseline 1990. Usage of worn out technologies led to considerable losses in the power supply system, which have reached 3 billions of kW/h in 1998 that is by 17% above the normal level. Losses in the power distribution and heating systems were high as well and made up 4% and 35% respectively.

Technical indicators of the **oil and gas sector** are unsatisfactory as well. More than 70% of the oil deposits' production reserves are in a bad condition. As a result of considerable technological losses while production, storage, transportation and refining of oil and gas the atmospheric emissions of hydrocarbons occur. Average energy consumption level per one ton of produced oil exceeds the normal one by 2.6 times proceedingly.

Current condition of the gas transportation system of Azerbaijan is unsatisfactory. The most critical problem is corrosion challenged by considerable portion of gas distribution system. Losses of gas occurred while its' transportation, distribution and consumption are also critical. They make up 18-20% that exceeds the losses in the other South Caucasus states (1.3-2.7%).

Current condition of **industry** is also considered critical. This state is caused by the following factors:

- structural inefficiency, out-dated equipment and production technology. Radical modernization and technological re-equipment of a sector is required;
- 70% overexploitation of the main production reserves;
- poor efficiency of the usage of fuel and energy resources, specific consumption of which exceeds the level achieved by technologically developed countries by 15-20%;
- imperfect structure of the metallurgy with extremely low level of final production.

Ferrous metallurgy includes mining and tube-rolling plants and bentonite clay production administration. The structure of a sector is imperfect and the only final products manufactured are ferric concentrate and seamless steel tubes. Sector needs to be radically modernized and technically re-equipped. The structure of metal production has to be improved.

Non-ferrous metallurgy is mainly represented by the enterprises of aluminium industry. There are alumina industrial complex, aluminium plant and alunite mine. This is the world's single complex to use the alunite ore as input for aluminium production. Unlike the ferrous metallurgy there is an exclusive production cycle established there.

Low market competitiveness of final products coupled with the mounting prices of energy and raw materials led to decline of the **machinery construction complex**. Sector's production volume has bluntly reduced within the period of 1990 through 1998. Currently production facilities of the machinery construction industry are used only by 8-10% of their capacity.

Chemical industry is the one of most energy intensive industrial branches. Share of that sector in total fuel and energy consumption exceeds 11.8% in electrical energy and 33.1% in thermal energy. In 1998 the energy intensity of sector's production totaled at 47.6%.

Building materials industry includes cement, lime, gypsum, brick and glass factories. However the following factors brought about the decrease of sector's production volumes:

- crisis, which have overwhelmed the economy of Azerbaijan in 1990'es;
- overexploitation and unservicability of existing technological equipment;
- production, which does not satisfy the international quality standards and consumer requirements;
- Severe reduction of investments.

Light industry of a country has a great production and technical capacity and accomplished sectoral structure, which is sufficient to cover the domestic demand and organize an export of some goods. There are many textiles, spinning, knitted goods and other factories within the light industrial sector of Azerbaijan. Currently many of these enterprises do not work and they are included into the list of enterprises, which have to be privatized.

During the privatization process the number of enterprises of **agricultural sector** has considerably reduced and in many cases stopped their production due to a crisis occurrence in that sector. Currently only 15-20% of a sector's production capacity works. Practically there was no renewal of industrial and production reserves conducted so far. Decrease of production volumes, poor functioning of enterprises, use of out-dated equipment, low automation level of technological processes and other factors led to 40% increase of a sector's energy intensity.

Studies showed that the most of sector's existing technological equipment is out-dated and energy intensive due to which poor competitiveness of agricultural products occurs.

Transport is an important energy and fuel-consuming sector of Azerbaijan economy. Technology used in the automobile and railway transport needs to be substituted. Reorganization of a sector's management system is also required.

Commercial and residential sectors are the large energy consumers. Population of Azerbaijan has increased by 5% within the period of 1990 through 1995 while at the same time the energy consumption has increased by four-folds. Increase of the volume of energy consumed comes from inefficient work of our country's heating system and lack of natural gas supplied to the rural areas of Azerbaijan Republic (since 1994 provision of gas to these areas has stopped at all). People use electrical devices with low efficiency to heat their houses and for cooking purposes. In the rural areas consumption of kerosene and wood increased by 17 and 4 times respectively. Active heating systems of some parts of the cities are working inefficiently and require periodical supply.

In general there are many problems faced by the commercial and residential sector of Azerbaijan, which require a complex solution of organizational and regulative and technological issues.

Energy saving technologies were never used in the agricultural sector for manufacturing of goods and utilization of manure for methane production.

Currently industrial and urban wastes are stored in the landfills without being technologically processed and sorted.

2.2. Capacity improvement for technology needs assessment.

2.2.1. Electrical energy.

Nowadays the energy system of Azerabijan has a fixed capacity, which is enough to cover domestic demand for electrical power. However there are many problems, resolution of that is

mainly dependent on improvement of energy and economic efficiency [10]. In 1994-1995 the Joint Stock Company "Azerenergy" with technical assistance of EU has developed the "Plan of perspective development of electrical energy system of Azerbaijan till 2010". Main trends of system's development are identified by the document as follows:

1. Reconstruction of Thermal Power Plants (TPP) and Hydro-Power Plants (HPP) through the substitution of old and worn out equipment, which has been exploited for 30 to 35 years, for the state-of-the-art equipment meeting the modern technological standards;
2. Improvement of country's energy system by means of increase of a share of HPP;
3. Construction of sub-stations with the voltage of 220-230 kW with the view to reduce the energy losses and improve the power supply of the regions;
4. Creation of experimental equipment for usage of alternative renewable energy sources.

One of the most critical problems is the high level of specific fuel consumption on some TPP units, which has been overexploited for a long period of time. For these stations it is planned to introduce more economical steam-gas and steam turbine equipment with the specific fuel consumption of 260 kW-hour that is approximately by 30-40% less than currently used technology. Substitution of obsolete technologies used on TPP would let us save about 3.5 millions of Conventional Fuel Tons (CFT). Entire transition to the natural gas would decrease the atmospheric CO_2 emissions by 14 millions of tons per year (see Fig. 2).

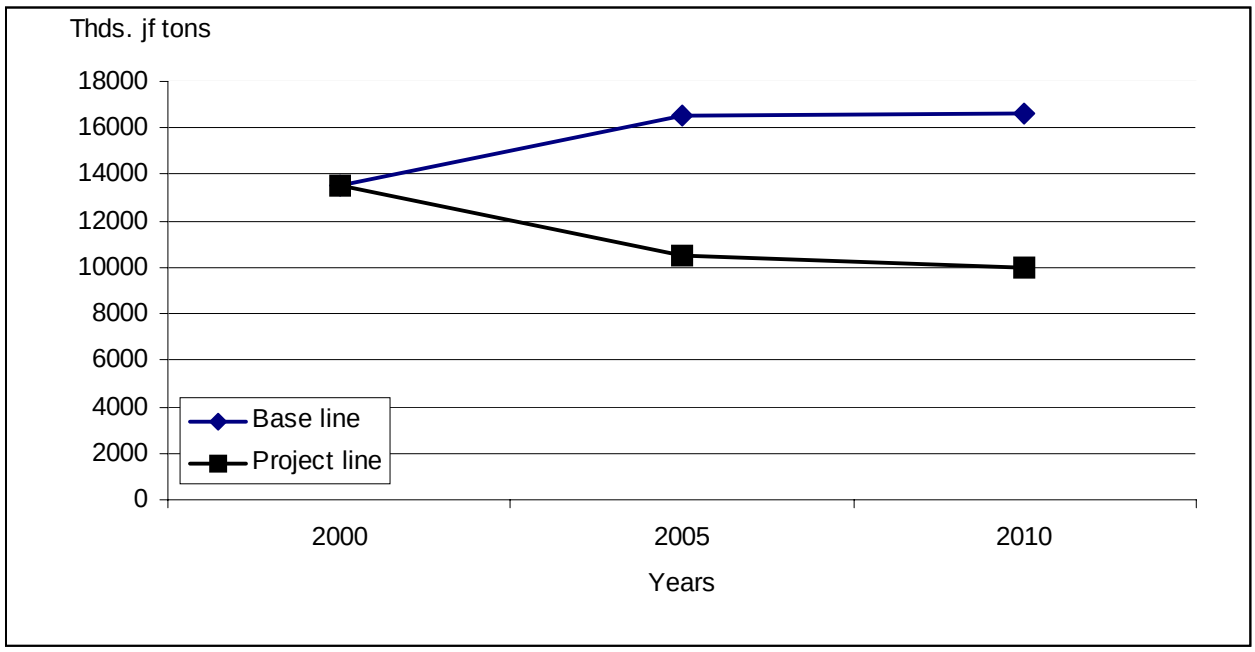

Fig. 2. CO_2 emissions reduction capacity on TPP's after the technological modernization.

Introduction of new facilities would allow increasing the energy production up to 5626 MW by 2010 that is by 1395 MW more than it was in 1995. 70% improvement expected to be maintained due to the entire modernization of existing TPP's.

Hydro-energy resources are very suitable for Azerbaijan both in terms of capacity and availability. In the nearest future it is planned to introduce the new facilities on the Nahchivan's rivers and Kur. Moreover the capacity of Mingechaur HPP is also to be improved through the replacement of out-dated generator (see Table 4).

Table 4. New facilities introduction program for the period of 1999-2010 [11].

Years	Name of Power Plant	Introduced capacity, MW, +	Required investment, $ mlns.
1999-2002	**Nahchivan AR: smaller HPP's**	+32,1	66,0
2000	Azerbaijan TPP (block 9)	+270	20
2002	Baku TPP-1 (2-nd unit)	+56	50
2001	Mingechaur HPP (replacement of two generators)	+20	8
2002	Wind Power Plant	+30	60
2003-2004	Sumgait TPP-1 (gas turbines)	+420	295
2005-2008	Alı-Bairamly TPP (steam-gas device)	+790	595
2007	Touz HPP	+380	450

Smaller hydro-energy production also has a strong potential in Azerbaijan. Estimated technical capacity of that sector equals at 4.9 billions of kW-hour, while economically efficient capacity totals at 1.7 billions of kW-hour. However the role of smaller hydro-energy production facilities is low and they work only at 2% of a fixed capacity.

In 1950'es there worked 45 smaller HPP's in Azerbaijan [12] and today there are only six of them left - working and running on dated mechanical and electromechanical equipment.

Smaller Hydro-energy Production Development Program of Azerbaijan provides for technological modernization and reconstruction of existing smaller HPP's as well as the construction of new stations on the mountain rivers and irrigation canals (see Table 5).

Table 5. Smaller Energy Production Development Program.

Name of HPP	Fixed capacity (MW)	Average productivity (millions of kW-hour)	Required investment $ millions
1. technical modernization of existing HPP's			
Varvary	16,5	90,0	16,5
Sheki	2,8	14,7	2,8
Gusar	1,2	2,6	1,2
Guba	1,15	6,3	1,15
Mugan	3,8	14,38	3,8
Zurnabad	2,76	12,76	2,76
2. Reconstruction of neglected HPP's			
Leninkend	0,8	2,99	1,2
Belokan	0,3	1,32	0,45
Nugedi	0,83	2,94	1,25
3. Construction of smaller HPP's on reservoirs and canals			
Тахтакерпю	31,0	155,0	46,5
On the Mil canal	30,0	150,0	45,0
On the Upper-Shirvan canal	10,7	55,0	16,1
On the Upper-Qarabakh canal	12,0	50,0	18,0
Arpachay	8,5	42,7	12,8
Vayhir	4,7	13,2	7,1
Jegamchay	3,3	14,6	4,95
Aqstafachay	2,8	13,8	4,2

Currently many regions of Azerbaijan suffer from the shortage of electricity. Smaller HPP's might help with solution of this problem. There are many advantages of smaller HPP's. For example

- they may be located close to energy consumers

- losses occurred during this energy's long distance transportation are low
- smaller HPP's conserve the natural landscape
- smaller HPP's eliminate the possibility of GHG emissions.

For smaller HPP's located on the irrigation canals it is recommended to use water releasing constructions, which have permanent drain with considerable head of water. Economic advantage of smaller HPPs is evident. It takes only cost to construct the machine hall of smaller HPP. Such HPP's were constructed on the Vayhir reservoir of Nahchivanchay river. Among the canals, on which the smaller HPP's may be constructed, there are Samur-Apsheron, Mil, Upper-Shirvan and Upper-Garabakh canals. Moreover there are 20 channel water reservoirs used for irrigation purposes in Azerbaijan. They are mainly located on the foothills and in the low mountain areas.

However there are also some serious disadvantages of smaller HPP's to include the high costs and impossibility of their projects' constructive combination, which occurs due to individual character of each technical decision to be made. Average cost of one kW of fixed capacity is around $ 2000 for smaller HPP's.

In general improvement of existing and construction of new HPP's would allow the 28.2% increase of the share of energy produced by the HPP's. In other words two-fold increase as compared to a baseline year might be achieved resultedly.

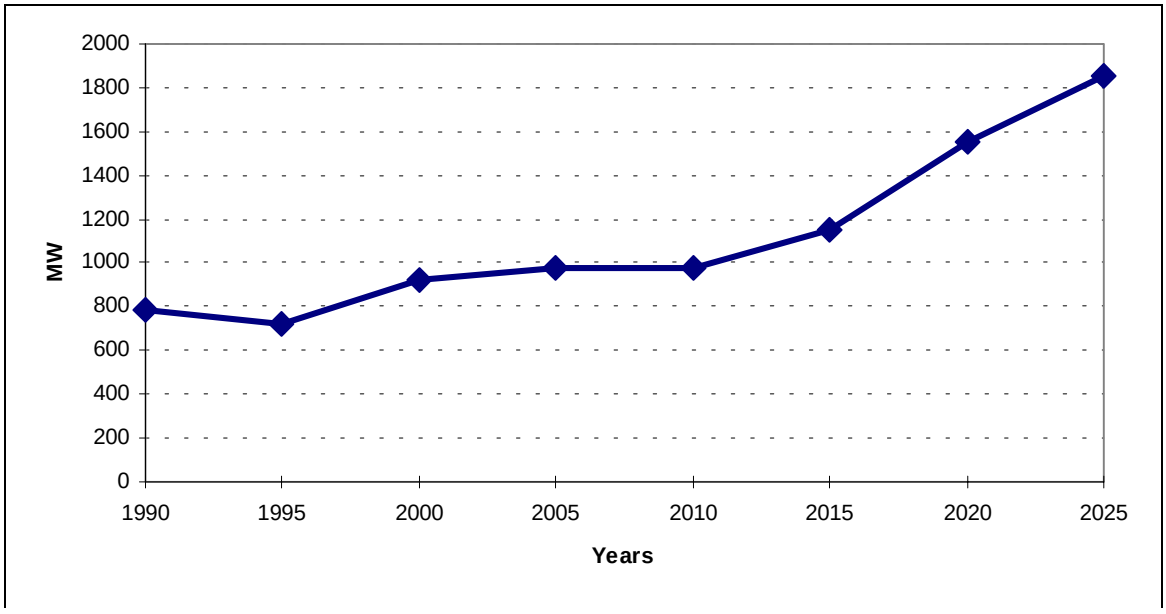

Fig. 3. HPP capacity development forecast.

Increase of electrical energy production on HPP's would enable saving of oil fuel and reduction of CO_2 emissions (see Table 6).

Table 6. Amount of fuel saved and CO_2 emissions reduced due to introduction of HPP's.

Indicators	Years					
	2000	**2005**	**2010**	**2015**	**2020**	**2025**
Electrical power production Billions of kW-hour	1,9	2,0	2,0	2,4	3,3	3,9
Fuel oil saved (thousands of tons)	570	600	600	720	990	1170
Volume of CO_2 emissions reduced (thousands of tons)	1755	1847	1847	2216	3047	3602

Potential volume of GHG emissions reduction, which may be maintained as a result of technical modernization and introduction of new HPP's is given in Fig. 4.

Energy distribution and consumption systems also require an introduction of more efficient technologies. But the uncertainties existing in the energy consumption system as well as the lack of effective payment system negatively affect the efficient functioning of our country's energy system. That is why – as an experiment - the government of Azerbaijan decided to pass some electrical power networks to the private hand [10]. List of some projects on energy efficiency in the electrical energy sector is presented as attachment to this paper.

2.2.2. Usage of unconventional renewable energy sources.

Due to its' geographical position and climatic conditions and peculiarities of economic structure Azerbaijan is a promising country in terms of renewable energy sources application prospects. Besides the energy sources of rivers the "renewable energy" category includes the solar, wind, geothermal and biomass energy.

