# SECOND NATIONAL COMMUNICATION OF TURKMENISTAN UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

ASHGABAT - 2010

**MINISTRY OF NATURE PROTECTION OF TURKMENISTAN**

# SECOND NATIONAL COMMUNICATION OF TURKMENISTAN UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)


The Second National Communication on climate change has been prepared in Ministry of Nature Protection of Turkmenistan under the UNEP/GEF-supported project "Turkmenistan: preparation of the Second National Communication on UNFCCC".

Ministries and agencies participating in preparation and discussion of the Second National Communication:

- Ministry of Nature Protection of Turkmenistan
- Ministry of Agriculture of Turkmenistan
- Ministry of Water Management of Turkmenistan
- National Hydrometeorology Committee under Cabinet of Ministers of Turkmenistan
- Ministry of Economy and Development of Turkmenistan
- Ministry of Education of Turkmenistan
- Academy of Science of Turkmenistan
- Ministry of Oil and Gas Industry and Mineral Resources of Turkmenistan
- State Concern "Turkmenneft"
- State Concern "Turkmengaz"
- Ministry of Energy and Industry of Turkmenistan
- Ministry of Construction of Turkmenistan
- Institute of Oil and Gas of State Concern "Turkmengaz"
- State Committee of Statistics of Turkmenistan
- National Institute of Deserts, Flora and Fauna of Ministry of Nature Protection of Turkmenistan
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- Institute of Land Management of Ministry of Agriculture of Turkmenistan
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# Introduction

Climate change is a global issue linked inseparably to environmental and economic aspects identifying the sustainable development of the country. This pressing problem has predetermined undertaking by Turkmenistan of essential measures to implement international programs on mitigation of global climate change and taking of necessary steps at the national level.

Turkmenistan ratified the United Nations Framework Convention on Climate Change (UNFCCC) on July 5, 1995 and the Kyoto Protocol to UNFCCC in December, 1998. To implement the main provisions of the environmental conventions, a State Commission has been created to ensure implementation of obligations of Turkmenistan arising from the international environmental conventions and programs.

Clean Development Mechanism of the Kyoto Protocol enables inter alia attracting of investments and advanced technologies to reach high economic indicators and ensure the sustainable development. To achieve the goals of the Kyoto Protocol the Designated Authority (DA) on Clean Development Mechanism (CDM) was created in Turkmenistan.

Having signed UNFCCC and the Kyoto Protocol to it, Turkmenistan demonstrated its willingness to be actively involved in decision making with respect to the broad-range tasks specified in these documents. This position was reflected in the fundamental state programs, and primarily in the "Strategy of Economic, Political and Cultural Development until 2020" as well as "National Environmental Action Plan of President of Turkmenistan (NEAP)". These documents reflect the environmental policy of the state for the nearest future that considers national and climatic features of Turkmenistan.

Turkmenistan participates in discussion process on development of a new agreement on climate change which shall come into force after completion of the first period of the Kyoto Protocol. The experts and managers of the involved ministries and departments have taken part in the broad discussion regarding the Copenhagen accords. Turkmenistan supports a preparation of this international agreement based on the principles of UNFCCC that should take into account the interests of the developing countries.

The Second National Communication of Turkmenistan is submitted as per Articles 4.1 and 12.1 of the Convention. This National Communication has been prepared in compliance with non-Annex I Parties Guidebook of the UNFCCC.

In 2000, Turkmenistan prepared and submitted the Initial National Communication on Climate Change to the UNFCCC Secretariat describing national conditions and possible climate change with its impacts on ecosystems and economy, assessment of greenhouse gas emissions and prevention measures on their decrease. In 2006, there was published the report on conduction of the second phase of the communication considering in detail the issues of capacity building in priority areas of the economy of Turkmenistan due to climate change. The Second National Communication is a logical continuation and further development of the Initial Communication.

The Second National Communication of Turkmenistan on climate change has been prepared by the Ministry of Nature Protection of Turkmenistan that is responsible for implementation of international environmental programs and conventions in Turkmenistan in close cooperation with other ministries and departments, with active involvement of the National Committee on Hydrometeorology under the Cabinet of Ministries of Turkmenistan.

Turkmenistan is willing to further support the efforts of the international community to reduce anthropogenic impact on the climatic system of the Earth.

Turkmenistan confirms its commitment to the UNFCCC goals to mitigate dangerous anthropogenic interference into the climatic system. Turkmenistan will perform its obligations arising from the UNFCCC and will try to be involved in fulfillment of obligations of the industrially developed countries according to Kyoto Protocol.

## Executive Summary

Turkmenistan located in center of the Eurasian continent has a hot, sharply continental climate due to its natural and geographical conditions. Its major territory (about 80%) is occupied by the Garagum Desert with no surface water resources.

In this connection, in Turkmenistan particular attention is paid to solving the issues of sustainable development. The climate change issue is considered to be a possible serious impediment for future plans on the economy sustainable development and standard of living increase.

The Second National Communication under UNFCCC in compliance with UNFCCC and IPCC recommendations considers the questions pertaining to climate change. The national conditions are precisely described and socio-economic development analysis is presented.

Assessment of greenhouse gas emissions and sinks in Turkmenistan showed that contribution of the country to the global warming from 1994 to 2004 was steadily growing. On the basis of such assessment there have been defined the priority directions in reducing the GHG emissions and in attracting the foreign technologies and investments through the flexible mechanisms of the Kyoto Protocol.

Assessment of vulnerability and adaptation has allowed determining of most vulnerable sectors of the socio-economic development and regions of Turkmenistan to climatic changes. Adaptation measures on climate change impacts mitigation have been proposed.

The Second National Communication under UNFCCC reflects the activities of the Government in respect of mitigation of hazardous anthropogenic impact on the climatic system. Being rich for energy resources, Turkmenistan pays a particular attention to decrease of anthropogenic impact on the environment primarily through using of environmentally safe and energy-saving technologies in the oil and gas industry, power engineering, transport and other branches of the national economy.

Successful solution of the climate change problem is tightly linked with adaptation of the national legislation to norms of international economic law, improvement of institutional structure, training of personnel, environmental education and promotion of public awareness among different groups of the population and finally with the capacity building to conduct measures on climate change adaptation and mitigation. The job done within the preparation of the Second National Communication has identified a strong necessity of further implementation of work as per abovementioned directions.

On the whole, the Second National Communication of Turkmenistan under UNFCCC covers the current status of work on the climate change problem solution and suggests new directions to ensure the growth of contribution of Turkmenistan to mitigate global warming.

# CHAPTER 1. COUNTRY OVERVIEW

## 1.1. Geography, relief and climate

### 1.1.1. Geography

Turkmenistan lies in the west of Central Asia between the Caspian Sea in the west and the Amudarya River in the northeast. It is one of five littoral states of the Caspian Sea along with Azerbaijan, Islamic Republic of Iran, Republic of Kazakhstan and the Russian Federation. Turkmenistan is located within 35°08`- 42°48` N and 52°27`-66°41` E. Its territory from west to east is about 1100 km, from north to south – about 650 km. Its area is 491 thousand km$^2$. Turkmenistan area is divided into five administrative regions (velayats): Dashoguz, Lebap, Mari, Akhal and Balkan. The capital of Turkmenistan Ashgabat founded in 1881 is the biggest administrative, political, scientific and cultural center of the country.

In the north, Turkmenistan borders on Republic of Kazakhstan, in the north-east and east – Republic of Uzbekistan, in the south-east – Afghanistan, in the south – Islamic Republic of Iran, in the west it borders on the Caspian Sea (Fig. 1).

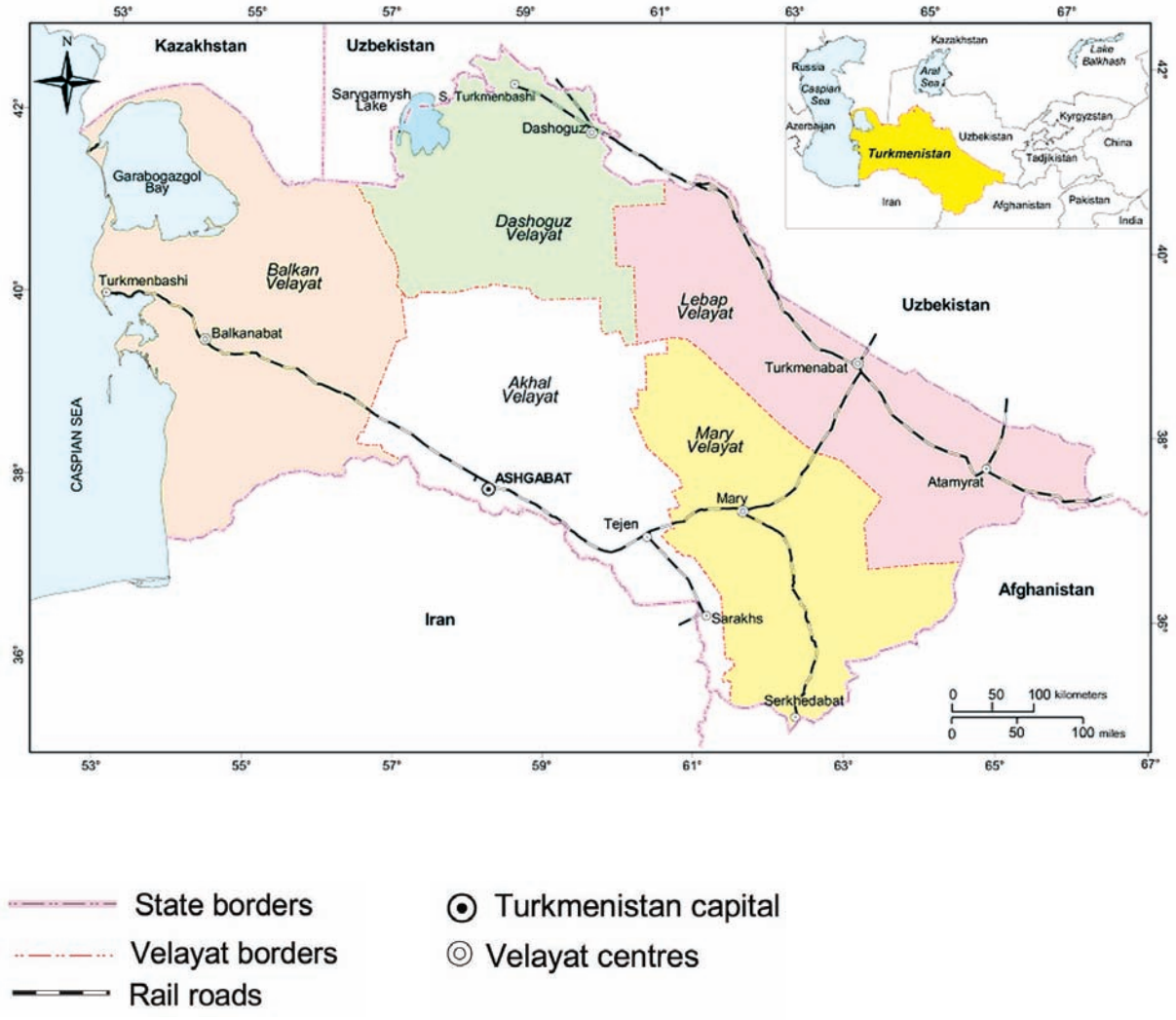


Figure 1. Political and administrative map of Turkmenistan

### 1.1.2. Relief

Over 80% of the territory of Turkmenistan is the level land covered with deserts and semi-deserts. This level land part of the territory has a continuous gradient to the Caspian Sea from east to west. Most of the level area lies at 0–200 m altitude.

Around 20% of Turkmenistan's territory is occupied with mountains. In the south, sandy deserts change over the hill and foothill area of Kopetdag Mountains – mid-high mountains (2942 m above sea level); farther to the north two separate mountain ridges stand: Maliy Balhan (777 m) and Bolshoy Balhan (1881 m) The Kopetdag adjoins in the north a foothill plain interlocked to the Caspian Sea lowland plain in the west. In the south-east, Turkmenistan hosts the northern foothills of Paropamiz – Badhyz (up to 1267 m) and Karabil (up to 984 m) highlands separated by the Murgab River. In the east, there are the Koitendag Mountains (the highest point of the country is up to 3139 m above sea level). In the west, Turkmenistan borders on the Caspian Sea, the bed of which is rich with hydrocarbon resources, and the mild climate and ecologically clean coast make this region a magnificent recreational zone.

### 1.1.3. Climate

Climate in Turkmenistan is sharply continental and extremely dry. In the far south of the country, the average monthly air temperature reaches considerable values – 28–33 °C. The largest diurnal range is marked at the end of summer when according to average many-year data it reaches 18–20 °C in the south.

The average air temperature in the territory of Turkmenistan varies within 21–34°C. January is the coldest month. In the warm period of the year (from May to September) the daily air temperature often exceeds 40°C. Absolute minimum of air temperature is –36.0 °C (Dashoguz velayat), and the absolute maximum is +50.1 °C (Repetek, South-East Garagum Desert).

In northern regions of the country, the annual range reaches 32 °C, and in the south it is about 26 °C. The largest diurnal range is marked at the end of summer and according to average many-year data makes around 13–16 °C in the northern regions and 18–22 °C in the southern ones.