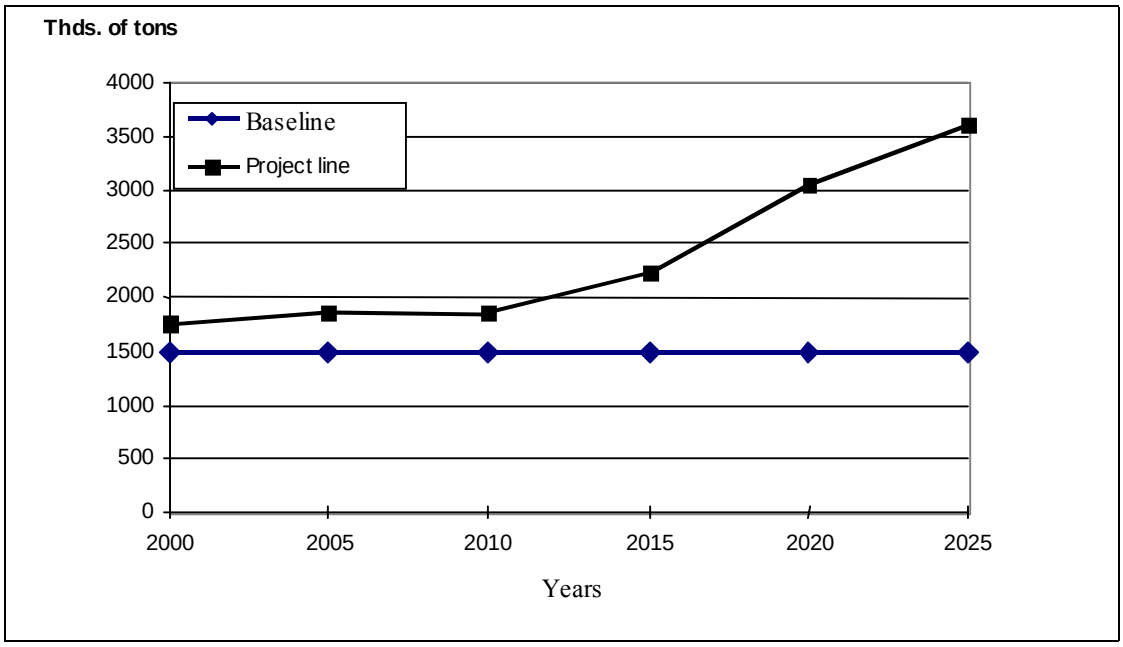

Fig. 4. Potential volume of GHG emissions reduction, which may be maintained as a result of technical modernization and introduction of the new HPP's.

Solar energy

Usage of solar energy is considered logical in the regions with entering solar radiation of over 120 kW-hour/m^3 per year [10]. In many regions of Azerbaijan the volume of entering solar radiation makes up 1600-1800 kW-hour/m^3 while average annual duration of solar radiance is 2200 to 2600 hours there [13, 14] with the radiation level of 3-6 kW/m^3. These figures show that the practical use of solar energy is economically justified for our republic. That is because location of solar stations conforms to the principle saying that "the closer the energy source is, the more efficient and economic its' usage becomes".

Use of solar energy in Azerbaijan is preferable in the sectors such as heating and hot water supply, air conditioning, industry, communications and transport. Relative simplicity of the usage

of solar energy enables mass construction of standard small power plants with capacity of 50 to 3000 kW.

It is estimated that saving of one thousand of CFT is possible if we practice the usage of solar energy through construction of solar collectors with total area of 10.000 m^3.

Implementation of a project providing for practicing the usage of solar energy would allow saving of 0.13 millions of CFT of fuel and reduction of CO_2 emissions by 232.000 tons after ten years.

In order to develop the solar energy production in Azerbaijan there was proposed the pilot project "Usage of Solar Energy for Hot Water Supply" (see the Appendix).

Wind energy

In Azerbaijan there are quite favorable climatic conditions for development of wind energy production. Winds with the strength of 3 to 5 m/sec. prevail in the foothills and lowlands of a country. Strength of winds in coastal regions varies between 6 and 8-20 m/sec. In the Apsheron peninsula – besides predominant North – there are also NorthWest and South winds observed. With all that the probability of wind strength gradiation between 9 and 20 m/sec. is 30%.

Perspective in terms of wind energy production are the Apsheron peninsula, coastal area nearby the "Nizovaya Pristan" meteorological station, Sumgait zone, Jiloy Island, Oil Rocks, Puta, Svinoy and Sara islands. Attractiveness of these areas is predetermined by the average annual strength of winds, which is 5.5-8.0 m/sec. there. Moreover the fact that the winds are blowing 250 days a year in Azerbaijan makes it unreasonable to ignore the wind energy production opportunities.

Joint Stock Company "Azerenergy" together with Japan Company "Tomen" is currently working over the project providing for construction of wind energy station with capacity of 30 MW. This station will be located on the SouthWest Apsheron – in Qobustan. The projected wind station will consist of 50 wind turbines by 110-150 meters distant from each other. Capacity of each turbine will be 800 kW. Construction of a wind energy station is expected to start and complete within the course of 2001. Anticipated budget of a project is 30-40 millions of dollars. In two years the outlay of a project will be covered and running the station will become profitable.

Technical potential of wind energy in Azerbaijan allows increasing the production capacity up to 800 MW [5]. With that capacity given it is possible to produce 4 billions of kW-hour of electrical energy. Practicing the wind energy production would considerably contribute to development of the national power production sector. That is because the production of wind energy will make up 17% of a baseline total electrical energy production. Taking into account the energy development baseline, the introduction of wind energy would lead to saving of 2.4 millions of CFT of fuel and reduction of CO_2 emissions by 4.4 millions of tons after 20 years.

Fig. 5 presents the wind energy production development forecast for Azerbaijan.

Construction of wind turbines would allow increasing electrical energy production and saving consumed fuel and reducing CO_2 emissions (see Table 7).

Table 7. Results expected after introduction of wind energy production.

Indicators	Years				
	2005	2010	2015	2020	2025
Electrical energy production, mlns. of kW-hour	163	325	434	542	651
Fuel oil saved, thds. of tons	49	98	130	163	195
Reduction of CO_2 emissions, thds. of tons	150	300	400	500	600

İn order to use the wind energy the pilot project "Introduction of wind turbines for electrical energy production" is proposed (see the Appendix).

Bioenergy

Biomass is a sustainable renewable energy source, which could be used for production of electricity and other energy resources.

Used in the present energy systems – biomass contains the residues of wood, food and agricultural products. In the future economies developing profitable energy types such as wood and grass will considerably extend the biomass supply.

Biomass may be considered a neutral alternative for electrical energy production as it comes to the carbon emission. In spite of the fact that biomass produces carbonic acid gas during combustion, its' equivalent volume is being adsorbed from the air while growing the biomass itself. Thus the biomass re-circulates the atmospheric carbon and minimizes the impact of global heating.

Azerbaijan is a region with poor forestry. An average share of wooded areas makes up about 11% here that are by 2.5 to 3 times lower than the internationally accepted norm. Calorific value of forests' wood is 6 to 12 TJ/thds.m^3. Average calorific value of the solid biomass makes up 18.4 TJ/thds. of tons.

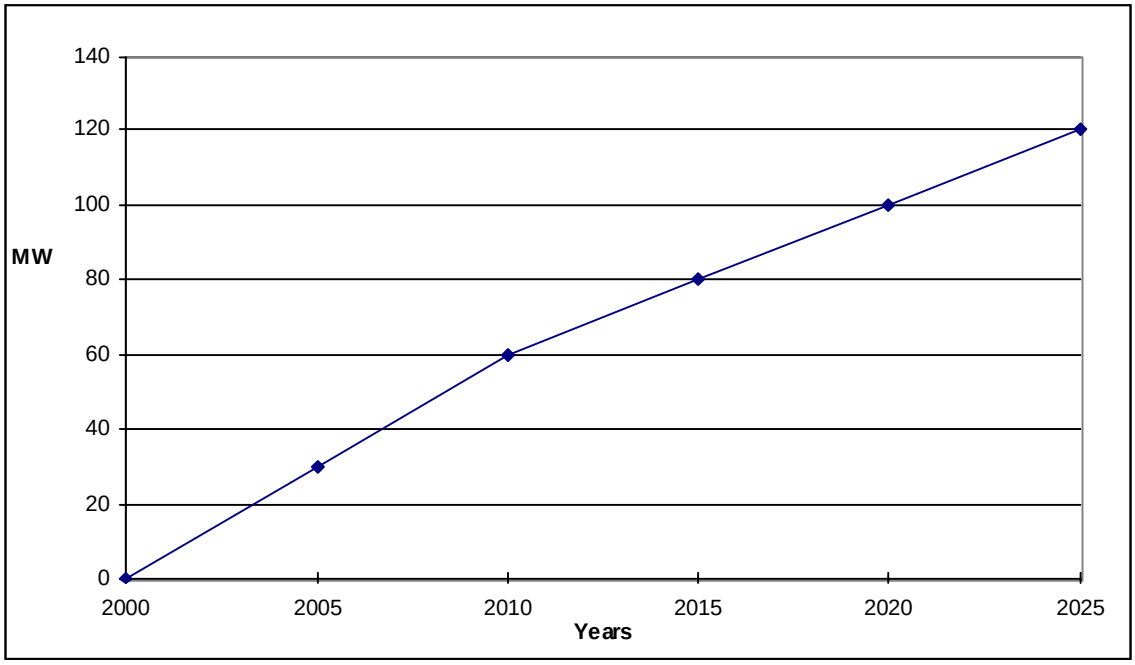

Fig. 5. Forecast of the dynamics of electrical energy produced by the wind energy stations.

Azerbaijan is an agrarian country producing 2 millions of tons of agricultural crops per year. It is calculated that in the agricultural sector up to 2-4 millions of tons of wastes are being produced after the harvest.

There are two projects on usage of biomass and they will be described in the "Housing sector" and "Agriculture" sections (see the Appendix).

2.2.3. Oil and gas sector.

Technological losses of oil and gas occurred while production and transportation of latter result in considerable air emissions of hydrocarbons. Occurrence of these losses is firstly caused by

application of old and worn out technologies. Usage of such technologies predetermines the energy intensity of manufactured products as well. While in 1990 it took 76.5 kW-hour of electrical energy to produce 1 ton of oil, then in 1998 this value made up 197 kW-hour for the on-shore deposits.

Replacement of existing outdated pumps for new and energy efficient technologies would enable reduction of sector's energy intensity by 185 millions of kW-hour and save 76 thousands of CFT. CO_2 emissions reduction capacity would make up 138 thousands of tons per year correspondingly.

Currently for about 2.4 billions of m^3 of accompanying gas are being extracted annually while the production of oil on the on-shore and offshore deposits. Due to the lack of necessary technologies 195 thousands of cubic meters of gas are being flared. Full refining of accompanying gas would make it possible to use the products received (electrical energy, heat and etc.) for domestic needs. This would lead to saving of 17.6 thousands of m^3 of gas within 25 years that is equivalent to 19.3 millions of CFT. As a result of fact reduction of CO_2 emissions by 1.4 millions of tons will be achieved. Annual volume of fuel saved and emissions reduced will make up 0.8 millions of CFT and 1.4 millions of tons respectively.

Oil refining

Oil refining is the one of most energy intensive industrial sectors. In Azerbaijan there are two refineries with the total capacity of 20.5 millions of tons.

Oil heaters are the main sources of GHG emissions. Maintaining the high level of heaters' efficiency would be decisive factor in achievement of entire sector's economy.

Therefore the improvement of oil heaters efficiency is very actual issue. First and the most important step to be made in this field is organization of thorough monitoring of the heaters and then - basing on the monitoring outcomes - preparation of relevant activity package.

Thermal efficiency assessment showed that the efficiency of heaters is around 51-53% there. This level is by 20% lower than the projected one. Some elements of heaters' construction are out of date.

Moreover in refineries there are some flares continuously flaring the hydrocarbons emanating from the technological equipment. Construction of a smaller electrical power station would allow producing the energy for internal use (the surplus energy even can be sold).

Development of oil refining sector must base upon the construction of new technological equipment with lower energy intensity and large refining capacity. Construction of equipment for secondary resources utilization is also preferable for energy production.

Emissions in the oil-refining sector are mainly coming from the flaring of fuel in the heaters. Emissions volume depends on the sort of technology used and the type of fuel flared and etc. In order to reduce the GHG and other emissions emanating from the oil refineries it is necessary to apply the latest technologies providing for the rational use of fuel. It is also required to reconstruct the heaters and other refining equipment.

Recently constructed heaters are provided with the low-pressure equipment with high thermal resistance. This and other technological innovations increase the efficiency of technologies applied in the oil-refining sector. Further technological re-equipment would provide the saving of 55 millions of CFT of fuel and reduction of CO_2 emissions by 100 millions of tons after 20 years.

Refining, transportation and distribution of natural gas

Estimations conducted by the IPCC methodology showed that about 443 thousands of tons of methane go into the atmosphere as a result of production of oil and gas. That volume is equivalent to 632.85 millions of m^3 of natural gas. In other words approximately 7% of fuel produced are being thrown into the air.

Calculations show that the total volume of methane emissions exceed that indicator by two- to three-folds. It is necessary to implement the additional studies in order to avoid the uncertainties occurred on that topic.

Overall national reserves of natural gas in amount to 1 trillion of cubic meters. Annual transportation of about 30 billions of m^3 of gas is planned by the country government. Increase of methane emissions is evident once we ignore changing the existing structure of national gas transportation system. Therefore it is important to radically reconstruct the entire gas production sector of Azerbaijan.

Great significance is attached to a transit gas main at the length of 2000 km., construction of which would allow the natural gas from Turkmenistan and Kazakhstan into the European market through the Caspian Sea bottom. Maximum carrying capacity of a designed pipeline will be 30-35 billions of cubic meters of gas. Construction of main will cost 2.5 to 3.1 billions of dollars that includes the 0.5-0.6 billions for Azerbaijan sector.

As the oil and gas production continues to grow the volumes of methane emissions would increase by four times by the year of 2025, unless the technological innovations in the field of gas transportation and distribution are introduced.

Reconstruction of main and distributive gas pipelines, application of state-of-the-art technologies in the distribution stations and introduction of control and measuring equipment is beneficial for the national economy.

Implementation of relevant activities would save 44.4 millions of CFT and reduce the GHG emissions by 590 millions of tons of CO_2 equivalent.

Rehabilitation and improvement of existing gas transportation system provides for implementation of the following activities:

- replacement of the most corrosed parts of a distributive network (1000 km);
- reconstruction and extension of underground gas storehouses;
- modernization of gas regulating and measuring stations;
- minimization of gas losses occurred while its' transportation.

Investments, which are expected to flow into the sector for the period till 2025, are estimated to total by 409.1 millions of dollars. Importance of gas production sector for the national economy makes it necessary to introduce the new technologies as soon as possible. With the view to reconstruct the national gas sector the project named "Introduction of Energy Efficient Technologies into the Gas Transportation System of Azerbaijan" was proposed and submitted to the Global Environment Facility.

2.2.4. Transport

Transport is the main energy-consuming sector, in which the government is facing some difficulties with identification of GHG emissions mitigation policies.

Transport is a large consumer of fuel and energy. Therefore the structural reconstruction policies must base upon the saving and rational use of fuel and energy resources and development of effective control and regulating equipment. Recently needs of the railway system for GHG emissions reducing technologies were studied and relevant proposals were prepared.

Currently the national railways are in need of a new technologies introduction, while the substitution of old equipment is required as well. As a result of conducted studies there were identified the most potential sectors for implementation of new technologies serving for GHG emissions mitigation:

1. Full electrification of the railways might reduce the consumption of fuel by 3.2 times. Railways' electrification would result in saving of 60.500 of CFT and reduction of CO_2 emissions by 139.000 of tons.

2. Traction of electrical trains is being conducted with the help of direct current in Azerbaijan, while in the European states and Russia the alternating current is being used for this purpose. Transition to the alternating current would save 141.000 of CFT per year and reduce CO_2 emissions by 256.000 of tons respectively.
3. Implementation of energy saving activities would lead to 10% economy of electrical energy. In other words 39.000 of CFT will be saved within one year. CO_2 emissions reduction would make up 71 thousands of tons respectively.

Therefore the total volume of fuel saved and CO_2 emissions reduced would make up 241 thousands of CFT and 466 thousands of tons respectively.

2.2.5. Commercial and residential sectors.

Commercial and residential sector is one of the most important "Energy" category sectors in terms of energy efficiency and fuel economy.

Statistical data shows that in 1990 the available dwelling space per capita in Azerbaijan was equal to 12.5 m^2. Total dwelling area was 88.7 millions of m^2 while there were 1381.4 thousands of families. Per every 100 families there were 102 TV-sets, 83 refrigerators, 51 washing machines, 34 vacuum cleaners, 81 radios and 10 air conditioners available [16]. 10.8 millions of kW-hour of energy was consumed by the commercial and residential sectors in 1990. That made up 1.02% of total energy consumption throughout the republic. 24 millions of 75W lamps it would take to light the dwelling fund equal to that of 1990. Replacement of existing lamps for the 20W-equivalent compact fluorescent lamps (CFL bulbs) would provide saving of 7.8 millions of kW-hour of electrical energy (73%).

Creation of integrated and automated energy supply accounting and management system would help with achievement of energy and fuel efficiency through the implementation of detached energy consumption accounting. Introduction of that system would eliminate the considerable losses of energy occurred while its' consumption. According to expert assessments as a result of creation of such system 30% saving of energy consumption will be achieved and certain volume of CO_2 emissions will be reduced (see Fig. 6). After 20 years 2.1 millions of CFT of fuel will be saved, while CO_2 emissions reduction volume will make up 4 millions of tons by that time.

Projection and implementation of an integrated and automated energy supply accounting and management system in the cities must be the one of most important stages of governmental resource saving policy.

In the year of 1990 there have been produced 21399 thousands of GCal of thermal energy. Statistical data shows that by 1998 this volume decreased by 68%, 12% of which was due to the housing sector. In practice the reduction percent of heating supply in the housing sector was much higher, since the energy consumption level increased and became 7268 thousands of kW-hour that is by 7 times more than that of 1990. Heating system was completely destroyed and it requires the conduct of additional technology needs assessment studies. In order to implement such assessments the project named "Removal of Barriers for Energy Efficiency in the Municipal Heating and Hot Water Supply System of Baku" was elaborated and submitted to GEF for consideration.

Calculations demonstrated that in Baku alone rehabilitation of heating and hot water supply system would provide the annual saving of 383 thousands of CFT of fuel and reduction of CO_2 emissions by 600 thousands of tons in average.

Total potential for 20 years will make up 7.7 millions of CFT of fuel saved and 12 millions of tons of CO_2 emissions reduced.

According to statistical data total natural gas consumption by the commercial and residential sectors has made up 5.6 billions of cubic meters in 1990. GHG emissions inventory prepared by the

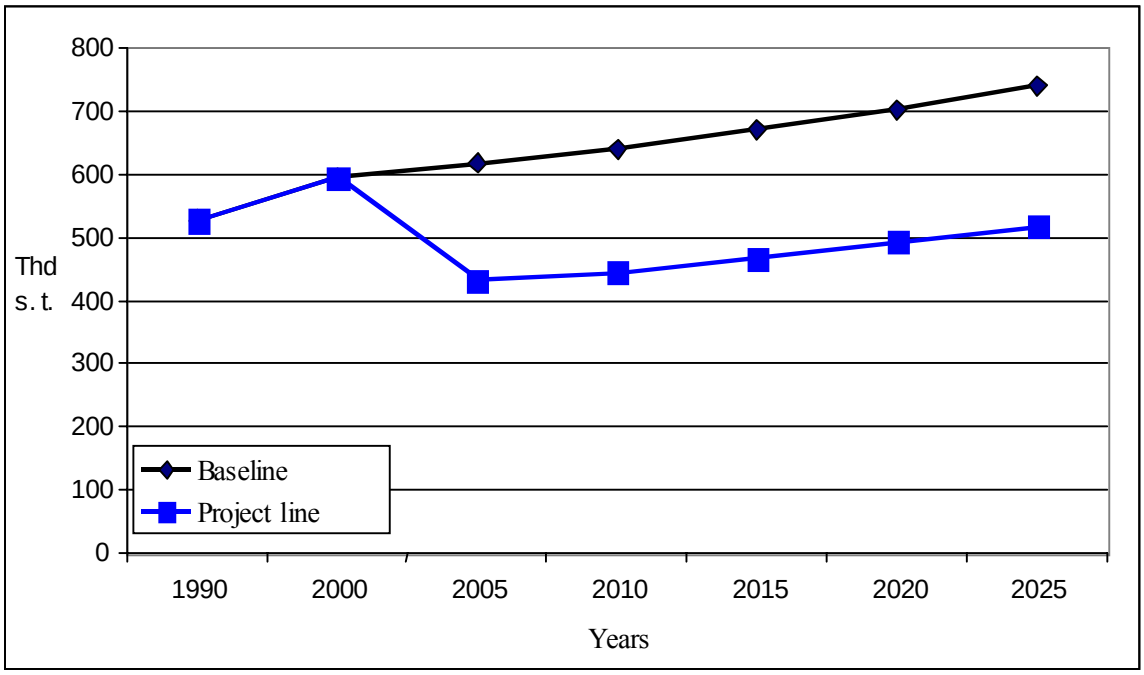

Fig. 6. Potential CO_2 emissions reduction after the introduction of new technologies of the automated accounting and management system.

IPCC methodology indicated that in the same year the CO_2 emissions of those sectors has made up 10 millions of tons [1].

There was no control and measuring equipment (meters) in Azerbaijan till the year of 1996. After 1996 JSC "Azerenergy" together with the World Bank implemented the experimental establishment of gas meters in some buildings of Azerbaijan's capital city. Expert and other data [17] showed that the consumption of natural gas in the covered buildings decreased by 40% resultedly. Thus the introduction of control and measuring equipment will certainly lead to considerable reduction of CO_2 emissions (see Fig. 7).

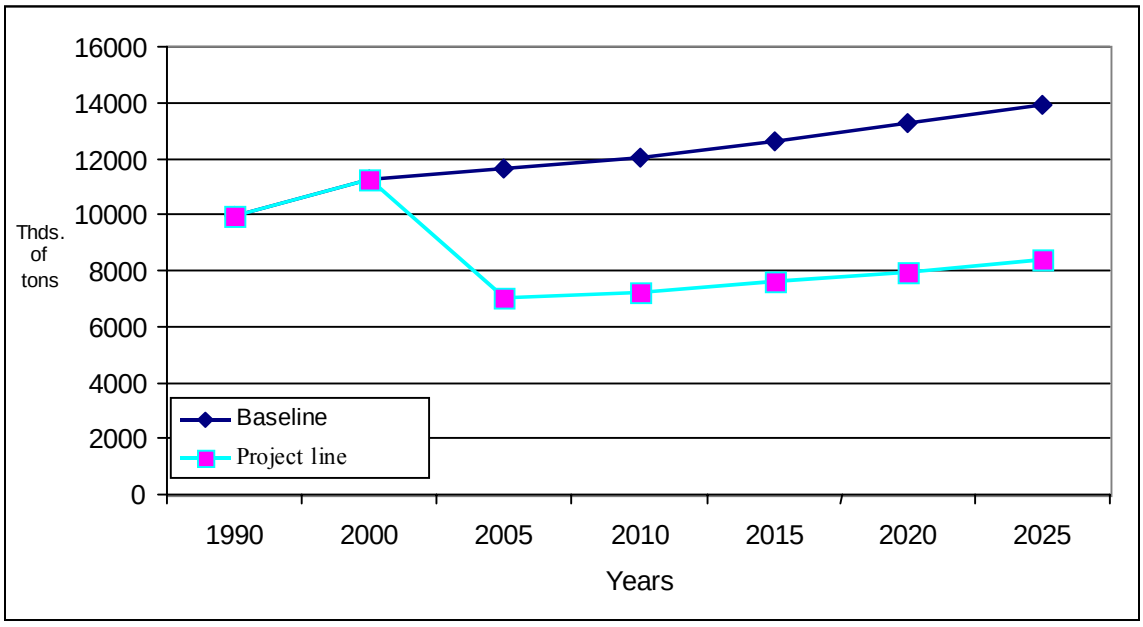

Fig. 7. CO_2 emissions reduction potential after the introduction of gas meters.

Establishment of gas meters in the commercial and residential sectors would allow saving 63.2 millions of CFT of fuel and reducing CO_2 emissions by 102.4 billions of tons after 20 years.

2.2.6. Agriculture.

Currently the agricultural sector of Azerbaijan is living through its' critical period related to radical changes of production processes and increasing degradation of production capacity. As a result of agrarian reforms most of the collective farms and soviet farms were disintegrated and new forms of agricultural holdings were organized. There were created more than 26 thousands of private farms, 5 thousands of collective farms, one thousand of rented farms, 800 smaller enterprises and etc.

Conducted reforms coupled with lands' privatization enabled the development of a private sector. The share of latter increased both in the structure of sawn areas and crops production. While in 1995 the share of private sawn areas was just 5% of the total, then by 1998 it increased and became 82%.

Agricultural sector has a great potential for implementation of renewable energy sources. Introduction of contemporary climate relevant technologies and efficient use of those resources would surely lead to reduction of GHG emissions (see Table 8).

Table 8. GHG emissions reduction potential in the agricultural sector.

GHG gases	GWP factor	Gas volume (thds. of tons)	CO2- eq, (thds. of tons)
CO_2	1	30938	30938
CH_4	21	875	18375
Total			49313

Implementation of new technologies providing for production of energy from horticultural biomass enables saving the primary energy. On the basis of solid residues' heating capacity of 10 TJ/thds. of tons, substitution of fuel oil for this type of fuel would reduce the CO_2 emissions by 30 millions of tons after 25 years.

GHG inventory says that every year - as a result of manure's anaerobic decomposition - approximately 30 thousands of tons of CO_2 or 43 millions of cubic meters of methane is being thrown into the atmosphere. This volume of methane emissions is a result of inadequate methods of storage and distribution of manure applied in the agricultural farms of Azerbaijan. Sizeable increase of methane volumes is possible once the modern manure-based energy production technologies are introduced.

Utilization and use of manure for the energy production purposes would lead to saving of 1374 thousands of CFT of fuel and reduction of CO_2 emissions by 938 thousands of tons after 25 years.

2.2.7. Wastes.

Currently industrial and municipal wastes are being stored in the various landfills without being processed and sorted. Storage of a large amount of wastes in the landfill causes the anaerobic decomposition of organic waste with further production of methane and other by-products. On the other hand sewage-cleaning machines are another source of methane production.

These sources are important in terms of utilization and collection of methane for its' further use.

Methane emissions from solid waste disposal sites (SWDS)

GHG inventory conducted for the period of 1990 through 1994 and compiled by the IPCC methodology indicated that methane emission from the municipal landfills of Azerbaijan has made up 64-67 Gg. Expected growth of the total and especially urban population would therefore bring about the increase of solid wastes.

Currently there are more than 200 landfills in use at the total area of 900 ha in Azerbaijan. Now those landfills are in unsatisfactory condition causing environmental contamination and methane emissions. Total volume of solid waste reaches 6.0-6.5 millions of cubic meters. By 2025 this volume is expected to make up 12.9 millions of m^3 that is by 2.2 times more than in the baseline 1990 [1].

Within the period of 25 years methane collection capacity will reach 1976 thousands of tons or 41469 thousands of tons of CO_2-eq.

Methane emissions from contaminated wastewater handling

35 of 78 regional centers and towns of Azerbaijan have undeveloped sewerage systems. There are 304 kilometers of main collectors and 188.3 and 660.7 kilometers of district and street collectors respectively.

Nowadays more than 50% of country's urban localities do not have the wastewater handling systems. Moreover existing sewerage systems occupy only 30 to 35% of the territory of each city. That is why the wastewater is considered the stationary source of environmental contamination and infection and environmental degradation of the regions.

Within the period of 25 years methane collection capacity is expected to equal 500 thousands of tons or 10.5 millions of tons of CO_2-eq.

Introduction of the state-of-the-art climatic technologies would let us reduce the volume of methane emissions from the wastewater.

2.3. Capacity building for technology needs assessment.

Capacity building opportunities provided by the Convention committed the Parties to:

- identify their technology needs
- assess the role of technologies in climate change mitigation
- identify mechanisms that support the development of sustainable market and business relations providing efficient transfer of new EST's.

Implementation of these commitments requires the building of capacity for technology needs assessment. Study of the methods of how to access and use the technological information provided by the international centers and networks is also required.

2.3.1.Building of organizational capacity.

Institutional structure of existing multi-component national system dealing with climate change issues is identified by the relevant governmental documentation [1]. Interrelations between the components of that system and relevant international institutions are presented in Fig. 8. The State Hydrometeorological Committee of Azerbaijan Republic (SHMC) implements the coordination with UNFCCC.

In 1998 - in order to provide the coordination of activities between different national agencies in the field of climate change there was established a National Center on Climate Change (NCCC) under State Hydrometeorological Committee. Experts from various governmental and non-governmental organizations and other institutions take part in the Center's activities. Among the

activities these experts implement there is solution of some sector-specific issues to include the technology transfer problems.

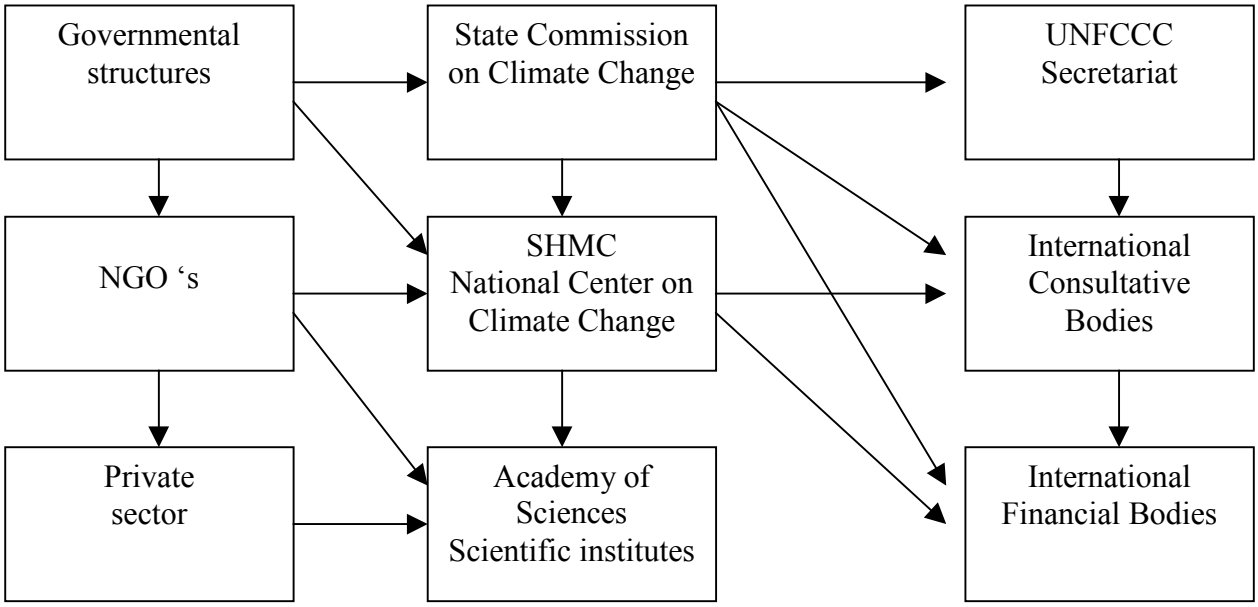

Fig. 8. Interaction scheme of national and international institutions.

However the established institutional structure is gradually getting short of constructiveness due to intensification and detailization of UNFCCC and Kyoto Protocol requirements. Said is also the case in the technology transfer issues, which serve as an important part of climate change mitigation activities in Azerbaijan. In those terms development of organizational capacity for technology transfer is considered at the context of creation of more flexible and constructive body for implementation of tasks and commitments taken under Convention itself and Kyoto Protocol Mechanisms. In order to implement those commitments and introduce the climate relevant technologies it is necessary to establish an inter-institutional body coordinating and managing the all of relevant issues. Such body may be created at the initial stage with technical assistance of international financial agencies such as GEF and UNDP.

Establishment of such institute would promote the organization and coordination of activities of all national organizations. It would also help with maintenance of relations between the national and international structures in the field of climate relevant technologies' dissemination and adoption. On the other hand this organizational structure would assist to minimize the hazard related with technology acquisition and enable the mobilization and coordination of the efforts by existing organizations, e. g.:

1. Energy Efficiency Center funded by the European Union within the framework of TACIS Program;
2. Private informational, scientific and technical and consulting organizations dealing with environmental and technological issues (this category includes the local and foreign companies and firms, non-governmental organizations and funds and other voluntary environmental institutions).

2.3.2. Building the informational capacity.

Access to information and its' assessment is an important factor in technology transfer. Paying less attention to informational barriers and disregarding the recurrent stages of technology transfer [2] process might turn to be less productive. There is no definite system for selection and

dissemination of information on climate relevant technologies in Azerbaijan. Within the course of the last few years the companies using these technologies in the energy production sector as well as the private consulting and informational and technical firms have implemented the dissemination of technological information.

It is natural that under ongoing transition to the market economy the share of private sector in the information dissemination processes increases. Development of information market improves the quality and scope of disseminated information on technology transfer. The share of private stakeholders in technology transfer processes is expected to grow in the nearest future. But now the leading role in information collection and dissemination is played by the NCCC of the State Hydrometeorological Committee, which has the access to international climatic and technological data networks through the Internet and other communication means. Also there is close correlation established between the relevant governmental and scientific and technical agencies in that field.

In order to improve the technological information capacity in Azerbaijan it is necessary to create a perfect information system and connect it to the international and regional data networks via the specific-purpose organs and information firms, trade publications, NGO ‘s and other voluntary organizations.

2.3.3. Development of human capacity.

Transfer of the most types of technology requires a broad spectrum of technical and management and entrepreneur skills. By having the people with those skills Azerbaijan would attract a great deal of international capital thus promoting the technology transfer processes [2,3].

These people must

- have a concept of current national economic and environmental circumstances
- be able to conduct the technology needs assessment
- study the opportunities for implementation of necessary technology transfer activities
- provide the transmission of necessary information on technological collaboration between the local and international donors and promote the funding of proposed projects
- promote the dialog between interested organizations.