The absolute maximum of the soil surface temperature (80.0 °C) is marked in the South-East Garagum Desert (Repetek station).

Frost-free season in the north-east regions (Dashoguz oasis) of Turkmenistan lasts 187–200 days, on the other territory – 230–250 days.

Solar radiation intensity ranges between 606.7 kJ/cm2 (in the north-west) and 682.0 kJ/cm2 (n the south-east).

Turkmenistan is the insufficient wetting zone. The average annual precipitation is 76–380 mm.

Relative air humidity maximum is in January, 70–78%. The driest period is from June to September, when the relative humidity in the Garagum Desert equals 20–30%, and in the oasis – 30-35%.

In the level land territory of the country the average annual velocity of wind equals 3.2–4.2 m/s. During a year, the number of days with dust storms varies within 35–67, although in some separate years it is 106–113.

## 1.2. Environment

### 1.2.1. Air

Air pollution is identified by the level of natural and anthropogenic impacts on the environment. In Turkmenistan, natural dust prevails by its mass among the air contaminants. High temperature and big air humidity deficit, fast dryness of upper soil layer and high wind velocity make air dusty over the whole territory of the country.

Production sectors of the economy pollute air with such chemicals as carbon oxide, nitrogen, sulfurous anhydride, phenol, formaldehyde, hydrogen sulfide and others. In Turkmenistan, atmospheric air pollution is monitored at stationary posts located in big cities such as Ashgabat, Abadan, Turkmenabat, Mari, Dashoguz, Turkmenbashi and Balkanabat.

### 1.2.2. Water resources

The flow of such main rivers of Turkmenistan as Amudarya, Murgab, Tejen, Etrek and some small rivers is formed in the territories of bordering countries. Therefore, the volume of accessible water resources is determined not only by the natural water content of these rivers but also by the international agreements on water flow allocation. The Amudarya River, which is the major source for surface water in Turkmenistan, is used by six states – Afghanistan, Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan.

Total volume of water resources of Turkmenistan is 25 km3 per average annual water content. Amudarya provides 22 billion m3 or 88% of total volume of surface water resources, while the balance falls to Murgab – 1.631 billion m3 (6.5%), Tejen - 0.869 (3.5%), Etrek, Sumbar and Chandir - 0.354 (1.4%) and small rivers - 0.15 billion m3 (0.6%).

Over 130 groundwater sites have been found on the territory of the country that at present time are partially used for household water needs. The proved groundwater reserves in Turkmenistan in total make 3.4 million m3/day, while the explored reserves make 6 million and the estimated – 9 million m3/day. In the water balance, the share of used groundwater is 2.0–2.5%.

### 1.2.3. Land resources

Total land area of Turkmenistan is 49.1 million ha. As of 2005, the agricultural land area equaled 39,936.5 thousand ha. They include 38.1 million ha (95.5%) of pastures, over 1.7 million ha (4.3%) of irrigated lands, 0.1% - long-term planting.

Changes in the structure of agricultural lands mainly occur due to usage of pasture territories making the conservation fund of lands today of about 17 million ha suitable for further application

### 1.2.4. Biological diversity

Turkmenistan is distinctive with its ecosystems diversity. Ecosystems of plain desert occupy most of its territory; the other part belongs to river, lake, sea, coastal and man-made ecosystems. Each ecosystem has its own biological diversity. Over 20 thousand species constitute the biodiversity of Turkmenistan, of which 7,064 species of plants and about 13 thousand species of vertebrates and invertebrates

The Red Data Book of Turkmenistan includes 152 species of animals, of which 107 – vertebrates (15.9% of their total amount in the country), 109 kinds of plants, of which 101 – higher plants (3.4%).

## 1.3. Socioeconomic aspects

### 1.3.1. Social development

Turkmenistan is a multinational state where the representatives of 40 nationalities live, while Turkmen people make 90% of the population. The current population of the country is over 6 million. The rural population prevails and accounts for 54%. More than 50.3% are women and this indicator is equal both for urban and rural areas. Young people under working age account for about 40%, people of working age – 55.8%, retired people – 6.1%. Literate population is 99.8%. The population density is 11.5 people per one square kilometer. Turkmenistan has five administrative regions (velayats) and 50 sub-regions (etraps). The country has 25 cities and 77 villages.

After gaining the independence status, Turkmenistan has established a number of legislative acts to promote the housing construction in private sector of the economy. These

legal acts envisage providing people with construction materials at preferential prices for house construction, opening of soft credit lines, mortgage lending, etc. All this boosted the growth of housing constructed by private economic entities at expense of their own funds. If in 1991 the state investment share for these purposes was 45.0%, private investment share – 55%, in 2000 it was 27% and 73% and in 2007 – 23% and 77%, accordingly.

In 2007, compared to 2000, the investments for housing construction increased tree-fold. Over the same period, the housing fund of the country rose by 45%.

According to the data of 2007, housing accounted for19.9 square meters on average per one resident against 17.8 in 2000 (Fig. 2).

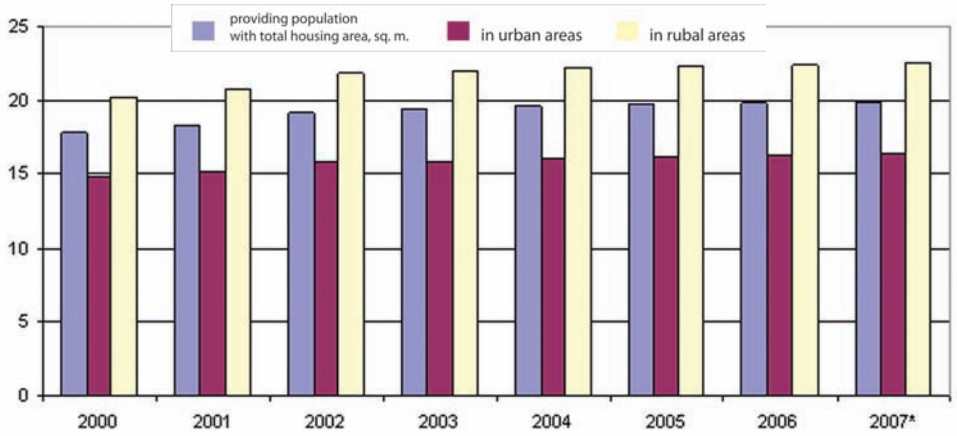


Fig. 2. Total housing area, sq. m

One of the primary state social programs of Turkmenistan is the program of free provision of the population with clean water, natural gas and electricity. Today, factually all human settlements are supplied with gas. The natural and liquefied gas is provided to 99% of households.

Especially much of work is being done to improve the drinking water quality. For these purposes, the existing facilities are reconstructed and new modern ones are built, modern advanced technologies and methods of drinking water purification are introduced, water supply and refining units as well as desalination units are built.

In late 2007, the "National Program of President of Turkmenistan on improvement of social conditions in villages, towns of etraps and etrap centers until 2020" was launched. Its primary goal is to bring the level of social and residential conditions in rural areas much close to the city conditions. In this regard, the program envisages measures on improvement of engineering infrastructure of villages, townships, towns of etraps and etrap centers. The program defines 15 directions of social and engineering infrastructure development: construction of hospitals, clinics and medical centers, preschool institutions, comprehensive schools, cultural facilities, sport schools and facilities, water pipelines, wells, sewage systems, highways, power transmission lines, communication and municipal facilities. The scope of this program covers absolutely all etraps and villages of the country.

Consistent implementation of this program will provide a strong foundation for improvement of social and living conditions for major part of the population.

### 1.3.2. Economic development

Favorable political situation and stability reached in the country after gaining the independence and neutrality status opened broad perspectives for economic and social development, cultural and spiritual renewal of the Turkmen society. There appeared the opportunity to define long-term goals and further sustainable development strategies of the state.

The strategic goal is to turn Turkmenistan to a dynamically developing state with efficiently working socially-oriented market economy providing high standard of living. This goal is specified in such programs as "Strategy of socio-economic reforms in Turkmenistan until 2010", "Strategy of economic, political and cultural development of Turkmenistan until 2020", etc.

Today, Turkmenis-tan is in possession of a sufficiently diversified industrial potential. The industry is represented by power engineering, oil and gas extraction, chemical, oil-refining, machinery and metalworking enterprises, as well as construction materials manufacture, light and food industries.

Huge and diverse mineral resources and varied selection of agricultural raw materials make a fundamental base for implementation in Turkmenistan of the policy of accelerated development of a multi-branch industrial complex (Fig. 3). Commencing from the 1990s, the industry share in the branch-based investment structure remains to be 40–48%. New enterprises equipped with advanced technologies operate today in all industrial sectors.

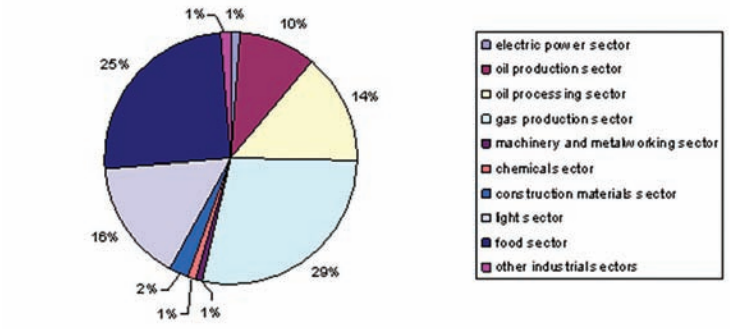


Fig. 3. Industrial production, by economic branches in 2007

At present time, the economy of Turkmenistan is characterized with high level of capitalization. In 2000-2007, the investment share in GDP accounted for 20–30% and higher. Over that period, like in the 1990s, there was broadly implemented construction of new enterprises that had to become an "engine" in the economy growth. Each year, the industrial production sphere received annually over 70% of investments.

Active investment policy, along with favorable for Turkmenistan price situation in the world market for oil and gas have created conditions for rapid growth of value added in the national economy. In 2000–2007, the annual average GDP growth (in comparable prices) posted over 15.2%, which was much higher of the population growth dynamics. Purchasing power remained in the upward tendency. In 2007, the GDP per capita (by PPP) exceeded 1.8 fold the same GDP indicator of 2000 (Fig. 4).

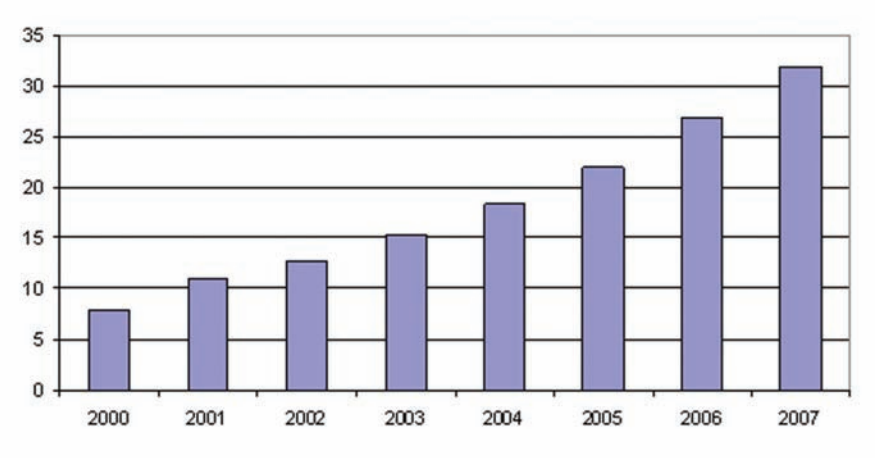


Fig. 4. Capital investments, in trillions of manat

This high GDP trend was mainly linked with the industrial production development involving a consecutive realization of the export-oriented and import-substitution directions model. In 2000-2007, the annual average growth of value added in industry posted 15.6%. In 2007, its share in the GDP branch structure increased to 36.7% against 34.4% of the reference year.

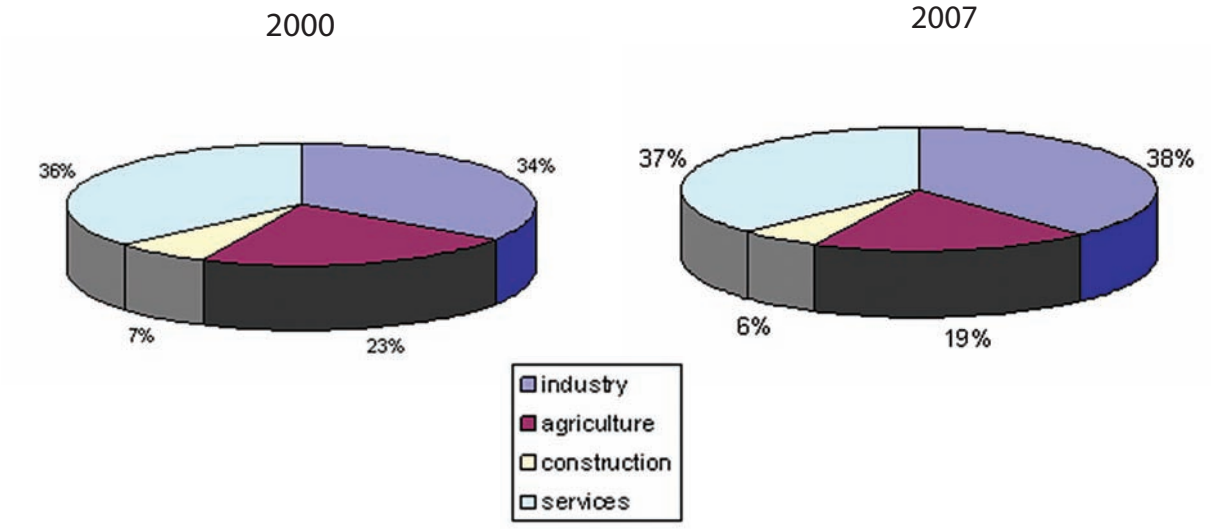


Fig. 5. GDP structure in 2000 and 2007

**Agriculture** remains one of the main branches of the economy of Turkmenistan being a base for food security of the country, an important supplier of raw materials for the processing industry. In 2007, the agricultural share in the GDP branch structure accounted for 19% (Fig. 5).

**Construction** in the GDP branch structure has a share of 6.4%. In this branch, that plays

a direct role in the investment process, contractual work volumes permanently increase. This indicator compared to the reference year has increased 4.9 fold. In 2000-2007, the annual average growth of value added in construction constituted 12.8%.

Along with industry, the high growth of value added was formed also in the **services sector.** In 2000-2007, the annual average growth of its gain was 17 %, mainly due to expansion of trade, transport, communication and financial services. Therefore, in the GDP branch structure the services sector share increased from 36.5% in 2000 to 39.1% in 2007 proving the tendency of balanced development of the manufacturing and non-manufacturing spheres in the economy of the country.

Higher GDP growth in Turkmenistan in 2000-2007 was directly connected with wide development of the **foreign economic relations.** In 2007, the foreign trade turnover was US$13.4 billion, and compared to 2000 this indicator increased more than 3 fold. The export volume made US$8.9 billion (3.6 fold growth) (Fig. 6) . The import volume increased 2.5fold, making in 2007 US$4.4 billion. The foreign trade turnover balance of Turkmenistan over these years remained steadily positive. In 2007, it exceeded the 2000 level more than 6fold.

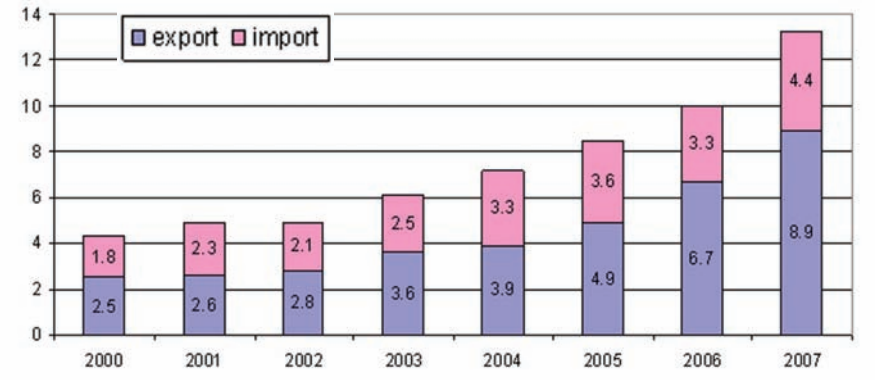


Fig. 6. Foreign trade turnover, in billions of USD

The export volume is closely connected with supply of natural gas to foreign markets. At the end of 2007, the natural gas share in total export rose to 54.6%.

The major part of import of Turkmenistan (70–80%) includes capital goods and different manufacture components. Due to active growth of food sector of the economy over the independence years, the non-foods prevailed in the consumer goods import.

The country territory perspective for gas and oil production is considered to be 85%, and the projected resources with taking into account the Caspian Sea shelf are evaluated as 28.5 trillion m3 of gas and 23 billion tons of oil. The major export items are the natural gas, petroleum products and electric power. Turkmenistan is rich with chemical and ore mineral resources such as sulfur, sodium sulfate, magnesium, iodine, bromine, common and potash salt, carbonate, bentonite, kaolin, onyx, ozokerite and others, as well as plumbum and zinc. The country is also rich with raw materials for the construction materials production.

International and local experts evaluate hydrocarbon resources of Turkmenistan as 45.4 billion tons in oil equivalent. Virtually, the whole territory of Turkmenistan and the immediate part of the Caspian Sea are attractive for oil and gas exploring.

Large revenues from export of primary energy resources promote significantly the balanced development of other socioeconomic sectors of the country.

**Machinery and metalworking production** development in 2000–2007 was mainly

aimed at adaptation to domestic market needs. Production of wholesale manufacturing includes wire, insulated cable, centrifugal pump as well as gas stoves.

However, despite the sustainable growth of production volumes, the branch is not at a high position in the industrial structure. In 2007, in the gross industrial output (medium and large enterprises) the machinery and metalworking branch share was about 1%.

**Construction materials industry** development in 2000-2007 was mainly based on construction and commissioning in 2005 of the cement plant in Baharlil etrap of Akhal velayat with the capacity of 1 million tons a year. Compared to 2000, in 2007 the cement production increased 2.2 fold and caused a dramatic drop in the import of cement. At present time, the country imports some particular brands of cement only.

In 2006, in Ruhabat etrap of Akhal velayat the factory on production of decorative materials from natural stones (marble, granite, etc.) was put into operation with the capacity of 205 thousand square m a year.

Production of non-metallic construction materials showed high growth (156% compared to 2000), mainly due to large-scale construction of railway and highway roads and pipelines.

Presently, construction materials industry share is 2.5% of total industrial output.

In 2000–2007, **textile industry** preserved its leading positions in the industrial development of Turkmenistan. Its production capacity was intensively growing and the production variety was expanding. Dozens of cotton-spinning factories, enterprises producing finished products, textile complex on producing terry fabrics and garments were built and put into operation.

In addition, there were completed the projects on silk processing enterprises modernization. In 2000–2007, textile industry share was 8-9% of total investments to the economy. Compared to 2000, in 2007 production of cotton yearn increased by 74%, cotton fabric – 3.2 times, washed wool – by13%.

In recent years the **food industry** development was aimed at expanding a variety of food production especially in such branches as dairy and meat, fat and oil, production of drinking water, alcohol-free drinks, and canned production. New enterprises have been built and the existing enterprises have been modernized. Modern grain processing production continued to develop in order to achieve food security on such strategic food production as flour. Nowadays the food industry is one of the technologically advanced economy sectors of the country aimed at development of export potential. In recent years, there started the export of sausage products, vegetable oil, dry vegetables and fruits, ethyl alcohol, ice-cream and other foodstuffs. Compared to 2000, in 2007 the vegetable oil production increased 1.5 fold.

### 1.3.2.1. Oil and gas industry

The oil and gas complex of Turkmenistan not only forms the economy structure but also plays a decisive role at all stages of its development. This sector is very important for the GDP and export potential of the country.

In the meantime, the oil and gas industry at all stages of its functioning impacts greatly the environment with adverse consequences for human health and biodiversity. This impact comes from emission to air of natural gas flaring products, emission of natural and associate gas, hydrogen sulfide, spill of oil and oil products, discharge of highly mineralized, toxic reservoir and technological waters, solid wastes as well as from mechanic, acoustic and thermal disturbance in the landscape balance.

Development of Turkmen shelf of the Caspian Sea was defined as one of priorities in exploring and producing of hydrocarbons. The hydrocarbon resource stocks of this area are estimated as 18.2 billion tons of conventional fuel of which oil equals 12.0 billion tons and gas 6.2 billion tons.

In the oil refining industry, new oil-refining facilities are built and existing facilities are reconstructed to raise the quality of oil products, expand their variety and increase the oil refining depth. This development attributes to the need of export potential expansion as well as analogous branches development, especially the petrochemical one.

The oil-refining industry of Turkmenistan includes Turkmenbashi Refinery and Seydi Refinery. After modernization and technological enhancement of the refineries the oil refining volume increased to 7 million tons a year and the oil refining depth reached 90%, the high-octane petrol is issued.

Today, the position of Turkmenistan is impetuously enhancing at the foreign market. Having met the own needs in the wide range of oil products, the country becomes one of the largest world exporters.

Oil and gas enterprises are the main source of contaminant emissions into air. Since 1999, to reduce these emissions new compressor stations have been functioning using the earlier flared gas to intensify oil production. Moreover, this associate gas is supplied by gas pipelines to consumers instead of emitting it into air.

In 2000–2006, the geological prospecting discovered new oil and gas fields in Turkmenistan. These new fields included such large non-sulfurous "dry" gas fields as Eastern Uchaji, Peschanoye, Yolguyi and others, and oil and gas fields – Gunorta Yoloten, Yashlar and others.

In 2007, the oil extraction made 9.7 billion tons, and compared to 2000 its increase rate was 36%(Fig. 7) . Share of foreign companies accounted for about 20.3% of produced oil.

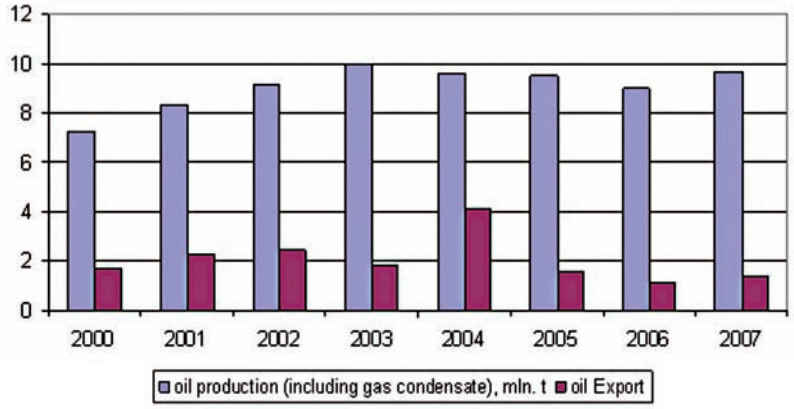


Fig. 7. Oil production and export, including gas condensate, in millions of tons

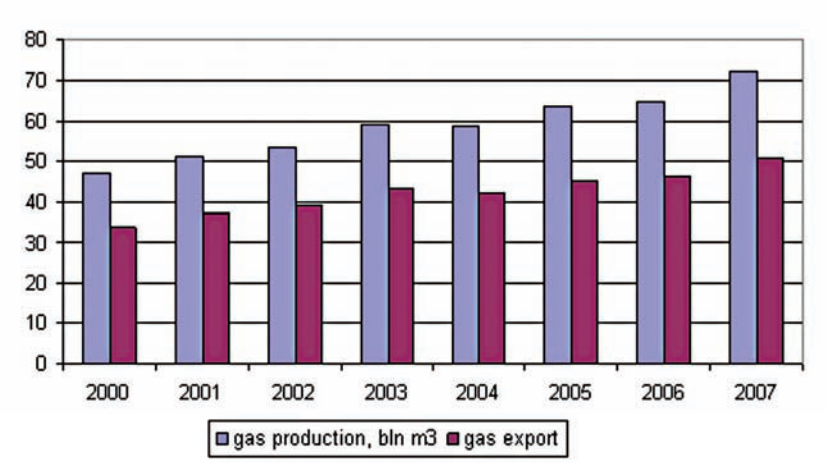


Fig. 8. Gas production and export, billions of m3

Gas production level is tightly connected with development of the pipelines system equal to 7 thousand km long, excluding outlet branches.

At present, natural gas export from Turkmenistan is performed in several directions. In the north direction it runs through the territory of Uzbekistan and Kazakhstan to Russia via the main pipeline system Turkmenistan (Deryalik) – Europe and Turkmenistan (Garabogaz) – Europe. In the south direction, gas runs by gas pipeline Turkmenistan – Iran (Korpedje - Kurtkui) put into operation in 1998. In late 2009 two new gas pipelines were launched: the 7 thousand km Turkmenistan – Uzbekistan – Kazakhstan – China with the capacity of 30 billion m3 and 30 km Turkmenistan – Iran pipeline.

In 2007, gas production in Turkmenistan was 72.2 billion m3, of which 50.9 billion m3 were exported (Fig. 8).

Further development of the gas industry depends on intensity of exploration and development of such fields as Southerm Yoloten – Osman and Yashlar located in the Amudarya basin.

According to results of international audit of gas stocks at Southern Yoloten – Osman field, the undervaluation suggests 4 trillion м3, optimal valuation – 6, high valuation – 14 trillion м3. Therefore, Southern Yoloten – Osman field is rated as the fifth or fourth one in the world by natural gas stock.

### 1.3.2.2. Power engineering

The overall capacity of all power stations in Turkmenistan was 7551.3 MW as per January 1, 2008. Electric power is generated by 7 power stations: Mari, Turkmenbashi (former Krasnovodsk), Abadan (Bezmein), Balkanabat (Nebitdag), Seidi, Ashgabat, Dashoguz and Gindukush power stations. In addition, Turkmenbashi Refinery has the in-house gas turbine power station of the capacity of126 MW (3x42), and Tejen Urea Plant has a turbine generator functioning with capacity of 119.9 MW.

Turkmenistan is the only country that provides its households with free electricity. The power engineering capacity is permanently upgraded to meet the growing needs in power at industry, construction and municipal sectors.