Unfortunately most of the local governmental organizations do not have enough qualified experts specialized strictly in the fields of climate change and technology transfer. A range of qualified young experts was prepared and trained during the implementation of Initial National Communication. Upon the completion of a project they left their jobs for the private firms because of low wages. Even though several private production companies and consulting firms as well as NGO ‘s and NCCC have some type of starting potential, now it is difficult to create the modern human capacity due to the insufficient wage rates in Azerbaijan.

Purposeful improvement of human capacity of the governmental and private organizations, strengthening of scientific and technical basis in the educational institutions, and development of regional and international partnership are the key activities to be undertaken in our republic.

2.3.4. Monitoring and assessment.

The ultimate goal of establishing the climate relevant technologies monitoring system is to provide an information on standards, which are necessary for comparative assessment of technologies applied. In order to achieve this goal the monitoring system has to implement the systematical observations and control over the contamination level of water and gases by physical and chemical indicators. Creation of a monitoring system is an important component of technology transfer and use.

Implementation of the monitoring must help with study of the characteristics of transferred technologies and their correspondence with the national standards and environmental requirements. Organizational structure of the monitoring system must engage the specialists from organs of State Certification Committee, State Environmental Committee and experts from various voluntary organizations.

2.4. Project development and management.

Under this section, the projects providing for implementation of latest mitigation and adaptation technologies in the priority sectors of country's economy were identified and developed.

Preliminarily there were elaborated logistical models for project preparation. Those models helped to formulate the general conception and identify the criterions and methods of how to assess some project elements. Using logistical model the external factors influencing project implementation were identified.

Logistical model consisted of the following elements:

Element 1: First of all formulation of a problem has to be made and relations of projects with climate change mitigation issues must be disclosed.

Element 2: Here the goals of a project have to be identified. Meanwhile not only the commercial benefits must be covered but also there has to be considered the GHG emissions reduction objectives. Assessment of a project's social and environmental effect has the goal to identify the possible negative impact and develop the action plan for its' prevention or limitation.

Element 3: This element includes identification of objectives and assessment of outcomes expected from the project implementation. All of the expected environmental and social benefits must be considered.

Element 4: This part of a logistical model consists of the methods (activities) applied during the project implementation. Every project proposal must identify the activities, implementation of that is required from the project executives. Preliminary assessment of the main and additional benefits is required. Resources to be used for implementation of designed activities (personnel, goods and services and etc.) and their sources must be shown.

Importance of financial assessment of the project realization creates the necessity for implementation of project feasibility study. In order to avoid the approval of projects based on too optimistic cost-effectiveness assessments it is advisable to use the cost exaggerating assessments. Projects, which do not lose their attractiveness after the application of such approach, must be selected.

Element 5: Under this element implementation of project sensitivity study is required. Project sensitivity study is assessment of how the project implementation conforms to financial and economic and social objectives, for solution of which the funding of project was requested.

The NVP (Net Price Value) indicator was used for assessment of a projects' cost effectiveness. This indicator evaluates the amount of profit received from the use of all resources with the relevant discount rate considered. The bank interest rate was taken as a discount factor. NVP turned to be positive in the most of selected projects.

In some projects environmental benefits are preferred to economic ones. This is the case mainly for those projects aimed at the usage of alternative energy. For example one might feel that the use of biogas in the rural areas is economically unattractive, while its' ecological benefits (i. e. prevention of deforestation) are evident. The reason of why the projects like that are selected is that they require little investments.

Project development and management requires implementation of the following activities:

- Development of short-term and long-term activities or projects targeted at some energy efficiency and fuel efficiency issues challenging the economic sectors (see Attachment);

- Creation of a management system and promotion of project development and implementation;
- Study of investment opportunities and technology market;
- Study and development of securities market of Azerbaijan;
- Study of the share of private sector in the technology transfer and acquisition processes;
- Study of the role played by regulations and laws in the technology transfer;
- Identification of barriers to introduction of new technologies.

For every project, there were evaluated the energy and fuel efficiency and GHG emissions reduction capacities. Both specific-purpose and pilot projects were prepared.

2.4.1. Investment climate and technology market.

Establishment of competitive and stable economy – able to satisfy the domestic demand of Azerbaijan and export some goods and services – requires a great deal of financial means and entrepreneur resources. Domestic and external investments are the key factors promoting the rehabilitation and growth of our national economy, which endured the long running stagnation and decline. Attraction of investments is the basic task of Azerbaijan's government nowadays. Investments flowing into different sectors might promote the growth of production and employment rates and increase the share of a specific sector in Gross Domestic Product.

Crisis, which has overwhelmed the country's economy soon after USSR dissolution, reduced the total volume of overall investments. As compared to the baseline 1990 in 1991there was 21% decrease of capital investments volume. In 1992 and 1993 this value equaled 31.6% and 18.4% respectively.

In 1994 due to conducted economic reforms there was for the first time growth of investments achieved. As a result of those reforms and the "Contract of a Century" (oil contracts concluded between the Azerbaijan's government and several foreign oil companies on exploitation of country's oil fields) concluded by the end of 1994, 54.9% of baseline total investments was obtained. By 1997 and 1998 success was further developed and this indicator reached 157.5% and 225% respectively.

The "Law of Azerbaijan Republic on Protection of Foreign Investments" and other legislation and international agreements joint regulate foreign investment relevant issues in Azerbaijan.

In spite of the fact that yet the considerable part of total investments falls on foreign companies the share of domestic investments increasingly rises.

There is an entire system of various privileges applied to potential investors in Azerbaijan. Privatization process, which has started in 1996, allows the serious companies to become the owners of various works needing some injections to resume and extend their production.

However besides the achievements made there are still some problems challenging the investment climate of Azerbaijan. Most of the foreign investors are more likely to put their money into the oil and gas and communications and building sectors, while the other sectors are suffering from shortage of capital investments. Currently oil production of Azerbaijan covers 66.4% of total foreign investments. Much private enterprise does not have efficient means to implement the large investment projects. Moreover there is the range of fiscal barriers, prevention of which is expected after the enforcement of a new Tax Code.

Investment policy pursued by the government of Azerbaijan has the goal to

1) optimize the national tax system and improve the privilege mechanism with the view to attract more domestic and external capital investments
2) create the favorable conditions for attraction of foreign investments from the "Energy" category to other sectors of national economy

3) rationalize and accelerate the privatization process enabling the local investments into different sectors of economy
4) provide the financial assistance and tax privileges to the new owners of privatized enterprises.

Government of Azerbaijan implements the programs and other activities necessary for achievement of these goals. In order to facilitate this process credits from numerous international funds such as World Bank, UNDP, EBRD and etc. are allowed. All these create the ground to think that the national investment climate will go on improving in future (see Table 9) and it will promote the economic growth and prosperity of Azerbaijan Republic.

Table 9. Investment volumes and prospects, millions of dollars.

Economic sectors	Years							
	1994	1995	1996	1997	1998	1999	2000	2003
Oil and gas	22.0	139.8	417.3	780.1	953.1	1178.5	1538.2	2783.0
Other	115.2	235.3	203.3	527.2	600.3	624.1	679.1	927.5
Total	137.2	375.1	620.6	1307.3	1553.4	1802.6	2217.3	3710.5

Projects with the overall budget of 507.2 millions of dollars are implemented and others with the budget of 792 millions are currently developed in Azerbaijan due to external investments.

Because of improvement of investment opportunities many countries are interested in contributing their money to development of our economy. By the total sum of investments flown Azerbaijan occupies one of the outstanding positions among the former Soviet republics. Figure 9 represents the shares of investments by different states.

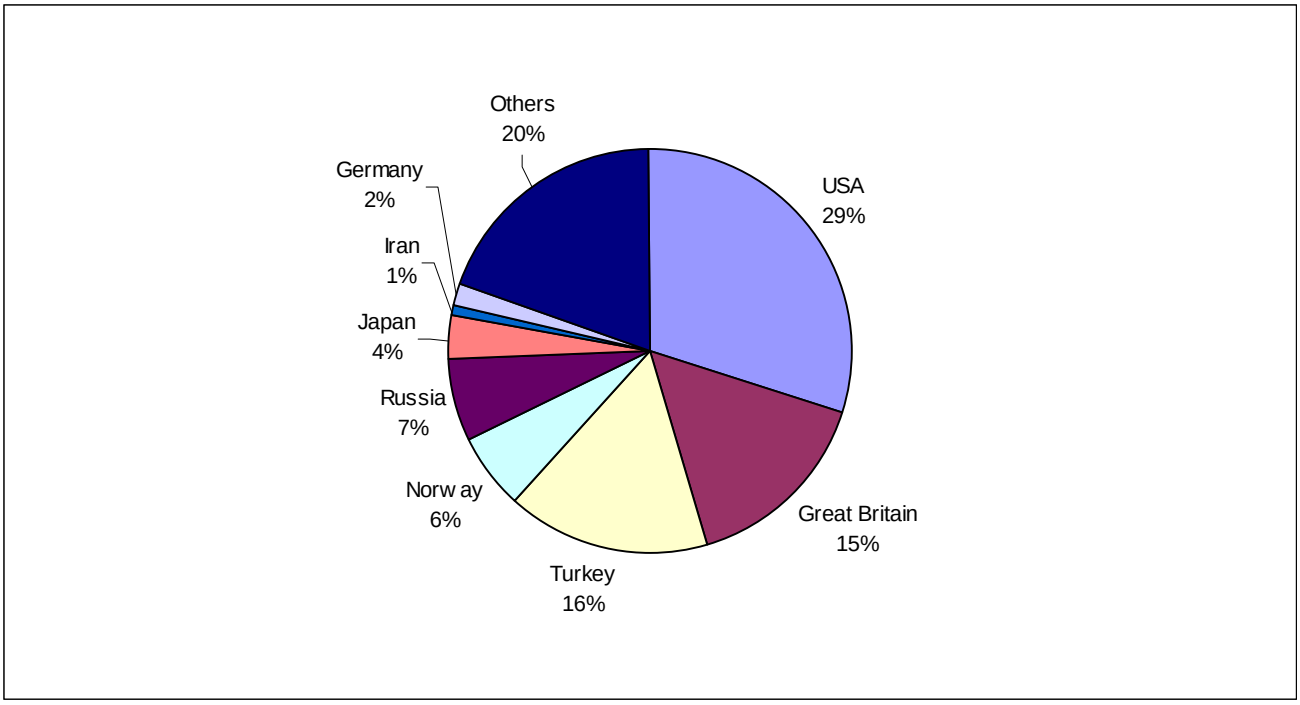

Fig. 9. Distribution of Investments by investing states.

Within the course of last few years many projects addressing various sectors of economy have been implemented with the help of foreign investors (see Table 10). Other perspective projects are currently being looked through by the donors (see Table 11) [10].

Since the declaration of national independence some positive changes in economy and political system of Azerbaijan have been experienced. Numerous banks agree to allow some credits that implies that they are shure in durability of economic and political stability in our country.

Table 10. Projects implemented with the help of foreign investors.

	Funding source	**Total budget, $ mlns.**
Farms' privatization	World Bank (WB)	28,8
Main Mil-Mugan collector	Islamic Bank of Development (IBD)	33,5
Reconstruction of gas system	WB	24,6
Mingechaur energy project	EBRD, IBD	43,6
Yenikent energy project	EBRD, IBD	72,2
Reconstruction of Alat-Qazi-Mohammad road	IBD, Bank of Kuwait	36,5
Construction of airport complex of Bina	Eximbank (Turkey), National West Bank (Great Britain), Kong-Shanghai Bank (China)	59,5
First aid to Bina airport	German Reconstruction Bank	6,6
Water economy system of Baku	WB, EBRD	94,9
Avianavigation system	EBRD	10
Production of the low pressure steam and energy on the ethylene propylene plant	Eximbank (Japan), "Nichimen" company	97

Table 11. Projects considered by the foreign investors.

	Funding source	Total budhet, $ mlns.
Reconstruction of Baku TPP-1	ABB company (Switzerland)	80,0
Construction of Garadakh-"Severnaya TPP" gas pipeline	"Mitsun" company (Japan)	55,0
Reconstruction of "Severnaya" TPP	"Mitsun" company (Japan)	250,0
Reconstruction of Qazi-Mohammad-Kurdamir road	EBRD	60,0
Reconstruction and development of international marine port	EBRD	30,0
Production of poly-propylene on the "Sintezcauchuk" plant	"Technimont" company (France)	138,0
Creation of blood donation bank	«Buig» firm (France)	14,0
Establishment of compressor station on "Bahar" oil field	Japanese companies "ITOCHI" and "Nichimen"	100,0
Construction of gas turbine station on Oil Rocks	Japanese companies "ITOCHI" and "Nichimen"	67,0

Favorable conditions for investing the national economy of Azerbaijan explain the increasing interest demonstrated by foreign companies to our republic. It is particularly evident in the oil and gas sector. There are 20 agreements concluded between the Azerbaijan and 33 companies from 15 states on development of on-shore (5) and offshore (15) oil and gas bearing areas. Predicted volume of investments, placement of which is to be implemented, totals at 57 billions of dollars. Predicted reserves of oil and gas in the project areas make up 4-5 billions of tons of oil and 4.5 trillions of

cubic meters of gas respectively. Oil and gas production sector attracts the largest portion of total investments flown into the Azerbaijan. 3.2 billions of dollars have been invested in that sector since 1994. Now there are 115 thousands of barrels of oil produced. For this year it is planned to produce 5.4 millions of tons of oil. Total volume of oil and gas extracted from "Chirag" deposit till 2000 made up 10.5 millions of tons of oil and 1.3 billions of m^3 of gas respectively. Azerbaijan oil is being transported to the international market through the two routs – Baku-Novorossiysk and Baku-Supsa pipelines with overall carrying capacity of 220 barrels per day. One of the main achievements of the last year was discovery of "Shahdeniz" gas field with total reserves amounting to 1 trillions of m^3 of gas and 300 millions of tons of condense. Another and the most important success was conclusion of agreement providing for construction of Baku-Tbilisi-Jeihan main transportation pipe-line, which is expected to be the turning point that can influence upon the entire region's energy policy.

2.4.2. Securities market.

In Azerbaijan the securities market developed only in 1990'es. By the International Financial Corporation's definition, Azerbaijan corresponds to the group of countries with "emerging markets". This group covers 169 independent states and territories.

Current securities market of a country comprises 32 millions of privatization checks, 18 privatization options, 200 millions of securities and 40 thousands of short-term state bonds. It is necessary to point out that this is just the quantitative outlay. There is no normally functioning secondary market for the absence of organized stock exchange. Depositories and registrars are another important organizations that must support the regular functioning of a securities market.

By the presidential decree "On National Depository System of Azerbaijan Republic" there was established the Central Depository, which formed the structural basis for emerging national securities market. Within the first year of Depository's functioning registers of over 635 Open Joint Stock Companies have been conducted and over 50000 of "depot" accounts have been served and 700 acts on purchase of individual securities have been registered. All of the characteristics, which are common for the "emerging market" countries, are general for Azerbaijan 's securities market that is:

1. Low liquidity (as compared to developed markets);
2. Intransparency of the market and poor awareness level (e. g. lack of information on emitents);
3. Considerable price fluctuations that increase the hazard;
4. Insufficient legislation.

Nowadays it is possible to create an organized and developed securities market in Azerbaijan. Increasing volume of investments and country's promising geographical situation creates the ground to assert that.

Among the key factors promoting the development of contemporary securities market of Azerbaijan there are:

- Expansion of the market through the increase of number and types of securities and numbers of investors and emitents. Creation and development of various market segments in accordance with interests of the stakeholders.
- Abandoning the domination of primary securities distribution and development of secondary market by increase of the share of public distribution of securities rather than the private one;
- Development of professional activities, definition of organizational forms of market. Creation of a system for trade of shares, bonds and other securities;
- Development of structure of a stock market;

- Regulation of securities market through the interaction between governmental authorities and professional stakeholder organizations.

Certain activities for creation of securities market are implemented in this field. With that end of view the Baku stock exchange was established and relevant operations are being conducted there. Recently new instruments were applied in the national stock market of Azerbaijan. Application of corporate securities and other practices increase the potential for the development of national securities market.

2.4.3. Role of the private sector in the technology transfer and acquisition process.

Straightly after the state independence had been gained and transition to a market system had been publicly declared, role of the private sector has started to continuously increase in Azerbaijan. Economic reforms have presented a good incentive for rapid development of private sector. Thus by 1998 the share of latter in the GDP structure has increased by more than 50% respectively (see Table 12).

Table 12. Dynamics of the private sector's share in GDP structure of Azerbaijan.

Share of private sector	Years			
	1995	1996	1997	1998
In GDP	34	38	46	58
In industry	5	7	15	26
In agriculture	60	68	85	95

According to 1999 statistical data, more than 21 thousands of smaller enterprises have been passed to a private hand. Privatization of smaller and medium governmentally owned enterprises continues at a slow rate. Most of these firms were passed to the Ministry of State Property for their further privatization. So far only 10% of total privatization checks distributed among the citizens of Azerbaijan were used. The Second Privatization Program was approved in the year of 2000 [3].

Above implies that the slow rates of privatization process hinder the participation of country's private sector in the technology transfer processes.