In 2007, the electricity production posted 14.772 billion kWh. Compared to 2006, electricity production growth accounted for 6.4% (Fig. 9). The domestic demand was satisfied and the surplus was exported.

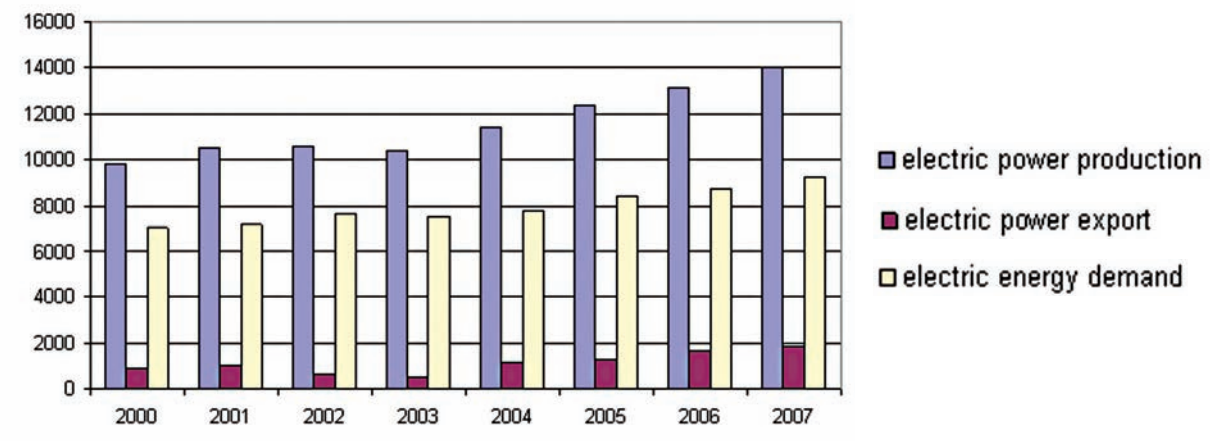


Fig. 9. Electricity production and consumption in 2000–2007, million kWh

A lot of job was done for electrification of cities and townships of neighboring Afghanistan. Built by Turkmen power engineers the new sub-stations and high voltage power transmission lines provided electricity supply to cities of Afghanistan – Mazari-Sharif, Hodjadukki, Shibergan and others. New power transmission line was constructed and put into operation from Serhetabat to Gerat enabling to significantly increase electricity export into the neighboring country.

Active investment policy facilitated to fully provide with electric power the rapidly developing socioeconomic sector of the country and constantly increase the electricity export. In 2007, in Turkmenistan, 14.8 billion kWh of power was generated, of which 1.9 billion was exported. Compared to 2000, the power production increased by 49% in 2007 (Fig.10).

In 2000–2007, the **power engineering** capacity was permanently increased, as further successful implementation of national plans on acceleration of the socioeconomic development of country heavily depended on this branch positions. In 2003, at Abadan power station the second gas turbine unit was installed (the first one – in 1998), and three gas turbine units were commissioned at Balkanabat power station. In-house power station was built at the Turkmenbashi Refinery. Due to the power consumption growth, a power station was built in Ashgabat in 2006. In late 2007, Dashoguz gas turbine power station was commissioned

All power stations of the power engineering system use the Turkmen natural gas. The fluctuation stock of this system ranging from 15 % to 30 % ensures stability of work of this system.

Presently, Turkmen electric power is supplied to Afghanistan, Iran, Turkey and Tajikistan owing to creation of inter-regional power supply lines.

The heat supply in Turkmenistan is performed by industrial and heating thermal power stations, large regional and small boiler units as well as heat generators provided in flats.

According to the statistical data for 2007, the main heating power producers are SC "Turkmenhimiya" and SC "Turkmengaz" with the respective shares of 41.1% and 39.3% of total heat power production . Other heat power producers are the Ministry of Energy and Industry of Turkmenistan, SC "Turkmenneft", Ministry of Textile Industry of Turkmenistan, Food Industry Association, etc.

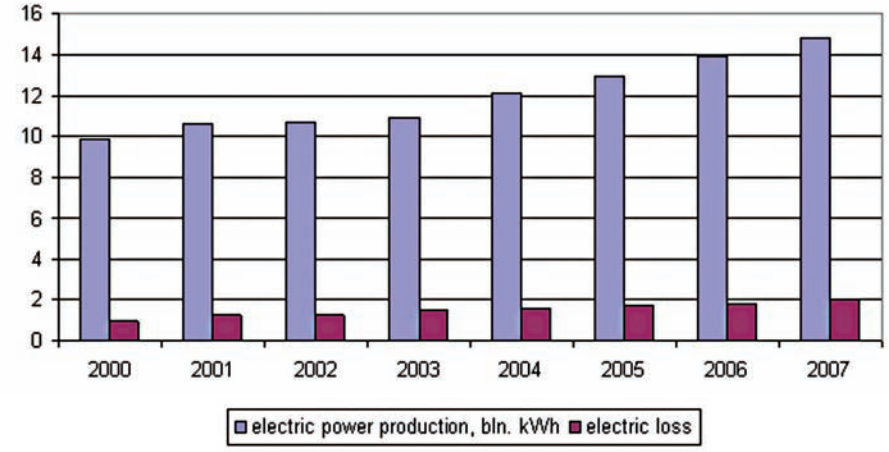


Figure 10. Power production and export, million kWh

### 1.3.2.3. Chemical industry

The chemical industry of Turkmenistan has the task to satisfy the agricultural demand on mineral fertilizers, thus contributing to achievement of self-sufficiency in food. The State Concern "Turkmenhimiya" includes 8 scattered over the territory of Turkmenistan industrial enterprises producing more than 50 kinds of products. Most of these products are mineral fertilizers including nitrogen and phosphor, iodine, magnesium sulfate, sulfur, sulfuric acid and technical carbon.

Development of the **chemical industry** first of all attributes to commissioning of the Urea Plant in March of 2005 with a capacity of 350 thousand tons of highly concentrated nitrogen fertilizers. New technologies and automated manufacturing processes as well as compliance with ecological requirements make this plant one of the best among the CIS countries. For instance, the technological chain design stipulates generation of electric power by using an excess steam formed while utilizing chemical reactions heat in the process of ammonia production. For this purpose, the special unit of 119.9 MW/h was constructed there.

Building and commissioning in 2006 of a plant on production of polymer and composite pipes of different diameters and functions (Ruhabat etrap of Akhal velayat) was another large-scale project in this industry. It is necessary to mention that the priority part of the output of this plant is hoses and pipes for drip irrigation system which is very important due to wide using of such systems in the agricultural production.

To provide pure drinking water to the population the Turkmenabat chemical enterprise and the "Maryazot" production association produce a new kind of coagulant – ferric sulfate. This high-tech preparation is widely used at plants producing purified drinking water.

At present time, the share of the chemical industry accounts for 1.6% of total output produced by medium and large enterprises.

Compared to 2000, in 2007 the technical iodine production rose by 59% and the mineral fertilizer production (physical weight) – 2.2 fold.

Along with natural gas, cotton and corresponding products, the chemical industry output is the important component of the export. Development of export-oriented chemical industry shall remain when producing iodine, sodium sulfate, technical carbon, bischofite and epsomite. Production of iodine and high quality sodium sulfate is especially perspective. Turkmenistan possesses huge stock resources for production of these items and consequently, the increase of production of iodine, sodium sulfate and afterwards potassium sulfate should be a priority direction in the chemical industry development.

### 1.3.2.4. Agriculture

Favorable agro-climatic conditions and availability of good agricultural lands serve to be a good basis for growing in Turkmenistan of cotton, cereals, vegetables and fruits, for animal breeding and therefore produce various foodstuffs domestically (Fig. 11).

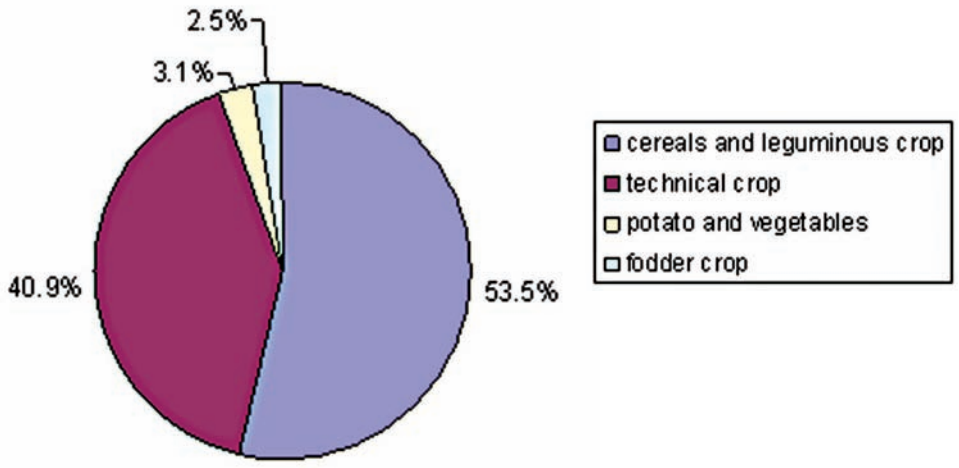


Fig. 11. Sown area structure, % of total area of agriculture

Pastures in Turkmenistan occupy rather large territory, which is 38.4 million ha or 78% of soil reserves. This territory (under complete water supply) can be used for pasturing sheep and goats and camels the whole year.

In 2005, the share of agricultural lands accounted for 81% of total area of Turkmenistan. Most valuable are the irrigated lands making 1.7 million ha out of 17 million ha suitable for irrigation. Limited water resources are certainly a constraining factor for irrigated farming development.

In 2000–2007, the agricultural output increased more than 4 fold and in 2007 it was 31.9 trillion manat including harvest output – 13.8 and animal breeding output – 18.1 trillion. This allowed satisfy the needs of the country in food for 80%.

### 1.3.2.5. Transport

Enhancement of the economic potential of Turkmenistan, strengthening of inter-region links owing to balancing of territorial development of production, as well as integration to the world economy have become the factors that boosted the transport sector development. Over 15% of total investments into the economy have been used for development of transport and communication system in 2000-2007.

The transport system of the country involves the automobile, railway, air, river, sea and pipeline transport. Operational length of the public tracks comprises 3.1 thousand km of main railways, about 13.7 thousand km of automobile ways and over 8.6 thousand km of main pipelines.

Over the independence years the number of automobiles has increased more than 3 fold. The automobile fleet is as follows: 77% - cars, 19% - freight and special transport, 4% - buses. Nevertheless, the automobile fleet still includes a big number of old and obsolete vehicles, and certainly they add to the increase of greenhouse gas and contaminant emissions into atmosphere.

The **railway network** has been substantially developed as well. The new railway Tejen – Sarakhs – Meshhed (over 300 km) connected the largest world railway systems of Europe

and Asia, thus contributing to completion of the project of creation of Trans-Asian main line – Great Silk Road. Now this road is used for transporting freight to the Gulf seaports.

The railway Turkmenabat – Atamurat (215 km) connected the velayat center with five etraps of Lebap velayat on the left bank of Amudarya. In 2005, construction of the railway main line Ashgabat – Garagum Desert – Dashoguz (530 km) was completed. It crossed the Central Garagum Desert to cut the way between two big velayats of the country – Akhal and Dashoguz.

Compared to 2000, in 2007 the railway freight increased 2.3 fold and passenger transportation – 2.2 fold.

In Turkmenistan, **air transport** is rapidly developing. New airports are built and the existing airports are modernized, the physical infrastructure of civil aviation has been strengthening and flights geography has been expanding.

There are flights now to all velayat centers within the country and to 11 countries of the world, as well as there is charter freight transportation – to several countries. The State National Civil Aviation Service "Turkmenhowayollari" has representative offices in 11 countries of Europe and Asia. There are 12 representative offices of foreign air companies in Turkmenistan.

The aircraft fleet of Turkmenistan includes the Boeing airliners and the helicopters produced at leading foreign companies.

Compared to 2000, the air transportation of passengers has increased by 46% in 2007.

The **water transport** has also been rapidly developing. Turkmen flotilla contains ocean, sea and river vessels. Their number is growing year by year. In 2000–2007, the national tanker fleet was actively developing for transportations at the Caspian Sea; old terminals for oil storage and transshipment are reconstructed and new terminals are built.

### 1.3.2.6. Tourism

Tourism is the newly developing industry of the Turkmen economy based on historical and cultural heritage and unique nature of Turkmenistan.

The country has many ancient historical and cultural monuments. In the ancient times the Great Silk Road was crossing Turkmenistan promoting in this way the cultural integration of East and West. The history of the Great Silk Road is quite attractive, and at present time many countries via which this Road was running express interest in establishing tourist routes to learn the ancient trade and cultural links.

Turkmenistan has a lot of big architectural monuments being in the ancient times the important points at the Great Silk Road: ancient settlements Mashad-Mesrian in Dehistan, Parau point near Serdar, Shahrislam in Baharden region, Nissa, Annau, Abiverd, Namazgadepe, Altin-depe near Ashgabat, Serakhs, Ancient Merv, Margush, Amul near Turkmenabat, Kunyaurgench, Shahsenem near Dashoguz.

Indeed, Sultan Sanjar Mausoleum in the Ancient Merv is the most wonderful of them. The so called "Merv ensemble of the XV century" - a mausoleum of fellow-fighters of Prophet Muhammed is very interesting by its architectural design. Mysterious Astana-baba Mausoleum admirable by its design is located in Lebap velayat where you can always meet palmers.

The most interesting monuments of Turkmenistan are situated in the town Kunyaurgench (Dashoguz velayat) – Il Arslan and Tekesh horezmshah mausoleums (XII century), amazing monuments of Ancient Horezm – Tyurabek-hanum mausoleum and tremendous 60 meters high minaret of Kutlug-Timur, the highest in Central Asia. Mysterious and mystical ruins of Ancient Dehistan rise above the waterfree plain of Balkan velayat, the most significant among them is Shir-kabir mausoleum. Near Ashgabat city, in vicinity of Bagir village, Nissa is located which was a capital of Parthia existing for almost 600 years (from III BC to III AD).

At the end of last century, in the Eastern Garagum Desert archeologists discovered the ruins of fortresses and temples similar by sizes and monumentality to the monuments of Assiriya and Vavilon. In 1992, in Gonur-depe an enormous necropolis was discovered. A lot of utensils, mirror, different pots, silver ornaments, alabaster and ceramic vases and many other items were found dated back to III century BC.

As a tourist place, Turkmenistan is attractive not only by its architectural and historical monuments but also by natural monuments (the Caspian Sea, Kugitang Massif with a famous Dinosaur Plateau, Kyrkgyz Cave, Daraydere Canyon, etc.).

Turkmenistan has many recreational zones – mountainous, seaside, desert favorable for treating and preventing many diseases. Turkmenistan has several popular health resorts such as Mollakara, Bairamali and Archman. Their mineral waters and mud are used to treat different and also severe diseases. Kidney, heart, nervous system, locomotor disorders, spinal column injures can be treated at these resorts as well.

Natural landscape diversity, history of the country, rich cultural heritage and many other sights can be seen by tourists visiting Turkmenistan. Big positive changes have happened in all spheres of life of Turkmenistan making it a dynamically growing state where ambitious plans are realized and unprecedented projects are implemented. One of such projects is the creation of National Tourist Zone "Avaza" at the Caspian Sea coast. This project was launched in 2007 at initiative of President of Turkmenistan and for today over a dozen of modern comfortable hotels, recreation centers and sanatoriums have been built in compliance with the highest international standards. People who come here can rest at the wonderful ecologically pure beach of the Caspian Sea.

"Avaza" attracts by its continuous summer tourist season, milder winter, which allows conducting at this place sport activities and trainings, and also favorable ecological environment – clean water, coast, biodiversity and the Turkmen hospitality.

## 1.4. National environmental policy

### 1.4.1. Institutional background

Turkmenistan is an independent, democratic and civil state with presidential form of government. The Constitution of the country was adopted on May 18, 1992 and was provided with amendments in 2008. President is the head of state and government, the guarantor of national independence, territorial integrity, compliance to the Constitution and international agreements. The President and the Cabinet of Ministers ratify along with various state acts the environmental programs as the guarantors of implementation of the state policy on ecology. Mejlis (Parliament) of Turkmenistan is the legislative power body.

In December, 1995, the UN General Assembly adopted a Resolution on permanent neutrality status of Turkmenistan supported by 185 countries of the world. Nowadays, Turkmenistan has diplomatic relations with more than 120 countries, serves as a member of over 40 international organizations including UNFCCC and IPCC and has representatives in such authoritative organizations as UN, EU, OSCE, UNESCO, etc.

The Ministry of Nature Protection of Turkmenistan is responsible for the nature conservation policy pursuance and for implementation of the decisions of President and Cabinet of Ministers of Turkmenistan on the environment protection issues.

Regulatory legal acts adopted by Ministry of Nature Protection within its competence are obligatory for legal and physical persons carrying out their work on the territory of Turkmenistan, regardless their ownership. Environment protection issues at the level of velayats (regions) are resolved by the corresponding velayat (regional) authorities.

Monitoring of atmospheric air and surface water is performed by Research Production Center of Ecological Monitoring (RPCEM) of National Institute of Desert, Flora and Fauna of Ministry of Nature Protection of Turkmenistan. The key aim of the RPCEM work is to provide the government authorities and the economic sectors with the updated state-of-environment information.

Monitoring of the Turkmen section of the Caspian Sea is performed by the Caspian Ecological Service "Kaspekogozegchilik".

Ministry of Water Management, as well as the Land Use Service of Ministry of Agriculture, the Sanitary and Epidemiologic Inspection of Ministry of Health and Medical Industry, the State Corporation "Turkmengeologiya" control the observance of nature protection legislation within the framework of their competence.

### 1.4.2. Legal background

The Constitution of Turkmenistan states a responsibility of the government to conserve the nature. Protection and rational use of natural resources is a fundamental principle of

the state policy, the observance of which facilitates the provision of socioeconomic development of Turkmenistan and serves to be one of the essential conditions of the balanced ecological policy. Therefore, the development and improvement of the nature protection legislation remains to be a top priority of the environmental activity of the state aimed at providing a compliance of the national legislation with the international law.

From the first days of independence of Turkmenistan the law-making process was directed on creation of a proper legislative system responding to the international standards in the ecology sphere. There have been issued the following regulatory legal acts of Turkmenistan:

- Law on nature conservation (1991)
- Sanitary Code of Turkmenistan (2009)
- Law on state specially protected natural territories (1992)
- Law on mineral wealth (1992)
- Forestry Code of Turkmenistan (1993)
- Law on protection and sustainable use of flora (1993)
- Law on standardization and metrology (1993)
- Law on state environmental impact assessment (1995)
- Regulations on implementation of the state environmental impact assessment (1996)
- Law on hydrocarbon resources (2008)
- Law on protection of atmospheric air (1996)
- Regulations on State Commission of Turkmenistan on climate change issues (1997)
- Law on protection and sustainable use of fauna (1997)
- Law on prevention and liquidation of emergency (1998)
- Law on hunting and conduction of hunting (1998)
- Regulations on State Commission to ensure implementation of Turkmenistan's obli gations under UN Environmental Conventions and Programs (1999)
- Water Code of Turkmenistan (2004)
- Decree to establish the State Commission on CDM (2009).

However, not all opportunities have been used yet when developing the national legislation of Turkmenistan on climate change issues control and synchronizing this legislation with the provisions of multilateral conventions. The law making process tends to continue further development and there are sufficient grounds to expect the national legislation will conform to the international law in this area.

As a party to the primary UN conventions on nature conservation aimed at protecting the environment and preventing the ecological disasters of natural and anthropogenic character, Turkmenistan demonstrates interest and willing to participate in decision making process on environmental global problems for present and future generation. A strong evidence of this is joining of Turkmenistan to the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol signed and ratified accordingly in 1995 and 1998; Convention on Biodiversity (June 18, 1996); Vienna Convention and Montreal Protocol on Ozone Depleting Substances (February 14, 1994); Convention to Combat Desertification (June 18, 1996) and others. Norms and rules provided at these multilateral documents as well as at the national legislation serve to be a legal base for implementing of practical activities by subjects of legal relations in Turkmenistan and of Turkmenistan according to the undertaken obligations in this area.

# CHAPTER 2. GHG INVENTORY

The Ministry of Nature Protection is responsible for the performance of the obligations stipulated in the UN international environmental conventions.

The National GHG Inventory Group is being established in the Ministry of Nature Protection of Turkmenistan during the preparation period of the National Communication on UNFCCC. For the implementation of GHG Inventory experts from various branches of national economy of Turkmenistan are being involved.

The National GHG Inventory Group is subdivided into seven target groups. Due to significance of Energy sector (the largest volume of works), three working subgroups are formed for Energy sector: «Stationary Combustion», «Mobile Combustion», «Fugitive Emissions» (Fig. 12).

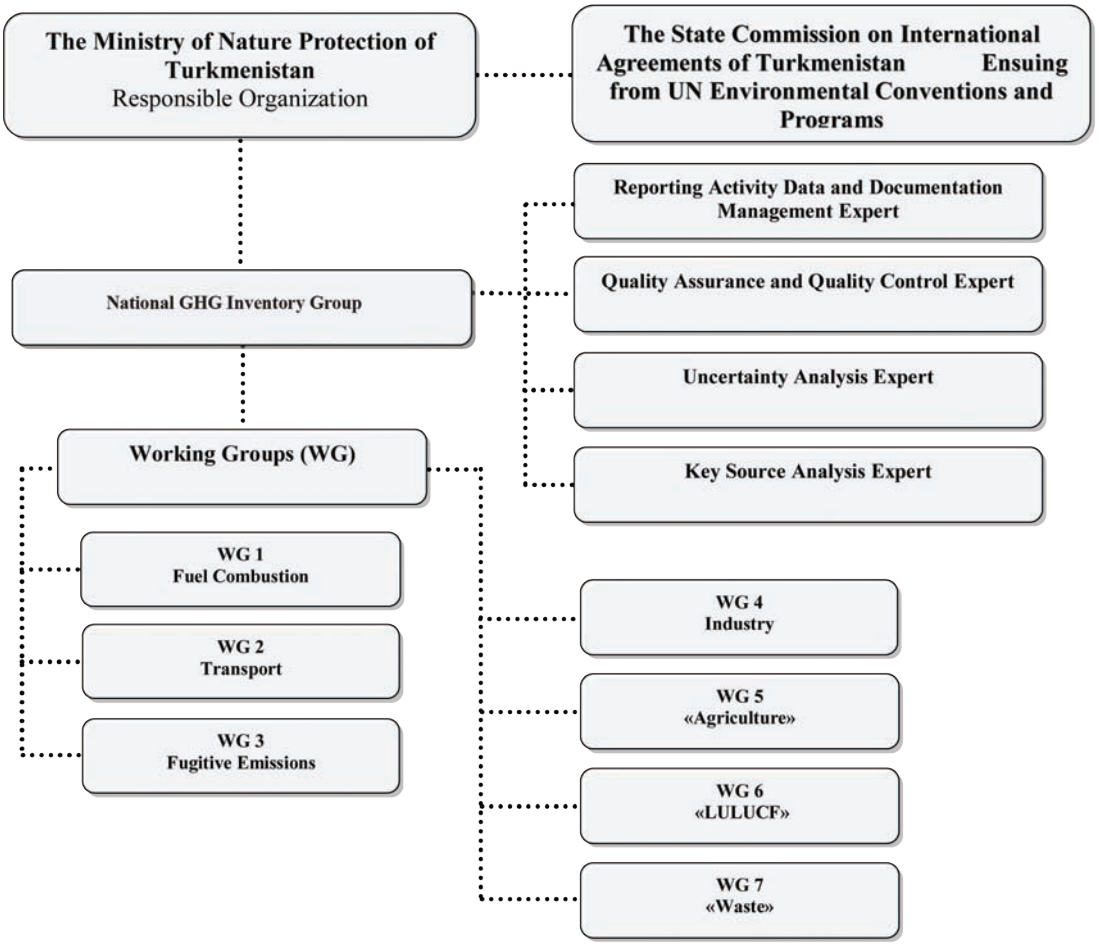


Fig.12. Organizational Structure of the National GHG Inventory System

In Turkmenistan the GHG Inventory in full volume was conducted in 1998 on the data of 1994. It was implemented within the framework of the First National Communication of Turkmenistan on climate change. Within the framework of the Second National Communication on climate change (SNC) the GHG Inventory was conducted for the period of 1995-2004. In order to ensure a consistent time series the data for 1994 used in the first GHG Inventory were reviewed and results were recalculated.

During the implementation of GHG Inventory the statistical materials as well as a data received from the branch ministries, departments and the large industrial enterprises using a fuel for the own needs were primarily used.

Emission estimations and also all emission factors correspond to requirements of the Revised 1996 IPCC Guidelines for National GHG Inventories. Additionally IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories (1999) and Good Practice Guidance for Land Use, Land-use Change and Forestry (2003) were used.

In some cases the country-specific emission factors, for example, net calorific value for oil, natural gas and fuel oil (residual oil) were used.

## 2.1. GHG Inventory Outputs

The estimation of GHG emissions and sink in Turkmenistan was performed for the period of 1994-2004. The total GHG emissions in 1994 made up 34901.31 Gg, and in 2004 – 60569.92 Gg (CO2-equivalent). GHG emissions have decreased in 1997-1999, during development of the country's economy. For instance, in 1998 GHG emissions decreased by 28425.51 Gg (CO2-equivalent). The next years, during intensive economy development the stable growth of GHG emissions was observed (Fig. 13).


Fig.13. Direct GHG emissions, Gg (CO2-equivalent)

### 2.1.1. Direct GHG Emissions Trend

Though some industrial recession in 90th of XX century and the reduction of fuel utilization at the enterprises of Turkmenistan, the carbon dioxide emissions during these years steadily have increased (Fig. 14). It is conditioned by countrywide gasification program at that time and accordingly by sharp increase of the amount of natural gas consumed by the population. The total amount of fuel used in the country has grown and GHG emissions have accordingly increased.