2.4.4. Role of legislation and other rules in the technology transfer.

Relevant laws and other regulations are very important for implementation of mitigation and adaptation projects, attraction of investments and normal development of technology transfer process.

Azerbaijan has already made its' first successful steps in achievement of the above objectives. Parliament has ratified several laws to include the following: "Law on enterprises", "Law on Joint Stock Companies", "Law on Firms", "Law on the custom duties from import and export operations", "Law on currency regulation", "Law on investment activities", "Law on protection of foreign investments", "Law on royalties", "Law on environmental protection", "Law on environmental security", "Law on public radiation security", "Law on production and commercial wastes", "Law on forests", "Water code". Relevant normative acts were passed by the Cabinet of Ministers of Azerbaijan Republic.

Economic re-structurization policy pursued by the government of Azerbaijan allows speculating that in the nearest future the industrial capacity and economic structure will be improved and modernized and GDP will increase. At the beginning of twenty first century the global community is oriented at the sustainable development conception. All the efforts of Azerbaijan government under environmental policy are done at the context of sustainable development.

2.4.5. Identification of barriers to new technologies introduction.

Achievement of goals identified by the Convention requires the creation of a basis for a) assisting the non-governmental organizations to implement their activities; b) promoting the removal of some barriers; c) awareness raising among the publicity and political institutions about necessity to overcome the existing barriers. There are certain technology transfer relevant barriers faced by the countries with economies in transition. Azerbaijan is not an exception here. Barriers challenging our republic are counted in the Table 13.

Table 13. Existing barriers and potential removal mechanisms.

Barriers	Possible resolution
1	*2*
1. Macro economic climate: high level of debts and non-payments	*Improvement of economic situation* Allowing grants and light credits Creation of energy efficiency funds
2.Lack of information and experience poor awareness level on energy and fuel efficiency and emissions reduction	Organization of workshops and scientific reports, TV-and radio-programs and advertising campaigns
Shortage of control and measuring equipment: Lack of energy efficiency measuring standards	Provision of such equipment and improvement of energy consumption accounting system Introduction of energy efficiency evaluation standards
Lack of business and risk management experience.	Preparation of technical and management personnel and finansists, creation of joint ventures
Ill-awareness of donors and project developers about their capabilities	Expansion of activities based on selection of projects for specific donors.
3. Lack of credit granting experience and low level of creditworthiness. Enterprises, municipalities and other borrowers do not have enough experience in obtaining the credits Poor flow of investments into the non-oil and gas production sectors. Absence of credit guarantees.	Leasing and issue of municipal commitments. Involvement of local banks into project development Improvement of a banking sector's structure. Establishing relations between energy efficiency relevant and other investments (for example residential sector relevant ones).
4.Organization and property. Legacy of a central planning policy. Governmentally owned energy monopolies. Different incentives for dwellers and owners of buildings Insufficient institutional framework.	Development and implementation of national energy efficiency policy Optimization and definition of property issues Enabling effective incentives such as implementation of repair works after the privatization of accommodation.
5.Limited scale of energy efficiency projects.	Support of development of local organizations by international banks, which are directly dealing with the small projects. Integration of projects. Formulation and solution of funding issues.
6. Energy resources prices. *Low prices of energy resources* Energy subsidies	Developments of price rising approaches reflecting the energy supply costs. Transparency and clearness of the subsidies allowance. Use of investments for energy efficiency in order to reduce the subsidy needs.

3.Capacity development for participation in the systematical observation networks.

In order to implement the commitments taken under the Article 4.1g of a Convention and with the view to improve the national capacity it is necessary for every country to collect and process the systematical climate change monitoring data [19]. National monitoring systems must be closely correlated with the international and regional monitoring networks.

3.1. Contemporary national climate monitoring system.

First regular monitoring over the climate was practiced in the middle of XIX century in Azerbaijan. By the end of last century there were several meteorological stations implementing the regular observations. Climatic conditions were summarized in the book named "Climatic zoning of Azerbaijan", which was written by I. V. Figurovsky and issued in early 1900'es [20]. By 1930'es the number of meteorological stations increased and reached 60-80. Meteorological monitoring data was summarized in the work of E. M. Shihlinsky and A. A. Madat-zadeh "Climate of Azerbaijan" [21]. In 1965 the Manual on Azerbaijan climate was issued. That manual covered the monitoring gathered from 1880 through 1960. This work still remains to be a comprehensive source for national climate relevant studies since there was not practiced the complex summarization and release of a monitoring information since far.

By the law of Azerbaijan Republic "On hydrometeorological activities", the State Hydrometeorological Committee was mandated to a) implement the meteorological and hydrological and oceanographical observations as well as the environmental contamination monitoring and b) control the relevant activities of other governmental institutions. Hydrometeorological committee has the status of National Hydrometeorological Service (NHMS) and has the right to represent the Azerbaijan in WMO and other international organizations. As a NHMS the Committee provides relevant institutions and enterprises and the whole public with hydrometeorological and climatic forecasts and information. In order to implement its' activities the Hydrometeorological Committee is given the relevant institutional structure, which includes the monitoring network, communications, processing centers, scientific and forecast departments.

Besides the Hydrometeorological Committee, the process of implementation of commitments also involves the following organizations:

- State Committee of Ecology and Control over the Natural Resources Utilization;
- Azerbaijan National Aero-Spatial Agency (spatial data processing);
- Committee of Geology and Mineral Resources (underground waters quality monitoring).

3.1.1. Meteorological, agrometeorological and aerological monitoring.

Onshore meteorological monitoring network includes 79 stations, 78 of which belong to the State Hydrometeorological Committee of Azerbaijan republic. One station refers to the National Railways Administration. Twelve meteorological stations are situated at the territories annexed by the Armenia and do not work now. Eight working stations are designed for operative services. One station (Lerik) was established recently. Fifty eight stations are invented to produce and process the climatic data at the national level. Density of climatic monitoring stations network makes up eight stations per 10 thousands of km^2. However location of stations by vertical zoning is not even.

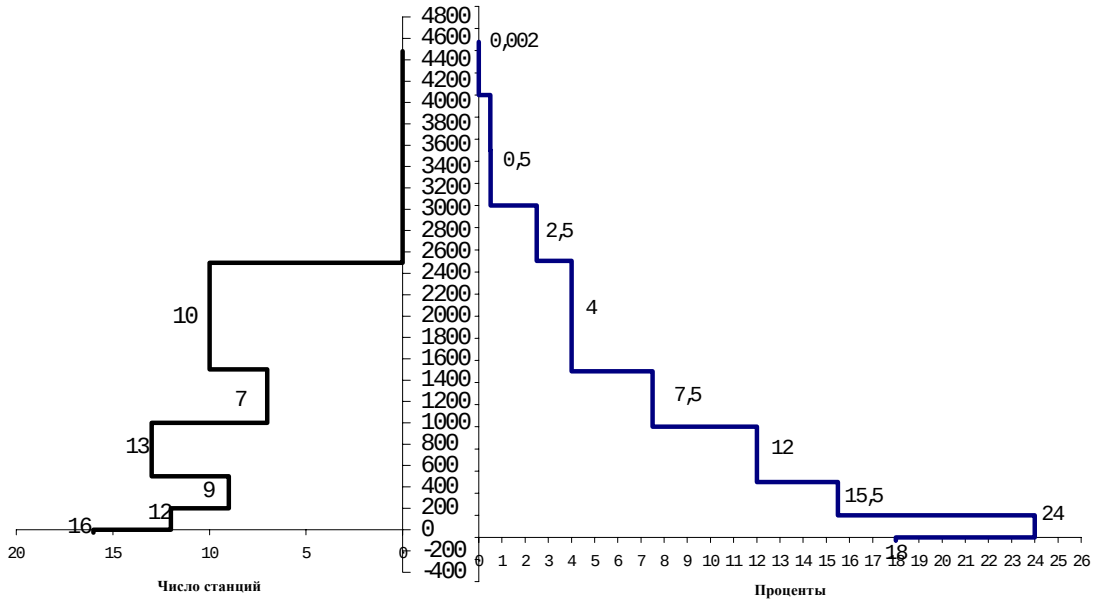

Fig. 10. Distribution of a country's territory (a) and number of meteorological stations (b) by heights.

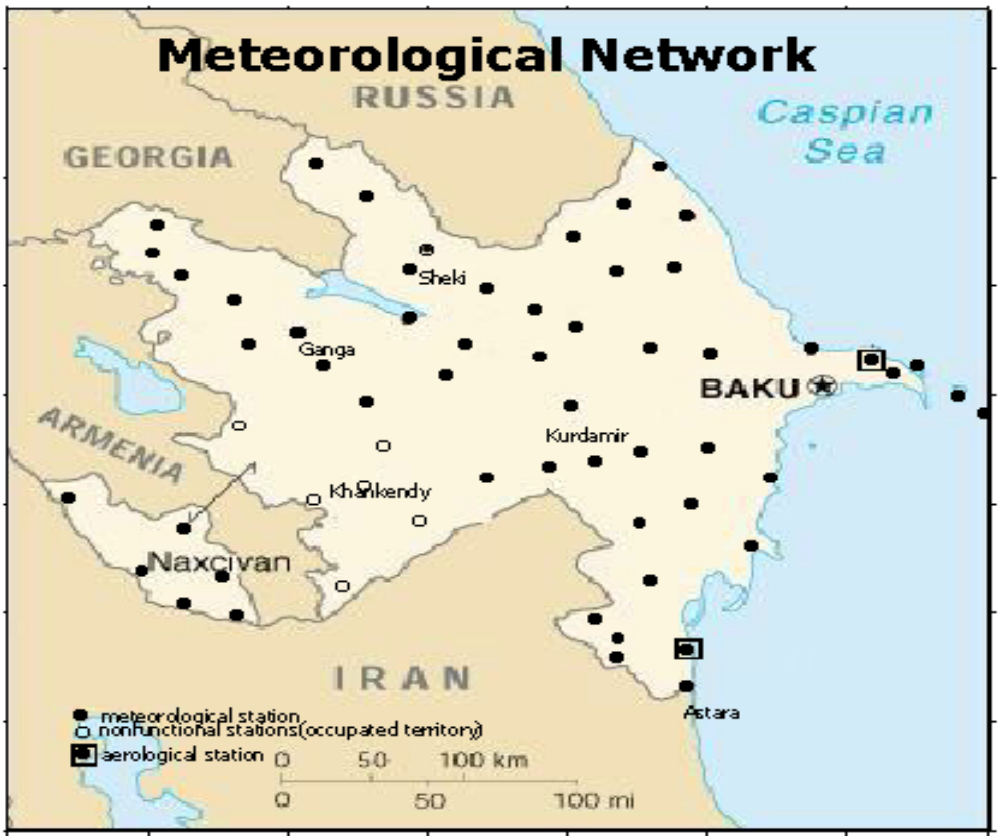

Fig. 11. Meteorological monitoring network.

Many stations (16) are situated below the sea level, while the relevant territory occupies 18% of total. These are mainly the coastal and island stations, which are very important for studying the hydrological regime of seawaters. Such stations are also significant for identification of climatic and wind regime of Apsheron peninsula, on which the capital city – Baku – is located. Some stations alongside the Kur River are also situated below the sea level. Twelve stations are between 0 and 200 meters above the sea level. Even though the 24% of country's total territories refer to that diapason, high density of the stations, which are located below the sea level, allows thinking that the monitoring stations tightly cover the low-lying areas of Azerbaijan. Meteorological stations are poorly represented in foothill areas (200-500 to 1000-1500 meters above the sea level). There are only 16 stations serving these territories, which occupy 23% of total. In spite of considerable importance for climate change studies there is no single station at all above the 2500 meters above the sea level. Therefore it is logical to assert that the way the meteorological stations are distributed in Azerbaijan is not so rational in spite of comparatively good density. It mainly comes from the difficulty to situate the station afar from the inhabited area that increases the required maintenance and organization costs by ten times.

- Moreover on 12 meteorological stations monitoring by a brief program is being implemented and minimum and maximum air temperatures and precipitation volumes are being measured at a daily basis.
- Actinometrical observations are being made on four stations, on which the total, direct, diffused and reflected solar radiation is being measured.
- Network consisting of 38 stations implements the agrometeorological monitoring thus serving the agricultural sector of economy.
- Aerological monitoring – atmospheric sensing – is being conducted on two stations (Mashtaga - since 1936 and Lenkoran – since 1953).

3.1.2. Ozone layer and atmospheric contamination monitoring.

Azerbaijan do not have the stations satisfying the requirements of Global Atmosphere Work (GCOS, GAW). Now the project for establishment of one such station on Pirguli Mountains is being developed. Existing special monitoring network is designed for satisfying the national level demand.

- Ozone layer monitoring has been implemented on the station situated nearby the Baku since the year of 1993. General concentration of ozone is being measured by the ozone meter M-124 (Russia). UV radiation is not yet measured, but the establishment of a new UV measuring ozone meter is projected. Monitoring data was not provided to the Global Ozone Data Center (Canada) and was used only for regional researches.
- Monitoring over atmospheric precipitation's chemical content has been practiced since 1991 and up to six ingredients has been covered. Nowadays the monitoring is being conducted on 18 stations. Collected samples go through the chemical analysis at the laboratories.
- Atmospheric air quality monitoring is implemented on 27 stations located in eight cities. Such parameters as dust, SO_2, NO_2, CO, CL and phenol are being measured.

3.1.3. Oceanographic monitoring

Caspian Sea, on the western coast of which Azerbaijan is located, is a unique natural water reservoir. Total areas of its' waters makes up 400 thousands of km^2. Caspian Sea is a type of indicator of climate change, i. e. the miserable change in climatic conditions reflects on fluctuations of a sea level. Since 1975 through 1996 the level of Caspian Sea has rose by 2.4 meters. As a result of fact only in Azerbaijan 468 km^2 of lands have gone under the water and damage caused to the national economy totaled by two billions of dollars.

Caspian Sea has the vital importance for Azerbaijan and our country has the broad network of monitoring stations there. By the number of offshore and island hydrometeorological stations (12) Azerbaijan occupies the second position next to Russia among the five Pre-Caspian states. Besides standard meteorological observations the following parameters are being regularly measured there:

- temperature of a sea surface
- choppiness
- sea level
- water saltiness
- streams.

One of these stations – Oil Rocks - is located on platforms in the open sea that creates a good opportunity for additional study and research. On the hydrometeorological monitoring station of "Oil Rocks" the expanded hydrometeorological observations have been conducted since 1949. Numerous scientific researches on identification of energy flows, deep-sea streams and turbulence and etc. have been implemented there. Relevant outcomes were covered by many scientific reports and publications. The monograph "Hydrometeorological and Hydrochemical conditions of the Caspian Sea" – scientifically important work - was compiled and issued together with Hydrometeorological Committee of Russia.

State Hydrometeorological Committee of Azerbaijan Republic also has a little flotilla consisting of four hydrometeorological ships. Besides standard monitoring activities this flotilla implemented the measurement of following elements:

- temperature of water at each depth;
- saltiness level by depth;
- streams;
- hydrochemical and hydrobiological content.

Since 1961 the eight "age-old" hydrological sections have been established in order to study the long-term dynamics of hydrometeorological and hydrochemical regime of the Caspian Sea. Three of them currently belong to the activity sphere of State Hydrometeorological Committee. Seasonal field studies are conducted on those sections since the year of 1992.

Nowadays Azerbaijan is not capable of providing the field trips itself. Therefore the expeditions are being organized episodically and by the order of sponsoring organizations - as a rule.

Marine meteorological monitoring on the passenger and other ships has been implemented since 1992.

3.1.4. Hydrological monitoring.

Hydrological monitoring of the territory of Azerbaijan is being implemented by the State Hydrometeorological Committee (land waters) and the State Committee of Geology and Mineral Resources (underground waters). Water consumption distribution and accounting is conducted by the State Committee of Melioration and Water Resources, which has the limited number of hydrological monitoring stations.

Azerbaijan has the ramified river system, even though the national water resources are addressed to as insufficient. Country's main rivers – Kur and Araz – are starting from the Eastern Turkey and then pass through the Georgia (Kur) and Armenia (Araz) and join at the territory of Azerbaijan then falling into the Caspian Sea. Other rivers may be divided into three groups – Great Caucasus and Smaller Caucasus and Lenkoran-Astara rover basins.

In total there are 102 hydrological stations at the balance of State Hydrometeorological Committee. 75 of them are located on rivers, 9 – on water reservoirs, 2 – on lakes and the 1 – on the canal.

Fifteen hydrological stations are situated at the territories, which are invaded by the Armenian warriors (Mountainous Qarabakh and adjoining areas).

Standard hydrological monitoring covers the following parameters:

- water level;
- water run-off;
- turbidity level;
- dispersed alluviums.

In the winter fixed routed snow measuring surveys are being implemented and the thickness, wateriness and density of a snow cover are being measured. During and after terrain the special trips are being organized in order to identify the characteristics of this disaster.

Monitoring of the water's hydrochemical content and contamination level of the water objects is implemented on 58 stations. Collected water samples go through the laboratory analysis.