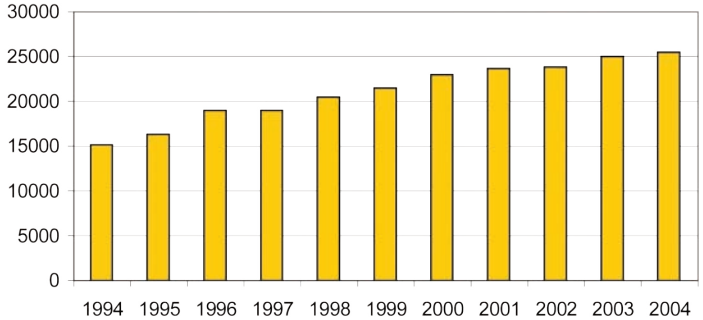


Fig.14. CO2 Emissions, Gg

The major contribution to methane emission in territory of Turkmenistan is made by oil and gas related activity. Rupture of the existing economic relations in the 90th of the last century has caused recession in production and realization of fossil hydrocarbon materials, which was the reason of sharp reduction of methane emissions (Fig. 15).

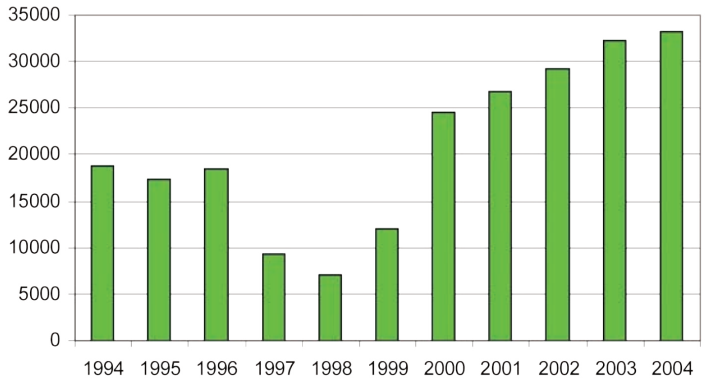


Fig.15. CH4 Emissions, Gg (CO2- equivalent)

Similar processes in agriculture and industry sectors became the reason of reduction of N2O emissions in 1994 – 1999 (Fig. 16).

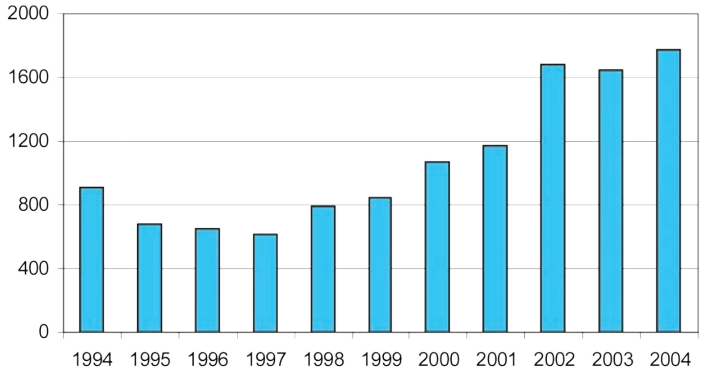


Fig.16. N2O Emissions, Gg (CO2- equivalent)

Correlation of the direct greenhouse emissions for 1994 and 2004 is practically identical (Fig. 17). Insignificant growth of methane fraction (2 %) and a similar decrease in carbon di-oxide is observed. The methane emissions increase due to high extractions of hydrocarbon materials.

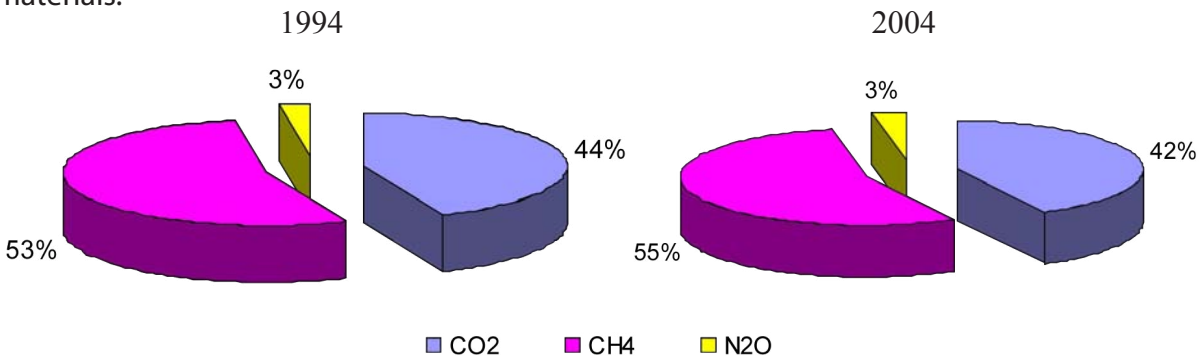


Fig.17. Direct GHG emissions in 1994 and 2004

### 2.1.2. Indirect GHG Emissions Trend

During the concerned period emissions with indirect greenhouse effect (Fig. 18) have stably grown. For this period these emissions have increased twice. In this case both Energy and Industrial Processes sectors make a significant contribution to the total national emissions.

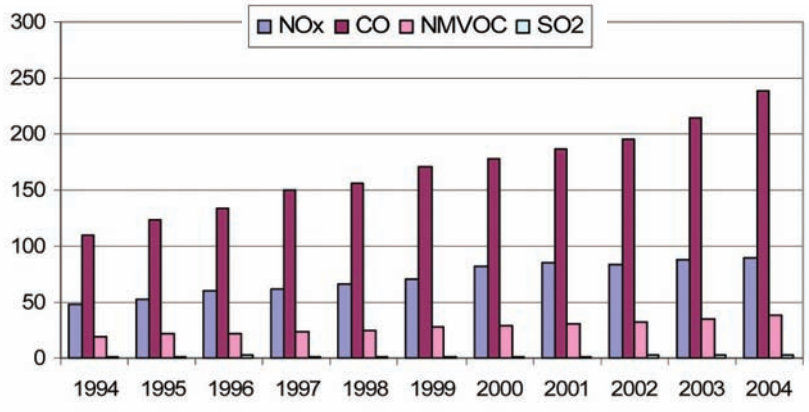


Fig.18. Indirect GHG Emissions, Gg

### 2.1.3. Hydrofluorocarbon Emissions

The consumption of hydrofluorocarbons (HFCs) in Turkmenistan has been determined on the basis of the registration data received from the State Customs Service of Turkmenistan, State Service «Turkmenstandard», the Ministry of Energy and Industry of Turkmenistan, the Ministry of Railway Transport of Turkmenistan, and also from regional departments of the Ministry of Nature Protection of Turkmenistan. The analysis of the received data showed that HFCs have not been produced in Turkmenistan as well as the equipment and the goods. However, HFCs are imported as in the pure state and as in products.

Emissions of hydrofluorocarbons (in Turkmenistan it is HFC-134A) are estimated only for the period of 2000-2004. Though these emissions are insignificant, the rapid growth of these emissions for the last years causes concerns (in 2000 – 1.0696 Gg; in 2001– 1.3556 Gg; in 2002– 0.4404 Gg; in 2003 – 1.3985 Gg; in 2004 – 11.4143 Gg).

### 2.1.4. Distribution of GHG Emissions by Economic Sectors

The distribution of direct GHG emissions by economic sectors of Turkmenistan shows that the Energy sector is major source of these emissions (Fig. 19). The second significant source of emissions is Agriculture sector. Thus, in these both sectors have steady growth of GHG emissions.

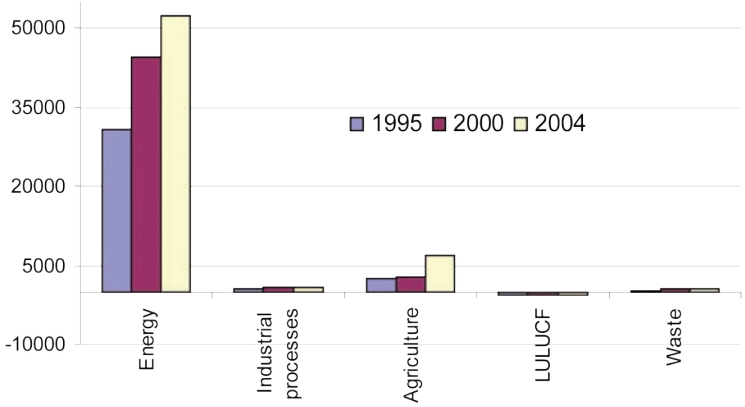


Fig.19. Direct GHG Emissions by Sectors, Gg (CO2-equivalent)

The comparative analysis of GHG emissions in various economic sectors for 1994 and 2004 shows insignificant growth of emissions by 3 % in agriculture sector, which caused by intensive development of an agricultural production at this period (Fig. 20).

Contribution of Energy sector to GHG emissions in Turkmenistan in 1994 constitutes up to 89% and in 2004 up to 87% (emission reduction by 2% does not mean reduction of total amount of emissions). The absolute magnitude of emissions in the sector steadily grows.

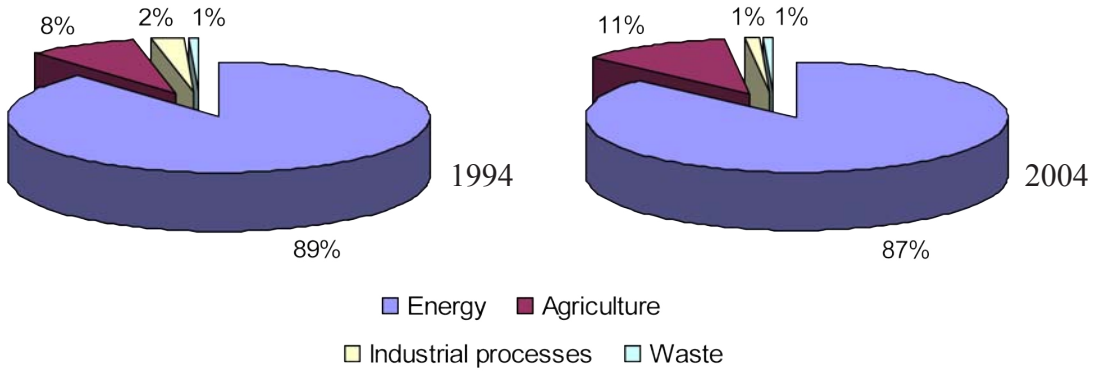


Fig.20. Direct GHG emissions by sectors in 1994 and 2004

## 2.2. GHG Emissions Trend by Sectors

### 2.2.1. GHG Emissions from Energy Sector

Considering the GHG emissions trend in whole Energy sector (Fig. 21), it is necessary to notice that GHG emissions for mentioned period have increased from 31000 to 52500 Gg (CO2-equivalent). In addition, it is expected the further growth of emissions since Turkmenistan increases the production of natural gas, oil and the electric power, the number of road vehicles is being enlarged in the country.

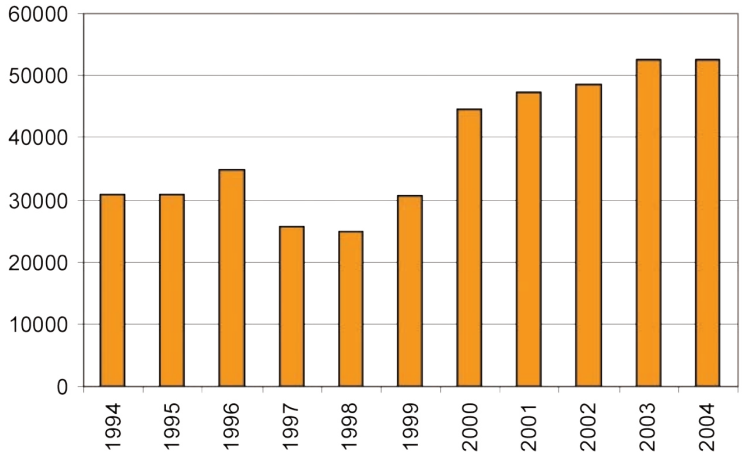


Fig.21. GHG Emissions in Energy Sector for 1994 – 2004, Gg (CO2-equivalent)

According to 2004 data (Fig. 22) the main fraction of GHG emissions is related to oil and natural gas complex (51.8 %), then the population (19.4 %), electric power industry (15.4 %), residential (municipal) sector (5.3 %), transport (4.5 %), emissions from other activities are insignificant.

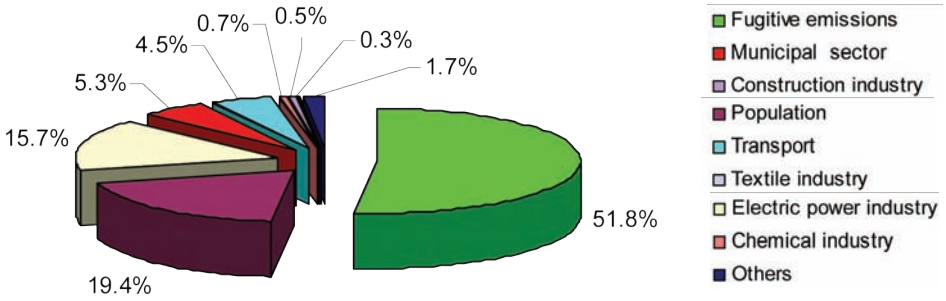


Fig.22. Contribution of Energy sector to total GHG emissions (data for 2004)

According to the data on the oil and natural gas and electricity sectors development it can be affirmed that in the future the oil and gas complex will keep superiority in GHG emissions release, the second place will take the electricity sector. The population sector in this process will decrease because actual fuel consumed by the population during the last years grows slightly grows (Fig. 23).