3.1.5. Icehouse monitoring.

There are several small icehouses at the territory of Azerbaijan. They are located around the Bazar-Duzi and Shakhdaq Peaks (4100-4485 m). This is the top eastern icehouse group of the Caucasus. Within the duration of several years (1938, 1956-59) the reconnaissance monitoring of some icehouses has been implemented. Not only the icehouse regime has been investigated but there were also conducted the half-stationary studies of a surface thawing and icehouse dynamics.

3.1.6. Spatial monitoring program.

Azerbaijan do not have its' own satellites and thus would hardly be able to implement any spatial monitoring program in the nearest future. Azerbaijan do not fund the joint spatial programs as well. Satellite information is being received through the international voluntary programs and includes the daily information coming from the meteorological satellites and used for analyzing the cloud system. This data is not being catalogued. Some projects are being implemented by the ANASA within the framework of joint research programs.

3.2. Data collection, processing, application and exchange.

Meteorology

Collection of the meteorological information is being implemented at operative basis and according to the GCOS documents. 67 stations transmit the SYNOP data to the National Center. 37 of those stations pass the data for all of the terms of 00,03,06,09,12,15,18,21 GMT.27 stations transmit the SYNOP data 3 to 5 times a day. SYNOP data is being published and disseminated as weather bulletins at a daily basis. Data coming from 35 stations is being transmitted for regional exchange, while the data produced by 7 stations is used for the global exchange. SYNOP data is hand-recorded on the special bulletin with the help of meteorological marks. CLIMAT data is being transmitted to the National Center through 18 stations. Data from four stations is being passed for the regional and global exchange.

Control over the SYNOP and CLIMAT data is implemented by hand and there is no Data Commutation Center established. This factor makes the computer storage of data impossible. In order to store and summarize the produced information, the data coding and transmission to the Calculation Center is being practiced at the end of each month. At the Calculation Center the input data is being stored in a computer storage, processed, summarized and archived. Currently we possess the daily information from all stations covering the period from 1936 through nowadays.

Copies of this information might be obtained at the Global Data Center in Moscow. After being formatted some of this data might be transmitted to a Global Data Center.

Azerbaijan is represented by one Astara station (GCOS/GSN) at the global ground climate network. Astara station is situated in the Southern Azerbaijan nearby the Iran boundaries. This station has a deeply rooted history and it has been implementing the range of observations for about 100 years. The station is located in the sub-tropical climatic zone, and the annual precipitation volume here (1500 mm/year) is not similar to those of other regions of Azerbaijan (400-500 mm/year in average). Minimum and maximum temperatures are softer here due to impact caused by sea.

Operative information (SYNOP, CLIMAT and etc.) is being processed by hand. Data designed for climatic summarization goes through the computer processing by the methods elaborated in the State Hydrometeorological Committee. Systematical information control is being practiced. There is also created a computer database of daily meteorological information collected from 1935 through 2000.

Multi-year climatic estimations are implemented by original research software with the help of computer archive. CLICOM system is not introduced. There is no data management system as well.

Meteorological data is being used for preparation of weather forecasts, river wateriness predictions and other purposes. Daily and monthly weather forecast and climatic bulletins are being released.

Agrometeorology

Daily data from 28 stations is being transmitted to the National Center during the vegetation periods. Once per decade the agrometeorological summaries are being provided by 57 stations. Daily agrometeorological surveys are being compiled and included into daily weather bulletins. Yet the agrometeorological monitoring data is being stored as a hard copy. It is planned to copy all of the agrometeorological information to the technical carriers. Phenological observations (lands humidity data, productivity and yield elements and etc,) are the key factors to determine the local climate change tendencies.

Currently there is a great need for development of a network of stations implementing the land surface evaporation process monitoring. There are some difficulties in implementing the programs providing for study of lands' hydrological and humidity characteristics and conducting the relevant field observations. We are short of modern equipment for the monitoring of lands' arable layer's temperature, lands humidity and evaporation process.

Aerology

Old aerological information is stored on the technical carriers in the Tashkent Regional Monitoring Center, while the hard copies of this information are available at the National Hydrometeorological Fund of Azerbaijan. Aerological stations aren't covered by the GCOS/GUAN network.

Data coming from the meteorological stations as well as the agrometeorological and aerological information are being processed by hand.

Quality of atmospheric air and precipitation and water resources

Atmospheric air quality assessment is being implemented in five large cities and three times per day – at 07, 13 and 19 o'clock. The air samples are being selected and then processed at the laboratories. Having been chemically analyzed the operative data is being coded and then goes to the National Environmental Contamination Monitoring Center. This data is being used for compilation of operative environmental quality forecasts and published in the daily ecological bulletins. By the end of each month the more detailed information is being stored in computer storage, and then processed and archived. National computer database contains the information

covering the period of 1993 through 2000. Information of 1980 through 1992 is kept in Russia in the database of Main Geophysical Observatory named after A. I. Voeikov.

Quality and contamination level of atmospheric precipitation is being determined at the laboratories. This data is mainly used for research purposes. Information is being stored in the National Database.

Quality of land waters (rivers, lakes and reservoirs) is being determined under laboratory conditions and processed by hand and stored at the National Database. Data is being used by governmental agencies and environmental organizations for water quality control.

In normal hydrological observations (water level) are being conducted twice a day and depending on conditions of the specific water object (water run-off assessment). Data is being operatively transmitted once per day. Information is being processed by hand and published in the State Hydrometeorological Committee as a "National Land Waters Inventory". Inventory also includes the data on underground waters, which is being received by the Committee of Ecology and Mineral Resources. Hydrological data is being sent to the Global Run-off Data Center (Koblens, Germany).

Oceanographic data collected through the offshore hydrometeorological stations and seasonal expeditionary surveys are being processed with the usage of special computer software prepared at the Hydrometeorological Committee. There are monthly and annual databases created. Data from the coastal hydrometeorological stations of Kazakhstan and Turkmenistan is also processed at the State Hydrometeorological Committee and using this software. In Azerbaijan it is planned to release the Marine Hydrometeorological Yearbook. Data exchanged is being organized between the State Hydrometeorological Committee of Azerbaijan and the National Hydrometeorological Services of Kazakhstan, Russia and Turkmenistan.

3.3. Shortcomings.

There are the following shortcomings, which are characteristic to the monitoring system of Azerbaijan:

- Equipment and devices used in the monitoring network are out dated and worn-out. Equipment testing and calibration system is insufficient and poorly developed. There is no computers and modern communication means.
- Within the period of 1961 through 2000 17 stations have been moved without the activities duplicating. Some monitoring activities (e. g. seasonal expeditionary researches on Caspian Sea, marine meteorological observations, aerological sensing, lands hydrometeorological characteristics assessment and etc.) are stopped due to a lack of financial means.
- For the absence of Data Commutation Center the operative data does not go through the computer processing and archiving at once. Data input in Global Telecommunications Network is implemented not directly but through the Global Data Center in Moscow. There is no automatic information exchange monitoring practiced.
- There is no system for receipt and processing and storage of satellite data of the medium and high resolution, which is used for hydrological parameters assessment.
- Data processing and control is being mostly implemented by hand. Shortage of computers and relevant software does not allow implementing the expanded analysis and secure data storage.
- Insufficient salaries prevent the employment of highly qualified specialists. As a result of fact frequent personnel re-recruitment occur.

3.4. Cooperation at the regional and international levels

Since 1993 Azerbaijan is the member of World Meteorological Organization (WMO) and participates at all of the regional scale projects developed by this agency. Azerbaijan also collaborates with the National Hydrometeorological Services of other states such as Georgia, Iran, Kazakhstan, Russia, Turkmenistan, Turkey, Uzbekistan and etc.

In 1994 the National Hydrometeorological Service of Azerbaijan initiated the creation of Steering Committee of Hydrometeorology and Caspian Sea's Environmental Contamination. Within the framework of this Committee and with financial assistance of WMO the Integrated Program on Hydrometeorology and Caspian Sea's Environmental Contamination Monitoring (CASPAS) has been developed in 1997.

Works on provision of hydrometeorological security of the Eurasian Transport Corridor (TRASECA) are implemented.

3.5. Perspective capacity development activities

In the nearest future it is planned to expand and improve the technical capacity of the National Hydrometeorological Service. Designed activities include the following:

- establishment of new monitoring stations and observation platforms in the Caspian Sea;
- establishment of new hydrological stations at the places of formation of drainage;
- organization of semi-stationary monitoring over the condition of snow cover and icehouses in the mountainous regions;
- improvement of the agrometeorological monitoring network;
- technical modernization of laboratory equipment and devices;
- creation of modern Communication System and Data Commutation Center;
- introduction of CLICOM system and automated data management system;
- improvement of data exchange process with the regional and international information centers;
- introduction of modern methods and relevant software for implementation of monitoring and data collection activities and etc.

Some of these activities are to be implemented both under various regional programs (e.g. CASPAS, TRASECA, HYCOS Caspian Sea ("Assessment of the Hydrological Cycle of the Caspian Sea river Basins") and etc.) and within the framework of WMO Support Programs. Development and implementation of specific multi-lateral projects are also planned in order to achieve these goals.

It is necessary to point out that some types of climate change relevant land's quality monitoring activities are not organized in Azerbaijan. Despite the economic difficulties the existing structure allows organization of these activities. But, on the other hand, it requires the relevant technical and methodological assistance. Organization and implementation of spatial monitoring of different environmental agents is very important. In order to implement such monitoring it is required to obtain the equipment for satellite data processing and receipt of digital satellite information of different resolutions.

Priority needs of Azerbaijan for capacity improvement in the systematical observations network are summarized and presented in Table 14.

Table 14. Priority needs for capacity development in the systematical climate observations system.

Type of observation	Type of activity	Needs
Meteorological observations	- monitoring stations - data collection, processing and management	Technical modernization and provision of 78 stations with standard equipment, establishment of 5 new stations; Introduction of modern telecommunication system for data collection and exchange; Automatic control of operative data; Improvement of existing and development and introduction of modern database and data management system.
Aerology	- monitoring stations - remote methods - data collection, processing and storage	Technical modernization of two radio-sensing stations, establishment of two more stations Introduction of modern system for data collection, automated control, processing and archiving.
Agrometeorology	- monitoring system - remote methods - data collection and processing	Equipment of monitoring stations with the modern equipment, enhancement of existing monitoring scale with regards to climatic program needs, introduction of remote agrometeorological observation methods; Equipment of modern data collection and processing system.
Hydrological observations	- monitoring network - data collection and processing	Reconstruction of destroyed monitoring stations, revision and certification of equipment; Introduction of modern system for data collection, automated control, processing and archiving.
Environmental contamination monitoring	- monitoring system - monitoring network - Operative service	Provision of laboratories with the new and modern analyzing equipment; equipment of a network with automated analyzers and contamination control systems.
Aero-spatial observations	- hydrometeorological and - environmental monitoring	Receipt and processing of digital satellite information; personnel training; technology
Improvement of scientific and technical capacity	- monitoring network - equipment and technology - data processing and exchange - solution of scientific and applied objectives	Training and re-training of personnel at the basis of scientific and technical progress achieved.

4.Vulnerability and Adaptation assessment for some resources to climate change

While implementing the first phase of Initial National Communication there have been conducted the vulnerability and adaptation (V & A) assessments for the water, land, agroclimatic and forest resources as well as for agricultural sector and coastal areas of Azerbaijan. Current phase provided for implementation of V & A assessments for fish resources and desetrification processes.

4.1. Vulnerability and Adaptation assessments applied to fish resources

4.1.1. Vulnerability of fish resources to climate change

The impact caused by climate change to fish resources is indirect and happens through the changes in water objects' hydrological and hydrochemical characteristics [25, 27, 28]. Contemporary and predicted climate change relevant changes of water objects' qualities have been assessed in previous researches [1, 26].

In order to assess the vulnerability of a Caspian Sea's fish resources there have been studied the impacts of hydrological and hydrochemical conditions [29]. The following parameters have been assessed:

- climate change impacts caused to the temperature of air and water and precipitation by UKMO, CCCM, GISS, GFDL-T and GFDL-3 scenarios.
- Perspective changes in the flooding level of coastal areas;
- expected changes of the rivers' hydrological qualities;
- changes of such parameters as saltiness and oxygen regime and water pollution level.

Conducted assessments showed that the realization of above-mentioned scenarios would lead to increase of the Caspian Sea level up to –26-25.0 m of abc. As a result of these developments the following changes are expected to take place:

- increase of a sea level by 150 more centimeters would lead to flooding of 87,7 thousand hectares of Azerbaijan's coastal areas by 2030-2040. Although the spawning-ground for fishes will increase therefore, on the other hand the territories surrounding oil production fields will get extremely contaminated by oil products. This would result in deterioration of the gas and heat exchange between atmosphere and sea and reduction of bioresources. Therefore it is not casual that even nowadays the species migrating from the Black Sea and Azov are in all terms predominant at the areas covered by oil production, while the share of domestic fauna is not so noticeable there.
- due to a rise of the Caspian sea's level a) the quality of coastal waters will get worse, b) the estuary spawning-ground for fishes will reduce, c)the spawning ground at the coastal shallow waters will change, and d) the serious decease among sturgeons will occur.
- insignificant changes of saltiness and oxygen regime will occur that would positively affect the fish resources.

The main element defining the spawning and reproduction conditions of fishes is the temperature of water. There was developed a method for assessment of expected changes of the water temperature both in general and at the moments of beginning and end of a spawning process. Basing on identification of functional interdependency between the air temperature and spawning terms and proceeding from the different climate change scenarios the changes in reproduction dates of the marketable types of fish have been assessed (see Table 15).

Table 15. Reproduction terms of the main types of marketable fishes according to the climate change scenarios.

Type of fish	GISS	GFDL-T	CCCM	GFDL-3	UK 89	Artificial	Actual
Kutum	01.03-05.04	27.07-23.04	02-04.04	18.02-24.03	24.02-30.03	12.03-13.04	March-April
Thorn	04.03-12.04	26.03-16.05	-16.04	28.02-14.04	22.03-17.04	04.03-06.05	April-May
Sturgeon	11.04-31.05	04.05-08.06	-23.05	31.03-19.05	07.04-23.05	16.04-20.09	May-August
Sturgeon (flesh of)	10.04-18.05	28.04-23.05	04-07.05	05.04-14.05	06.04-15.05	16.04-17.05	May-June
Vobla	04.02-12.04	05.03-10.05	05.02-16.04	19.02-14.04	05.02-15.04	20.02-07.05	March-April
Anchovy sprat	08.04-30.05 12.10-02.12	03.05-03.06 14.10-22.11	-23.05 09-24.11	01.04-18.05 13.10-28.11	03.04-23.05 27.09-11.11	13.04-02.06 22.09-21.11	May-December
Commonplace sprat	21.02-03.05	19.03-10.05	02-16.04	28.02-14.04	22.02-14.04	04.03-07.05	March-May

It is necessary to note that once the climate change scenarios (UKMO, CCCM, GISS, GFDL-3 and GFDL-T) come true, fish resources of the Caspian Sea would develop under normal conditions and then no emergencies are expected. Only the spawning terms will change and this would enable comparatively painless adaptation of fish resources to climate change.

4.1.2. Adaptation activities

According to assessment [30] the total reserves of fish in the Caspian Sea amount to about 2,9 millions of tons. 51.4% of them is occupied by the sprats, while 30.5, 6.9 and 4.8% refer to the sturgeons and river fishes respectively.

Caspian Sea is the world's single basin, in which the large shoals of sturgeons are accumulated, and make up 90% of the world's total sturgeon reserves.

Regulatedness of rivers flowing into the Caspian Sea and high level of legal and poacher catch resulted in that some types of valuable kinds of fish may get completely extinct within several decades to come. Due to the regulatedness of Kur and Araz rivers most of the sturgeons spawning-ground (90%) turned out to be under the water reservoirs. Reduction of water run-off made it difficult for fishes to reach the river. Natural reproduction volume of sturgeons went down in the Volga basin soon after the construction of Volgograd Hydro-Power Plant. Only the river of Ural could save the normal conditions in those terms.

Partial replenishment of fish reserves was obtained through the artificial fish breeding activities in Pre-Caspian countries. Fish breeding plants of Azerbaijan, Iran and Russia have produced 160 millions of fry sturgeons that made up 3% of total fry grown in a natural way. After 1980 productivity of these plants decreased by 40%. Two plants in Azerbaijan went under the water as the level of Caspian Sea rose.

One of the main reasons to why the fish reserves decreased within last years is increasing volumes of illegal poaching that basically targets the caviar production. Here it is logical to mention that the sturgeons reproduce very slowly -

Limited number and unique character of fish resources as well as their vulnerability to extensive exploitation require the governments for taking the radical actions in the field of fish production. With this end of view the implementation of following protective activities is necessary:

- enforcement of a legislation and regional standards aimed at conservation of fish reserves; regulation of catch in accordance with the national quotes; restriction of caviar processing and storage and export;
- revision of budget in order to cover the sturgeon and elk breeding plants funding and implement the quotes regarding catch volumes and quality control,
- regional scale collaboration in the field of trans-boundary contamination management of the Caspian Sea watershed and regulation of the trans-boundary fish production activities.