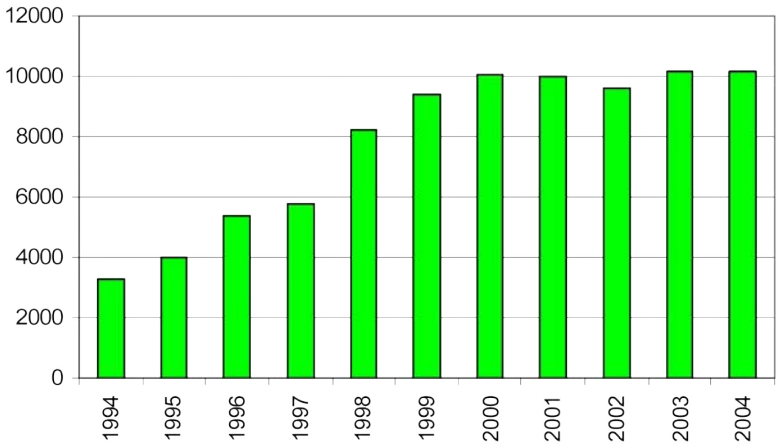


Fig.23. GHG emissions from fuel consumed by population (1994-2004), Gg CO2-equivalent)

### 2.2.1.1. Fuel Combustion

The natural gas is primary fuel for production of the heat and electricity in Turkmenistan. The fraction of other types of fuel constitutes less than 1%. Calculation was carried out for natural gas and fuel oil for each of the following year: 1994-2004 on the basis of the actual data. In 2004 GHG emissions made up 22918 Gg (CO2-equivalent) (Fig. 24). The carbon dioxide is the major greenhouse gas emitted from fuel combustion in considered sectors. The fraction of other gases in the total emissions is insignificant. It is necessary to note the stable growth of emissions in this type of activity. Taking into account that capacities of electricity production in Turkmenistan are being developed, increase of emissions is expected in the future.

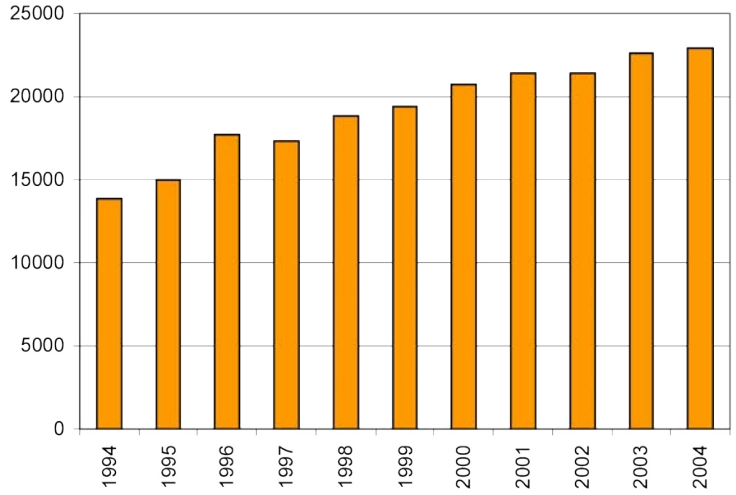


Fig.24. Dynamic of GHG emissions from heat and electricity production, Gg (CO2-equivalent)

According to the result of estimations for 2004 (Fig. 25), the fraction of population in GHG emissions from heat and electricity production constitutes 44.4%, electric power industry – 36.0, residential (municipal) sector – 12.2, chemical industry – 1.7, construction – 1.1, textile – 0.8, the fraction of other type of activities is 3.8%.

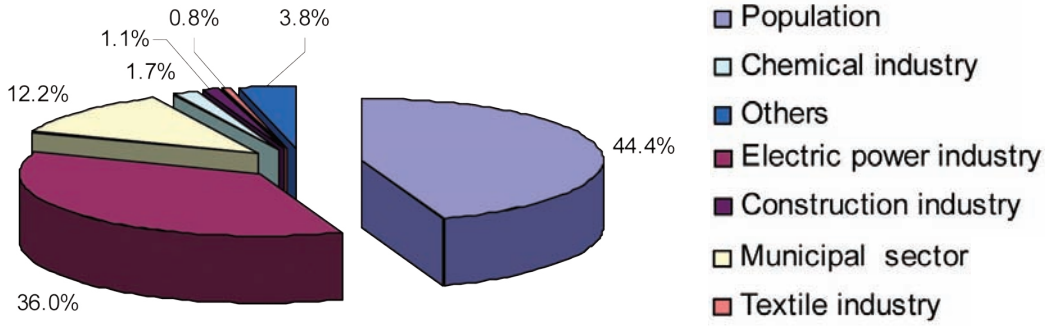


Fig.25. GHG Emissions from Heat and Electricity Production, 2004

## Transport

The transport and communication system of Turkmenistan is the integral constituent of the successful economic development. Realization of the National Program «Strategy of economic, political and cultural development of Turkmenistan for the period till 2020» stipulates the further development of a transport infrastructure and telecommunication network. According to the main operation index of transport sector the high growth rates are annually observed. The sector is presented by road, air, railway and marine vehicles. The main load of freight and passenger traffics belongs to road and railway transport.

Transport sector is one of the main sources of GHG emissions in atmosphere. Carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), sulfur dioxide (SO2), particulate matter (PM) and nitrogen oxides (NOx) which become a cause of emergence and aggravation of problem of local or regional air pollution.

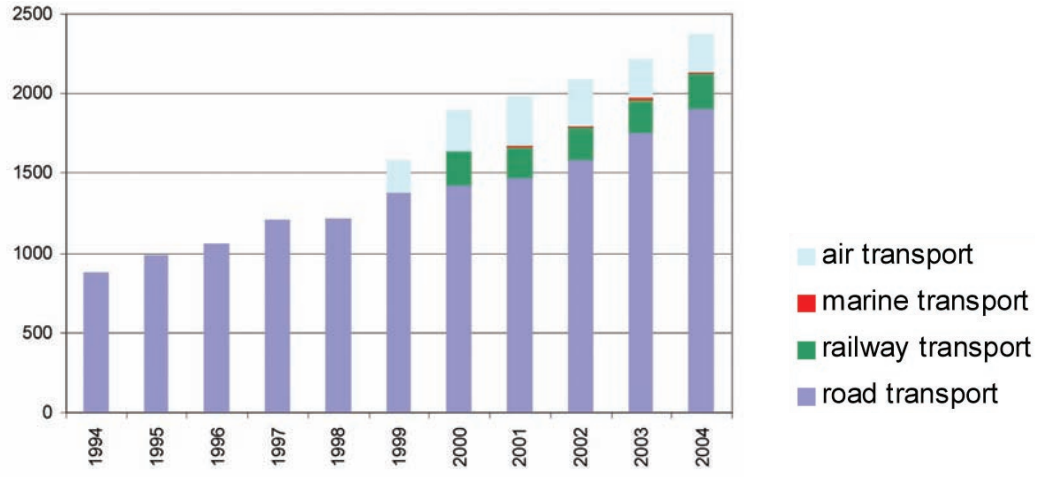


Fig. 26. GHG Emissions from Transport sector for 1994-2004, Gg (CO2-equivalent)

GHG emissions in Transport sector in 1994 constitute **878.769** and in 2004 – **2371.075** Gg (CO2–equivalent). Emissions from road transport in 2004 made up more than 90% (Fig.26). The growth of GHG emissions basically is because of increased number of road vehicles.

Emissions from the international bunker were estimated only on basis of emissions from air transport. From 1999 to 2004 emissions has increased from 65.130 up to 120.210 Gg (CO2-equivalent).

### 2.2.1.2. Fugitive emissions

Significant methane emissions in Energy sector occur in the oil and natural gas industry as one of the leading branches of the national economy of Turkmenistan. Established more than 40 years ago, this sector has rapidly developed and now determines economic growth not only of Turkmenistan, but also other consumer-countries as well as those through which oil and natural gas are transited. Since 1999 Turkmenistan annually expands the volume of extraction and exports of this most valuable energy material.

For the estimation of GHG emissions from the oil and natural gas industry the average emission factors specified for the former USSR countries, Central and the Eastern Europe were used.

Estimation of methane emissions were conducted for 1994-2004 (Fig. 27).

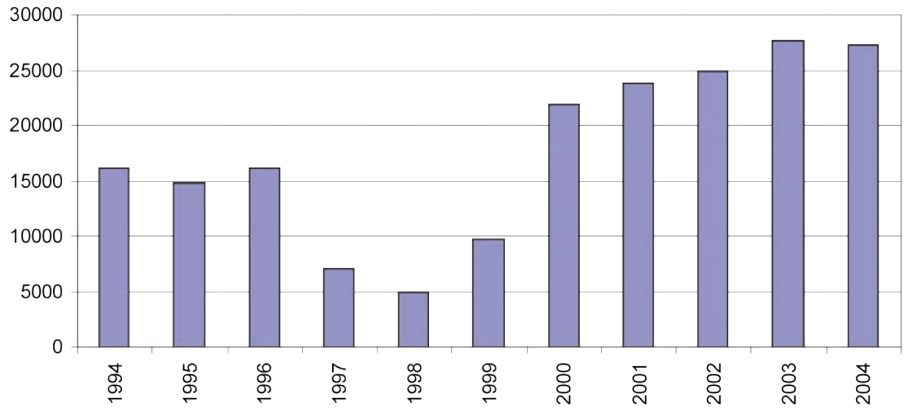


Fig.27. Methane Emissions from the oil and natural gas sector for 1994-2004, Gg (CO2-equivalent)

## 2.2.2. Industrial processes

Estimation of GHG emissions in the given sector was carried out for the following emission sources, taking into account a specificity of industrial processes:

- Activity connected with mineral raw materials processing;
- Chemical Industry;
- Food Production.

The main components of industrial emissions in Turkmenistan are CO2 - from mineral production (cement and limestone), chemical production (ammonia); N2O - nitric acid, ammonia; CH4 - technical carbon and coke.

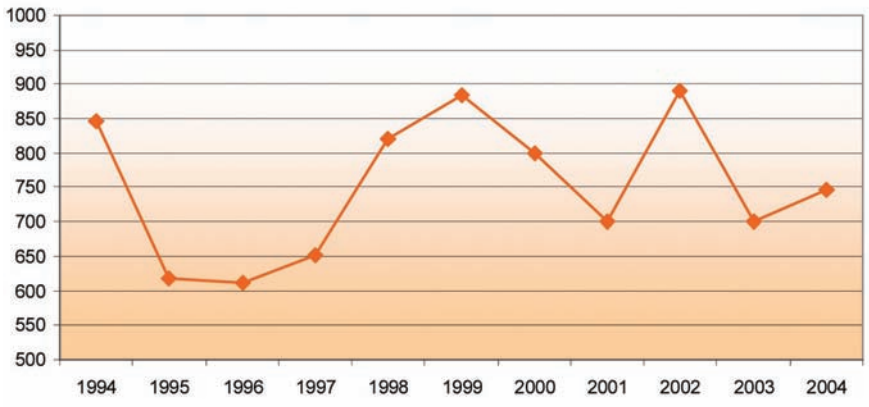


Fig. 28. GHG emissions from Industrial processes, Gg (CO2-equivalent)

In base 1994 year the total GHG emissions in the given sector constituted 846.652, and in 2004 – 746.292 Gg (CO2-equivalent). The least amount of emissions was registered in 1995 - 1997, 2001 and 2003 (Fig. 28).

In the given sector the fraction of mineral production in various years is 18-66% of emissions, and the chemical industry is 34-72% (Fig.29).

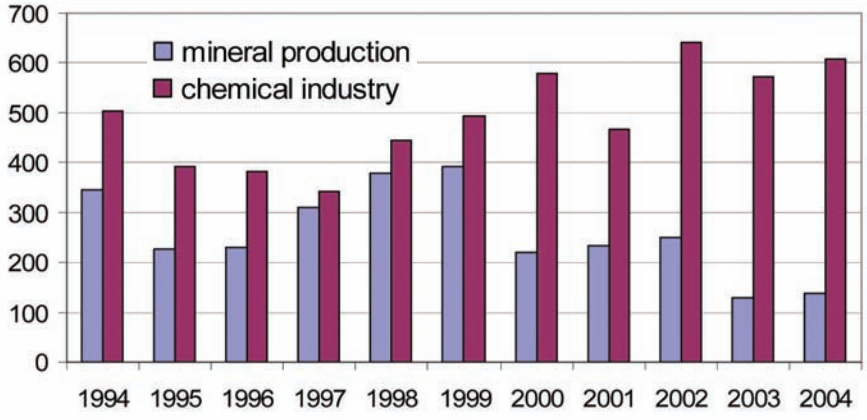


Fig. 29. GHG emissions from Industrial Processes for 1994-2004, Gg (CO2-equivalent)

Meanwhile the fraction of the chemical industry in total GHG emissions increases from 59% in 1994, up to 82% in 2004 (Fig. 30).