Preservation of unity and integrity of the Caspian Sea ecosystem requires saving of bioresources, among which the sturgeons are of priority significance. Therefore, the increase of fish reserves of the Caspian Sea requires harder attention to the artificial fish breeding issues. Implementation of required activities needs certain investments

- to reconstruct the existing sturgeon breeding plants and build the new ones in order to maintain the total annual fry production capacity of up to 60 mlns.
- to reconstruct the existing and build the new elk breeding plants with the view to maintain the total annual fry production capacity of up to 5 mlns.
- to reconstruct the existing and build the new kutum and carp breeding plants with the view to maintain the total annual fry production capacity of up to 100 and 900 mlns. respectively
- to remove the barriers preventing movement of elks and sturgeons through the Kur River.
- to expand the fish spawning-grounds in the delta of Kur River.
- to improve the existing fish catching legislation and market standards.

4.2. Assessment of impact caused by climate change to desertification process and development of relevant adaptation activities.

4.2.1. Current conditions

Studying of how the climate change process reflects on the arid and semiarid geological complexes and elaboration of relevant adaptation activities were not covered by the Initial National Communication. However the researches of climatic boundaries of contemporary and projected arid areas coupled with the studies of a climate change impact to water and land resources and agricultural sector [1] have formed a good ground for implementation of detailed researches in the future.

Analysis of country's natural damping conditions has shown that within the course of twentieth century there were observed the desertification processes, which has considerably increased since 1980'es.

Contemporary semi-deserts, which are defined by the dampness factor, do not create the single natural zone and occupy 15% of a country's total area and cover the eastern and western parts of Kur-Araz lowland and Pre-Araz plains of Nakhchivan AR.

Unlike the semi-deserts the climatic area of dry steppes occupying approximately 45% of a country's territory creates single natural zone, the bounds of which reach 600 through 700-800 m in the mountains and 1300-1400 m in Nakhchivan AR (Fig.12).

At the moment the greatest part of arid and semi-arid territories is presented by agricultural landscapes. Antropogenic factor varies from 0.10-0.33 in the eastern Kur-Araz lowland to 0.80-0.90 in the foothill plains and makes up 0.50-0.60 in the Greater and Smaller Caucasus low mountains [31,32]. Thus the Kur-Araz lowland's geological complexes are more reformed, within the limits of which the following types of landscape might be distinguished at the basis of at what extent they were used:

- not used at all. Occupy approximately 10% of total territory;
- irregularly used. Occupy approximately 30% of territory;
- often used. Occupy the rest part of a lowland.

Approximately 80% of agricultural products are produced within the arid and semiarid territories of a country. Eroded and salted lands, which are not used for agricultural purposes, are mainly used as the winter pastures. Wormwood, wormwood-ephemeral, Kengyz and multi-herbal and ephemeral and other semi-desert complexes present those lands. At the moment total area of winter pastures in Azerbaijan makes up about 1,6 millions of ha.

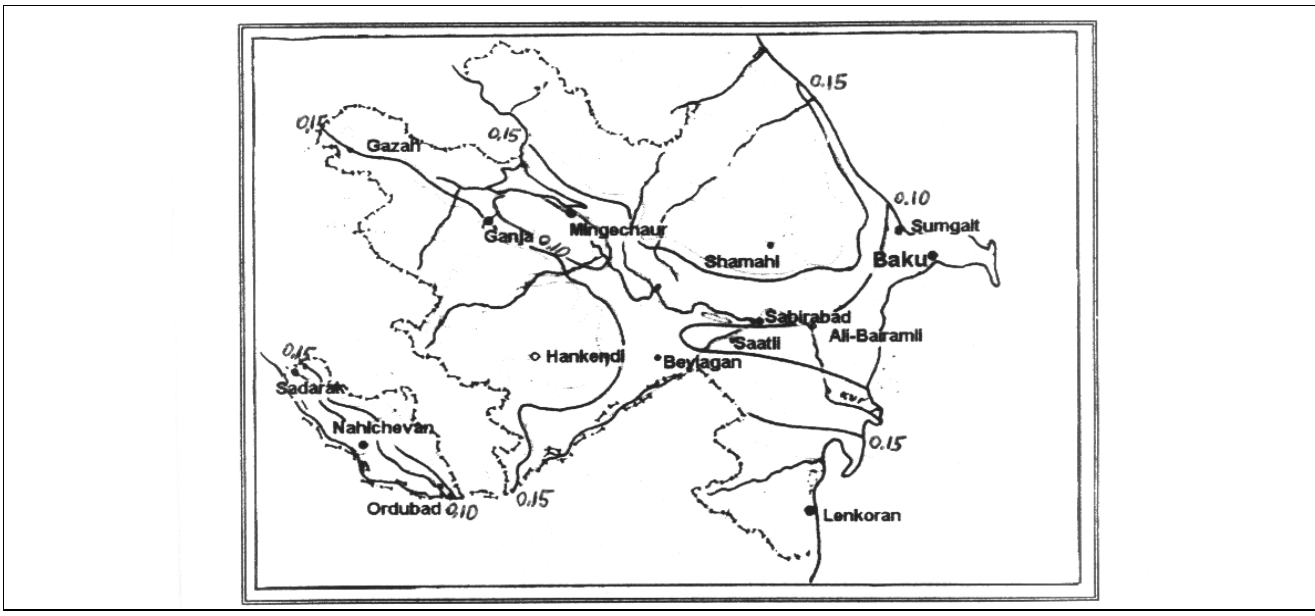

Fig. 12. Distribution of dry steppes at the territory of Azerbaijan Republic.

Annual volume of atmospheric precipitation in Azerbaijan does not exceed 400 m and makes up 200 through 150 mm in the most arid territories. Annual evaporation volume varies from 900 to 1500 mm, while the moisture deficiency reaches 1000-1300 mm in the hottest and driest territories. Drought is the most negative meteorological phenomenon oppressing and sometimes resulting in extinction of both wild and cultivated vegetation. Atmospheric and hydrological and lands droughts are common for the studied territory. Combination of these types of drought cause greatest damage to local vegetation. By aridity level there are three major groups of regions distinguished [33,34]:

- regions with atmospheric drought and comparatively low humidity of soils. Number of dry periods varies from 50 to 90 days per year. This group includes Kur-Araz lowland, Karabakh, Shirvan and Mugan plains and the lower part of Greater and Smaller Caucasus.
- regions with considerable lands drought and comparatively high level of humidity in the air. Number of dry periods varies from 10 to 60 days per year. Such conditions are characteristic for the coastal areas.
- regions with considerable lands and atmospheric droughts. Number of dry periods exceeds 50 to 100 and sometimes reaches 115 days per year. Such conditions are characteristic to Pre-Araz plains of Nakhchivan AR, Jeyranchol and Gobustan inside intermountain hollows.

Deficiency of moisture especially affects the plants due to the hot dry winds. The most dangerous areas in these terms are the central regions of Kur-Araz lowland, where the frequency of hot dry winds makes up 30-40 days per year, and Pre-Araz plains of Nakhchivan with the frequency of 70 days in some places.

Erosion and saltiness are other factors resulting in degradation of a land-cover of arid and semi-arid regions of Azerbaijan. These occurrences form a basis for formation of inter-zonal deserted complexes - desertification sources in semi-deserts.

Eroded lands occupy 36,4% of country's territory. Widespread in the arid areas are the following erosion types:

a) the water (mainly irrigation) erosion;
b) ravine erosion - in the mountainous parts of Kur-Araz lowland, Gobustan, Jeyranchol;
c) wind erosion - in the Absheron and Ganja-Gazakh massifs.

The most damage is caused by combination of the different types of erosion. In general 30% of Kur-Araz lowland's territories are subjected to various degrees of erosion [35, 36]. Salted lands occupy 1190,0 thousands of ha of Azerbaijan's territory. 121,9 thousands of them are salt marshes,

while the strongly salted areas occupy 549,2 thousands of ha. In general 222 thousands of ha of cultivated lands and 929,9 thousands of ha of the winter pastures are salted [37].

4.2.2. Possible climate change impacts to desertification processes.

It was assessed that realization of GISS scenario would lead to extension of climatic areas of semi-deserts and dry steppes. Their boundaries will increase up to 100-200 and sometimes 400 m in the low mountains. GFDL-3 scenario asserts that the limits of these areas would not go up for more than 50-100 meters. According to artificial scenario the forecasted increase would make up 50-100 meters.

Global warming caused by doubling of atmospheric CO_2 emissions would result in intensification of desertification processes in the contemporary humid zones of Azerbaijan, where the zonal semi-deserts and dry steppes are widespread, and which are distinguished by low and extremely low Biological Climate Productivity (BCP) [1,34]. This process will strongly affect those areas, in which the climatic and anthropogenic factors of climate change would coincide with each other [38]. Significant part of contemporary semi-deserts of the eastern part of Kur-Araz lowland, south Absheron and Pre-Araz plains would become deserts. Semi-deserts will replace the contemporary dry steppes, while the latter will move to the highlands with lower BCP. Total area of climatic deserts and semi-deserts in Azerbaijan would make up 43,5 thousands of km^2 therefore (more than 50% of a republic's territory). Once the artificial scenario proves itself, the total area of semi-deserts and deserts in Azerbaijan would occupy 30,5 thousands of km^2 (35% of a country's territory). Realization of GISS and GFDL-3 scenarios would result in increase of semi-desert areas by 3,4 times, while the artificial scenario foresees the 2,4-fold increase.

4.2.3. Relevant adaptation activities

Numerous researches dedicated to arid lands melioration have been implemented in Azerbaijan so far. Melioration activities proposed by those studies may be considered as preventive adaptation measures to a forthcoming warming of climate. Achievement of the latter is possible through the regulation of such important factor of climate formation as the spreading surface.

Irrigation activities.

Lands irrigation in Azerbaijan has a deeply rooted history. Tracks of irrigation canals constructed in the IV-VII centuries might be found even nowadays. However the development of irrigation in Azerbaijan corresponds to the last century. So, if in 1913 the total areas of irrigated lands had made up 550 thousands of ha, then by 2000 it reached 1,41 millions of ha. Per year, 14,6 km^3 of water is used for irrigation purposes and water supply of Azerbaijan's agriculture. More than 80% of the national agricultural output come from the irrigated lands. In the future it is projected to irrigate 1,66 millions of ha. However projected growth will be limited by increasing deficiency of the fresh water, reserves of which are expected to reduce by 15-20% as a result of warming. Currently 25% of irrigation water are spent for filtration that leads to swamping and second salting and desertification of adjoining lands.

Prevention of desertification process in irrigated lands would promote the optimization irrigation technologies and techniques and improvement and enlargement of a drainage system. What makes the things worse is the provision of 414 thousands of ha of irrigated lands with drainage systems, which are in most cases open (283 thousands of ha). That creates the appropriate preconditions for second salting and further desertification. Therefore practicing of melioration activities in a wrong way would certainly turn the positive features of irrigation upside down.

Considerable part of studied territories (~ 1,6 millions of ha) is used as the winter pastures. Most of those lands are degraded as a result of water and wind erosion, salting, and re-pasturing

activities. Lack of moisture necessary for plant's vegetation is another factor leading to decline of the pastures' productivity.

In order to mitigate the expanding desertification processes implementation of the following adaptation activities has been proposed:

- reconstruction of the main irrigation canals and systems, that would allow reducing losses of water spent for filtration and as a result of physical evaporation;
- rehabilitation of salted lands, among which the irrigated territories are of greater importance;
- reconstruction of existing and rehabilitation of out-of-order drainage systems, provision of latter to more regions;
- implementation of scientifically justified and regionally differentiated and environmentally sound irrigation standards, technologies and technique;
- implementation of irrigation activities in the winter pastures;
- creation of irrigated cultivated pastures.

Agricultural forest melioration

Forests covered studied territory in the near past. Influence of anthropogenic factors resulted in deforestation of those lands. Impact of natural and climatic factors, the share of which has increased as the forests were cut down, is also noticeable. Now it is possible to assert that the evolution of desertification processes in Azerbaijan might be looked at as a direct result of deforestation. Following activities were proposed as a result of study of existing literature and documentation:

- restoration of Pre-Kur bank forests
- creation of bank plantations and anti-abrasion forest zones alongside the irrigation canals;
- creation of forest lines alongside the collector and drainage networks;
- restoration and creation of protective forest lines;
- consolidation and reforestation of sands;
- creation of pasture protective plantations;
- creation of protective plantations for protection of animals from snow-storms and cold winds;
- creation of protective plantations surrounding the animal's watering-places;
- creation of the farm-side plantations.

Terracing of mountain slopes.

Terracing of slopes - one of the most effective melioration activities - has been practiced in Azerbaijan's mountainous and low mountain regions for a long time. Besides prevention of erosion processes, terracing of slopes allows involving the additional areas into agricultural production and improving the land productivity. Productivity of terraced slopes would increase by 8-10 times once we practice the cultivation of fodder crops. Increase of terraced slopes' productivity is maintained through the improvement of plants' water regime as a result of 2-3-fold decrease of a surface drain. Terraces are mainly used for growing the grapes, fruits and nuts. Only the ploughed terraces with wide lines are used for cultivating the grain crops in some regions of Azerbaijan. In spite of a significant role played by terraces in melioration, they are not so widespread in Azerbaijan as it should be. After 60 years of relevant experience lass than one thousand hectares of lands were covered by terraces, while the terracing of 105 thousands of ha.is required in Azerbaijan. When it comes to the studied region of possible desertification, so the terracing was very effective here on the moderately and extremely eroded lands of southern foothills of Greater Caucasus, Apsheron-Gobustan and Jeyranchol-Bozdag, which are currently used as winter pastures.

APPENDIX

Priority projects on energy efficiency and adaptation technologies

Box 1

Project title: Introduction wind turbines for energy production		
Objective: introduction of modern electrical energy production technologies with the use of wind turbines. Project implementation would provide saving of fuel and reduction of GHG emissions.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 800 mlns.
Description: In Apsheron Peninsula the number of windy days with the strength of wind of over 8 m/sec makes up 226 days per year, while in other regions this volume reaches 20-70 days. Winds with strength of 3-5 m/sec prevail in the foothills and lowlands. Winds in the coastal areas have the strength of 6 to 18-20 m/sec. Coastal and island territories are perspective in terms of wind energy production. Economic benefits of project are evident, since the wind energy production might make up 20% of total and considerably reduce the fuel consumption volumes. Wind energy may be used for many irrigation and water extraction as well.		
Expected results: Project implementation would considerably contribute to development of national energy system. Development of wind energy production would provide saving of 2,4 millions of tons of fuel oil after 20 years.		
Required technologies: Wind energy stations with different capacity, wind mills, wind turbines and etc.		
Potential GHG emissions reduction volume: Development of wind energy production would allow saving 2.4 mlns. of tons of fuel oil and reducing CO_2 emissions by 7.5 mlns. of tons after 20 years.		

Box 2

Project title: Energy efficiency by means of CFL bulbs application.		
Objective: The project has the aim to improve the energy efficiency in residential and commercial sectors that would result in saving of energy and reduction of GHG emissions.		
Country	**Sector**	**Total volume of financing**
Azerbaijan	Energy	$ 95 mlns.
Description: Currently conventional 40, 60, 100 and 500 W lamps are used for lighting the houses. Available dwelling area has made up 88.7 mlns. of m^2 in 1990 and there were 1381400 families. Calculations show that 17.74 millions of lamps is required to light 88.7 m^2 of available dwelling area. Energy consumption makes up 3.5 PJ/year in Azerbaijan.		
Expected results: Project implementation would result in considerable economy of organic fuel consumed.		
Required technology: Compact fluorescent lamps and etc.		
Potential GHG emissions reduction volume: Application of GFL bulbs would allow reducing CO_2 emissions by 305 thds. of tons per year. With lighting of commercial and residential sector considered CO_2 emissions reduction would make up 600 thds. of tons..		

Box 3

Project title: Use of hydro-resources with the view to construct smaller HPP's		
Objective: provision of remote regions with electrical energy through the construction of smaller HPP's in order to reduce GHG emissions		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 820 mlns.
Description: The smaller hydro-energy production has an important energy capacity, which is economically available for Azerbaijan. It is estimated that technical capacity of smaller hydro-energy production makes up 4.9 billions of kW-hour, while the economically effective capacity of use of these resources in smaller HPP's might be 1.7 kW-hour.		
Expected results: Project implementation would allow providing the remote regions with electrical power, reducing the GHG emissions and creating the new jobs.		
Required technologies: Hydro-generators of different capacity.		
Potential GHG emissions reduction volume: Project implementation would allow saving 30 mlns. of CFT of fuel and reducing CO_2 emissions by 67 mlns. of tons after 25 years.		

Box 4

Name of pilot project: Creation of integrated and automated energy supply accounting and management system in Sumgait.		
Objective: Project has the aim to create an integrated and automated energy supply accounting and management system in Sumgait. Creation of a system would provide a detached accounting of energy consumed, and increase of the payment rates. This would lead to annual saving of 30 thousands of tons of fuel.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 4.0 mlns.
Description: Currently there is no modern universal system for energy consumption accounting in Azerbaijan. Lack of such system makes it impossible to identify the volume of energy consumed by the users. Such condition leads to considerable losses of energy and increases the volume of organic fuel used in the power plants. According to estimations of international (TASIS) and local experts, the project implementation would result in annual economy of 80,7 mlns. kW-hour of energy that makes up approximately 30% of total municipal energy consumption		
Expected results: Realization of this project would allow creating the modern energy consumption accounting and management system and eliminating the losses occurred while the energy consumption.		
Required technologies: Equipment necessary for running the automated accounting system.		
Potential GHG emissions reduction volume: Current project has the global importance in terms of climate change mitigation. Reduction of CO_2 emissions would total at 98 thousands of tons per year.		

Box 5

Project title: Introduction of energy efficient technologies in Samur-Absheron irrigation canal.		
Objective: Construction of energy efficient canal		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 56 mlns.
Description: Transition of water in some parts of Samur-Absheron irrigation canal is implemented with the help of pump stations. That leads to considerable volume of energy consumption and increases the maintenance costs. This project provides for removal of Sitalchay and Jeyranbatan pump stations.		
Expected results: Removal of Sitalzhay and Jeyranbatan pump stations would enable saving of 167 mlns. of kW-hour of energy and economy of $13,07 mlns.		
Required technologies: Construction of a new part of canal from Valvalchay to Takhtakorpu at the length of 37 km.		
Potential GHG emissions reduction volume: Realization of this project would result in annual reduction of CO_2 emissions by 154 thds of tons.		

Box 6

Project title: Introduction of the latest energy efficient technologies in the oil production.		
Objective: Project's objective is to study the oil production sector's needs for energy efficient technologies that serve for GHG emissions mitigation		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 350 mlns.
Description: Average specific energy consumption level of the onshore oil deposits makes up 196.8 kW-hour/year. This volume exceeds the baseline average by 2.6 times.		
Expected results: Introduction of the new energy efficient technologies and replacement of existing energy-intensive equipment would resulted in economy of 185 millions of kW-hour of electrical energy. Calculations show that saving of about 41 mlns. of kW-hour of energy is possible once we introduce such technologies.		
Required technologies: New technological equipment foe oil production (pumps, pipes, compressors and etc.).		
Potential GHG emissions reduction volume: Project implementation would allow saving 1.84 mlns. of CFT of fuel and reducing CO_2 emissions by 3.42 mlns. of tons after 20 years.		

Box 7

Project title: Assessment of technological losses occurred while production, transportation and refining of oil.		
Objective: Project has the goal to implement the assessment hydrocarbon losses from the main sources. Preliminary estimations show that the losses of crude oil and light hydrocarbons amount to 13615 thousands and 142 millions of tons respectively within the period of 25 years.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 500 mlns.
Description: Separators, pumps, meters, gangways, various reservoirs, preliminary water dehydrating equipment, settling tanks of different types, oil-traps, bolt fixture, transportation capacity, sewage refining equipment, bulk devices and etc. are the main sources of occurrence of oil and gas losses. Statistical data shows that oil losses make up approximately 1,25% of total oil production, while the losses of light hydrocarbons amount to 13%. Continuation of contemporary production techniques would lead to more serious losses of oil and hydrocarbons.		
Expected results: Application of environmentally sound technologies would result in saving of 242 mlns. of CFT after 25 years. The average annual amount of fuel saved would make up 10 mlns. of CFT respectively.		
Required technologies: Technological equipment with high efficiency and low energy intensity (warm exchangers, separators, pumps, pipelines and reservoirs).		
Potential GHG emissions reduction volume: Average annual CO_2 emissions reduction volume is expected to make up 18 millions of tons. Reduction of emissions by 440 millions of tons of CO_2-eq is possible after 25 years.		

Box 8

Project title: Introduction of new technologies for collection and utilization of accompanying gas of the low pressure.		
Objective: Application of new technologies for collection and utilization of the flared accompanying gases.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 540 mlns.
Description: Accompanying gas of the low pressure produced while the production and transportation of oil is being flared for absence of gas collection and utilization technologies. According to statistical data the overall volume of flared accompanying gas has totaled at 194.3 millions of cubic meters in 1999. That volume has made up 11% of total fuel consumed by residential sector in the year of 1999.		
Expected results: Within 25 years the utilization of accompanying gas for energy production purposes would provide the economy of 17,6 billion m^3 of fuel that is equal to 19,3 millions of CFT.		
Required technologies: Construction of compressor stations and pipelines for collection and transportation of accompanying gas.		
Potential GHG emissions reduction volume: Realization of a project would provide the annual saving of 0.8 mlns. of CFT of fuel and reduction of CO_2 emissions by 1.4 mlns. of tons. Total volume of CO_2 emissions reduction would make up 35 millions of tons after 25 years.		

Box 9

Project title: Application of latest technologies for the rational use of fuel in the oil refineries.		
Objective: Project has the goal to introduce the state-of-the-art technologies with the view to rationally use the fuel and save about 2000 tons of fuel per year.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 120 mlns.
Description: Furnaces are **t**he main source of GHG emissions. Tubular furnaces are the main energy consumers in oil refineries. Estimations showed that efficiency of furnaces varies between 51 and 53% that is by 20% less than the projected level.		
Expected results: Annual volume of fuel saved would exceed 2000 tons as a result of project implementation. Within 20 years 40 millions of tons of fuel or 55 millions of CFT are expected to be saved.		
Required technologies: Application of modern equipment for rational use of fuel and reconstruction of furnaces.		
Potential GHG emissions reduction volume: The potential CO_2 emissions reduction volume would make up 100 millions of tons after 20 years.		

Box 10

Project title: Installation of new energy efficiency technologies in the Azerbaijan's gas transportation system.		
Objective: The objective of a project is to decrease the losses of natural gas occurred while its' storage, transportation and distribution.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 409 mlns.
Description: Estimations conducted by GHG Inventory showed that the transportation, storage and distribution of gas is followed by significant losses of this type of fuel. Those losses make up about 6-7% of a country's total gas production (production volume amounted to 9,93 billions of m^3 in a baseline 1990). Other sources even indicate that the losses reach 18-25%. Most of the gas pipelines have been exploited for over 60 years and now all of them are out of date and proper order. Disturbing is the fact that with projected economic development given, the losses of natural gas would make up 1,6 millions of tons per year by 2025..		
Expected results: Implementation of a project would allow saving 28,3 millions of tons (44,4 millions of CFT) of gas. These tendencies would lead to reduction of GHG emissions by more than 590 millions of tons of CO_2-eq after 25 years.		
Required technologies: Reconstruction of a gas transportation system through the introduction of new technologies (compressors, distributors, control and measuring equipment and etc.).		
Potential GHG emissions reduction volume: After25 years the volume of CO_2 emissions reduction achieved would amount to more than 590 millions of tons.		

Box 11

Project title: Installation of control and measuring equipment while the distribution of natural gas in residential and commercial sectors.		
Objective: Project is aimed at prevention of irrational use of natural gas by people and in the commercial and residential sectors. Project implementation would lead to the annual reduction of methane emissions by 4 millions of tons of CO_2-eq.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 200 mlns.
Description: In 1998 republic's total available dwelling area has made up 94,2 mlns. of m^2. The share of municipal dwelling area has been 57%. Statistical data show that in the 1990 total consumption of gas by residential and commercial sectors has amounted to 5584,8 mlns. of m^3 of natural gas. GHG Inventory says that CO_2 emissions from these sectors has made up 10 millions of tons. As a result of gas meters installation decrease of the residential and commercial sectors' natural gas consumption by 40% is expected.		
Expected results: The installation of control and measuring equipment would result in economy of about 2234 mlns. of m^3 of natural gas.		
Required technologies: Control and measuring equipment (meters), distributors, commercial gas devices.		
Potential GHG emissions reduction volume: After25 years the volume of CO_2 emissions reduced would make up 590 millions of tons.		

Box 12

Project title: Production of energy from the manure produced by livestock.		
Objective: Introduction of new technologies for obtaining the energy from manure. Utilization of biogas in the rural areas would result in economy of natural fuel and reduction of GHG emissions.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 70 mlns.
Description: Anaerobe decomposition of manure leads to air emissions of 30 thds. of tons of gases or 43 mlns. of m^3 of methane, that is equivalent to 1,3 PJ of energy. Such volume of methane comes from currently applied manure storage and distribution techniques. Application of new technologies at the local level would help with provision of farms with energy.		
Expected results: Utilization of manure for methane production would result in economy of 875 thds. of tons of fuel or 1374 thds. of CFT after 25 years.		
Required technologies: Biogas autoclaves		
Potential GHG emissions reduction volume: Implementation of a project would result in reduction of CO_2 emissions by 938 thds. of tons after 25 years.		

Box 13

Project title: Pilot project on energy production from agricultural wastes of Nakhchivan AR		
Objective: The ultimate objective of a project is to produce the energy (biogas) from solid agricultural wastes and products (fruits, vegetables and etc.) in the Nakhchivan AR, which is suffering from electrical power deficiency.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 35 mlns.
Description: Nakhchivan AR has the borders with the Turkey, Iran and Armenia, and its' energy system is not directly connected with other parts of Azerbaijan. In 1999 there were in total produced 55,6 mlns. of kW-hour of energy in Nakhchivan. More than 900 mlns. of kW-hour of energy were consumed. Currently produced and imported electrical energy satisfies approximately 65-70% of total domestic demand. Statistical data says that per annum about 80 thousands of tons of solid biomass wastes are being produced from agricultural products manufactured in the region.		
Expected results: Utilization of biogas in the rural areas would result in saving of fossil fuel and reduction of GHG emissions.		
Required technologies: Introduction of the state-of-the-art technologies serving for production of energy from wastes.		
Potential GHG emissions reduction volume: Implementation of a project would result in reduction of CO_2 emissions by 25 thds. of tons per year.		

Box 14

Project title: Pilot project on introduction of new technologies for methane collection, with the view to produce the energy from municipal wastes of Sumgait.		
Objective: Reduction of GHG emissions coming from municipal wastes stored in the Sumgait landfills. Use of produced gas for energy production. Dissemination of project outcomes in the other Azerbaijan cities.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 5 mlns.
Description: Annually 120-150 thds. of tons municipal wastes are being stored in Sumgait landfills. It is possible to collect more than 300 thds. of m^3 of methane per year from those landfills. That makes up approximately 10 TJ of energy. Population of Sumgait totals at 340 thds. of people that annually produce 524,8 thds. m^3 of municipal wastes. Till 1999 the urban landfills were not organized. Now the rubbish is being regularly collected and transferred to the special polygons. Storage of wastes in polygons causes environmental contamination and bad smelling,		
Expected results: Implementation of a project would promote the realization of methane collection and utilization activities.		
Required technologies: New technologies wastes utilization and methane collection (bunkers, collectors of methane, electrical engines, generators and other).		
Potential GHG emissions reduction volume: Implementation of a project would allow annual reducing GHG emissions by 4.4 thds. of tons of CO_2-eq.		

Box 15

Project title: Utilization of solar energy for heating of water		
Objective: Project has the aim a) to involve the renewable energy sources through the wide-scale introduction of heating and hot water supply systems running on the solar energy, and b) to decrease the consumption of conventional energy resources and reduce the GHG emissions		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 200 mlns.
Description: In Azerbaijan, the average annual duration of solar radiance is 2200 to 2600 hours with the radiation level of 3-6 kW/m^3. This factor makes the use of solar energy very perspective. Reasonability of the use of solar energy is explained by peculiarities of production facilities distribution and location of smaller energy consumers in the decentralized areas and far apart from each other.		
Expected results: Project would help with solution of many energy supply issues. Saving of 1 millions of CFT would be achieved as a result of project implementation. Moreover the advantages of renewable energy sources application will be demonstrated and reduction of pollution and GHG emissions will be maintained.		
Required technologies: New solar technologies for the heating of water.		
Potential GHG emissions reduction volume: Project Implementation would allow saving 0,13 mlns. of tons of CFT and reducing CO_2 emissions by 232 thds. of tons after 10 years.		

Box 16

Project title: Installation of new technologies on the rail system.		
Objective: Objective of current project is to implement the full electrification of rails, substitute the existing energy-intensive equipment for the new energy efficient one., which leads to GHG emissions reduction.		
Country	**Sector**	**Budget**
Azerbaijan	Energy	$ 370 mlns.
Description: PA «Energy provision» and «Locomotive» are users of the most energy intensive equipment. in 1999 overall energy-intensity in the railways made up 954,6 mlns. of kW-hour to include 258,1 mlns. of kW-hour of energy consumed for traction. Currently the railways of Azerbaijan need the introduction of new and substitution of the old equipment. Expert studies revealed the most promising sectors in terms of introduction of new mitigation technologies.		
Expected results: 1. Railway electrification would result in annual saving of 60,5 thds. of CFT. 2. Transition to alternating current would result in saving of 141 thds. of CFT. 3. Implementation of specified activities would lead to 10% saving of electrical energy (94 mlns. of kW-hour. of energy will be saved annually).		
Required technologies: Electrical locomotives, automatic switches, accumulators, copper contact drives, insulator, transformers, semi-conductor straighteners and etc.		
Potential GHG emissions reduction volume: 4820 thds. of CFT will be saved and 9320 thds. tons of CO_2 emissions will be reduced after 20 years as a result of project implementation.		

Box 17

Project title: Introduction of new energy efficient technologies in the gas transportation system of Azerbaijan		
Objective: Reduction of losses occurred while the storage and transportation and distribution of natural gas.		
Country	Sector	Budget
Azerbaijan	Energy	$ 18 mlns.
Description: In 1990 the total volume of methane emissions has made up 723 thousands of tons in Azerbaijan. 438 thousands of them or 61% has emanated from the indicated sources and were fugitive emissions. GHG inventory estimations show that about 6 to 7% of gas is being lost while the storage and transportation and distribution of this type of fuel (in 1990 there have been produced 9.93 blns. Of cubic meters of natural gas in Azerbaijan). According to other data the share of losses even reaches 18-25% of the total output. Proposed project has a global significance and its' implementation is necessary in terms of climate change mitigation.		
Expected results: Realization of this project would let us reduce the air emissions of natural gas and improve the environmental quality and annually save about 1 billion of m^3 of fuel.		
Required technologies: New compressors, gas distributive equipment and control and measuring devices.		
Potential GHG emissions reduction volume: Preliminary estimations show that the project would allow saving of 44,4 blns. of $м^3$ of natural gas and reducing 590 mlns. of tons of CO_2-eq after 25 years.		

Box 18

Project title: Plantation of field protecting forests at the area of 25 thousands of ha.		
Objective: Protection of agricultural fields		
Country	Sector	Budget
Azerbaijan	Agriculture and silviculture	$ 2 mlns.
Description: About 80% of the national agricultural production comes from the irrigated lands of arid zones, to which the frequent droughts and hot dry winds causing crop failures. Plantation of field protecting forests is efficient method of fighting with those calamities. Currently there are 8-9 thousands of ha of forest lines, while 33-35 thousands of ha are required in general. Institute of silviculture of Azerbaijan plans to establish 16 thousands of ha of forest lines by 2020. Plantation of another 9 thousands of ha is planned afterwards.		
Expected results: Protection of fields from erosion and hot dry winds and reduction of demand for water by 10-15% and increase of lines productivity by 15-30% is expected as a result of project implementation.		

ABBREVIATIONS

SHMC – State Hydrometeorological Committee
AS – Academy of Sciences
JSC – Joint Stock Company
AR – Autonomous Republic
WB – World Bank
GDP – Gross Domestic Product
WMO – World Meteorological Organization
SRHIRF – Scientific and Research Hydrometeorological Institute of Russian Federation
MGO– Main Geophysical Observatory
GTN – Global Telecommunications Network
HPP – Hydro-Power Plant
GEF – Global Environment Facility
EBRD – European Bank of Reconstruction and Development
IBD – Islamic Bank of Development
IPCC – Intergovernmental Panel on Climate Change
SOCAR – State Oil Company of Azerbaijan Republic
GDC –Global Data Center
NCCC – National Center on Climate Change
NGO –Non-Governmental Organization
GHG – Greenhouse Gas
UNDP – United Nations Development Program
UNFCCC – United Nations Framework Convention on Climate Change
GAW – Global Atmospheric Work
SCOS – Global Climate Observation System
TRASECA – Transport Passage Europe-Caucasus-Asia
TPP – Thermal Power Plant
TPM – Thermal Power Main
US - United States
Fig. - Figure

Measurement units:

V – Volt
kV – kilovolt
J - Joul
Cal – calorie
kW – Kilowatt
Bln(s). – billion(s)
Mln(s). – million(s)
CFT – Conventional Fuel Ton
Thds. - thousands

Chemical formulation:

CO – carbon oxide
CO_2 – carbon dioxide
NMVOC – non-methane volatile organic compounds
SO_2 - sulfur dioxide

***Names of Climate Change Scenarios*:**

GISS – Goddardov Institute of Space Studies, USA
CCCM – Canadian Center on Climate Meteorology
UKMO – United Kingdom Meteorological Office
GFDL-3 and GFDL-T – Geophysical Laboratory of Hydrodynamics, USA

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