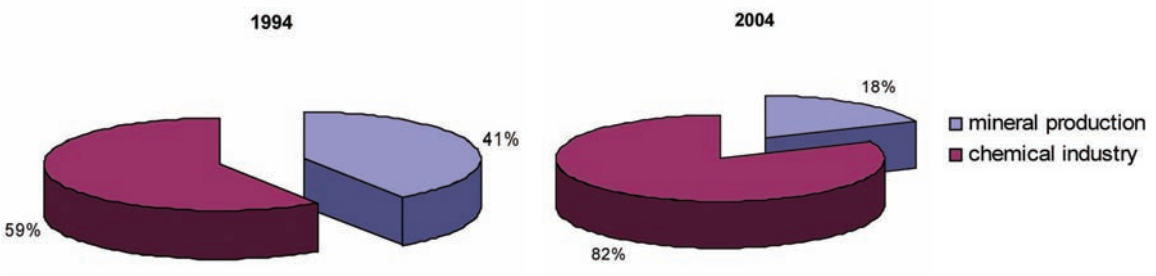


Fig. 30. Contribution of Industrial processes sources to total GHG emissions for 1994 and 2004

The most part of GHG emissions from mineral production is supplied by cement production, in the chemical industry by nitric acid and ammonia production (Fig.31-32).

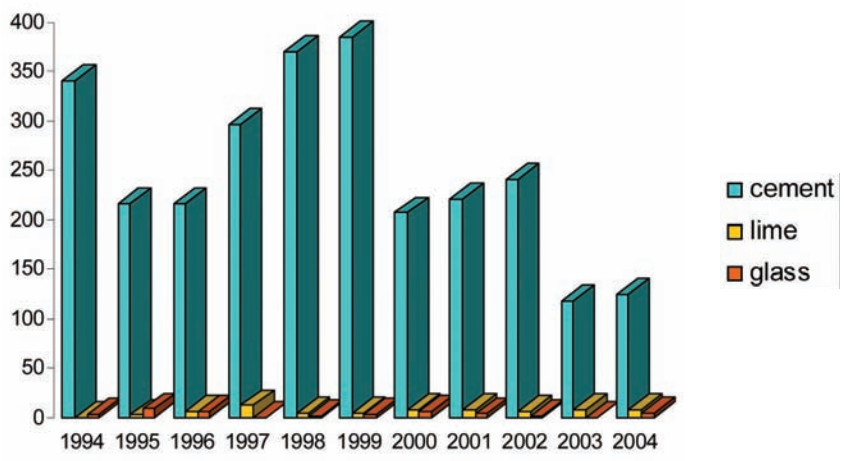


Fig. 31. Direct GHG emissions from the mineral production for 1994-2004, Gg (CO2-equivalent)

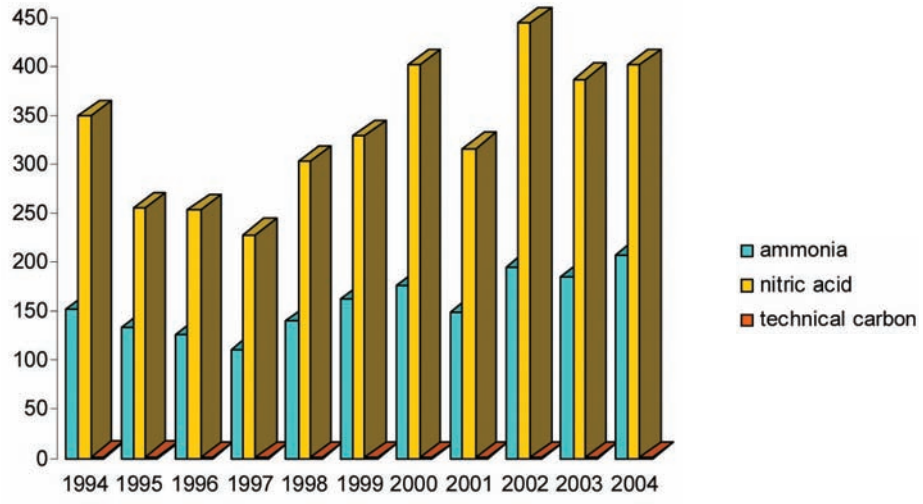


Fig. 32. Direct GHG emissions from the chemical industry for 1994-2004, Gg (CO2-equivalent)

N2O is the main constituent of total GHG emissions from sector «Industrial processes», methane emissions occur in much smaller quantity (Fig. 33).

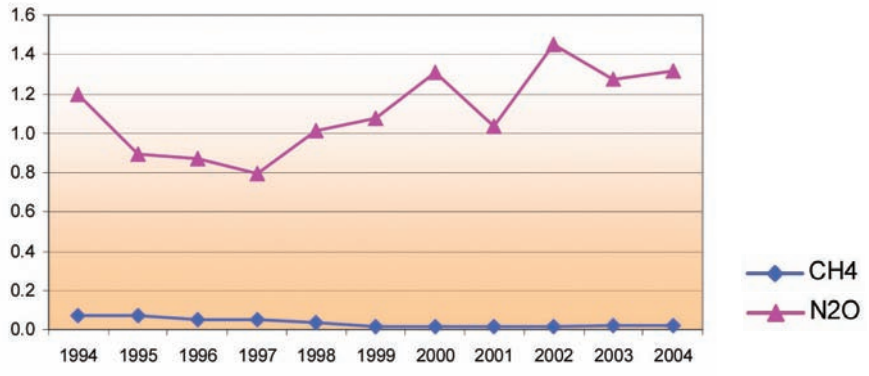


Fig. 33. Direct GHG emissions from Industrial processes for 1994-2004, Gg (CO2-equivalent)

NMVOCs prevail among the gases with indirect greenhouse effect (Fig. 34).

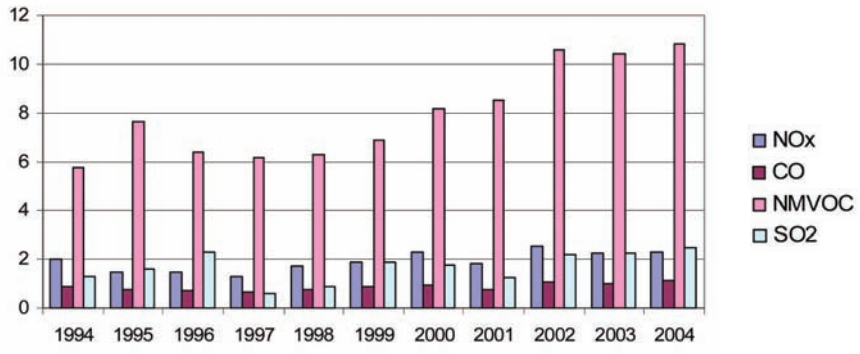


Fig. 34. Indirect GHG Emissions from Industrial Processes for 1994-2004, Gg (CO2-equivalent)

### 2.2.3. Agriculture

Agriculture is the important branch of country's economy. During the last years the country's agrarian sector has fundamentally changed. Stages and rates of agriculture development are defined by programs of the President of Turkmenistan such as "10 Years of Stability", "Grain" and "New Village". During the last years food relations and the ownership forms have radically changed in the country, the private entrepreneurship is under development.

The share of agriculture is about 20% of gross national product of the country. From year to year the manufacture capacity practically of all types of agricultural production increases. In order to raise rates of agricultural production, favorable conditions were created for commodity producers of all ownership form. The most progressive forms of lease relations have been developed, the class of private land users and entrepreneur is being formed.

At present, two sectors operate in agriculture structure: State sector (peasant associations, farms of the enterprises and organisations) and non-state sector (peasant farm, private commodity producers, households).

Estimation of GHG emissions in Agriculture sector was carried out for 1994-2004. The methane and nitrous oxide emissions were estimated from the following sources: domestic

livestock (mainly sheep, goats, camels, horses, swine, poultry etc.) – enteric fermentation and manure management, rice cultivation – the flooded rice fields, agricultural soils.

Results of estimation (Fig. 35) show a considerable growth of GHG emissions in Agriculture sector: from 2871.03 Gg in 1994, up to 6805.46 Gg (CO2-equivalent) in 2004. The agriculture fraction in total GHG emissions has grown up during the mentioned years from 8 % to 11 %. Methane is the major component of emissions (in average about 80%), the rest belong to the nitrous oxide.

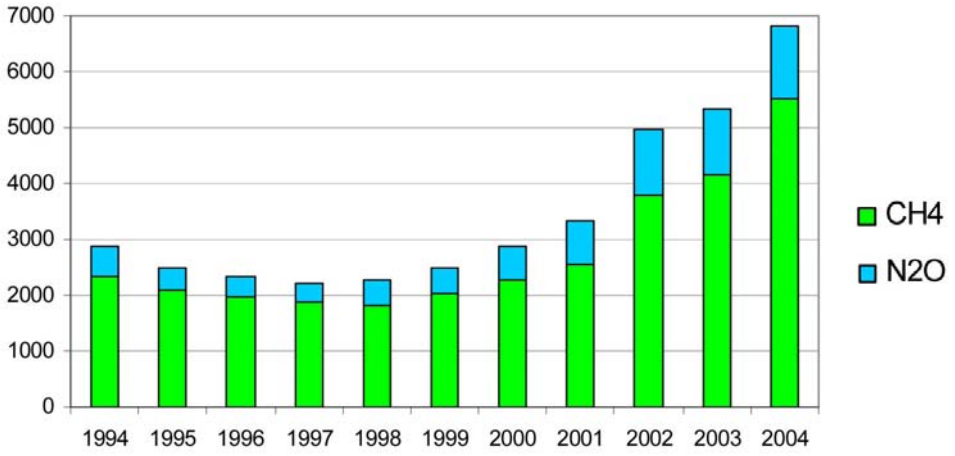


Fig. 35. Direct GHG Emissions from Agriculture Sector for 1994-2004, Gg (CO2-equivalent)

According to the data of 2004, the most part of emissions were emitted by an intestinal fermentation animal – 80%, utilization of agricultural land – 19% and only 1% by cultivation of rice (Fig. 36).

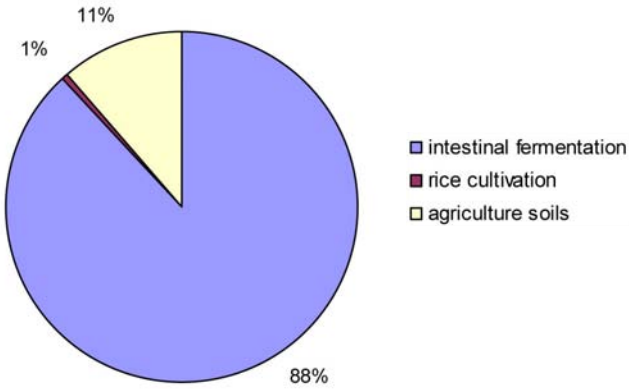


Fig. 36. GHG Emissions from sources of Agriculture sector, 2004

According to the data of 1994, the major part of GHG emissions in Agriculture sector belongs to the activity connected with livestock keeping (Fig.37).

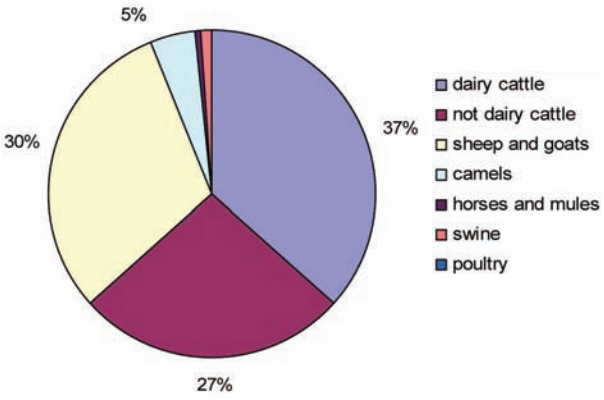


Fig. 37. GHG Emissions from Livestock for 1994

According to the data of 2004, GHG emissions from an intestinal fermentation have considerably decreased due to the change in livestock structure. The major part of emissions belongs to the activity related with dairy cattle breeding (31%), then sheep and goats (28), camels (23) and not dairy cattle (18), swine, horses and mules, as well poultry (less than 1%) (Fig. 38).

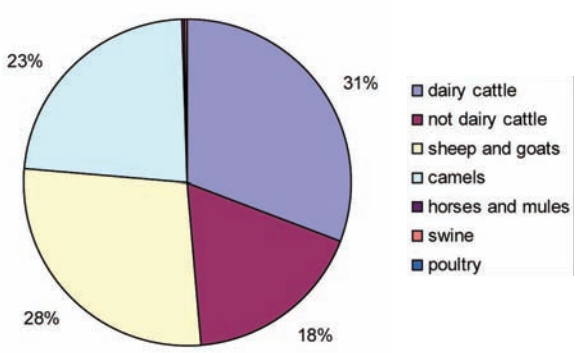


Fig. 38. GHG Emissions from Livestock for 2004

## 2.2.4. Land Use, Land Use Changes and Forestry (LULUCF)

The territory of Turkmenistan locates in a deserts zone with rather fragile ecosystems. The country possesses huge land and mineral resources (Fig.39). Therefore, the problem of rational use of nature and restoration of disturbed landscape productivity is priority issue.

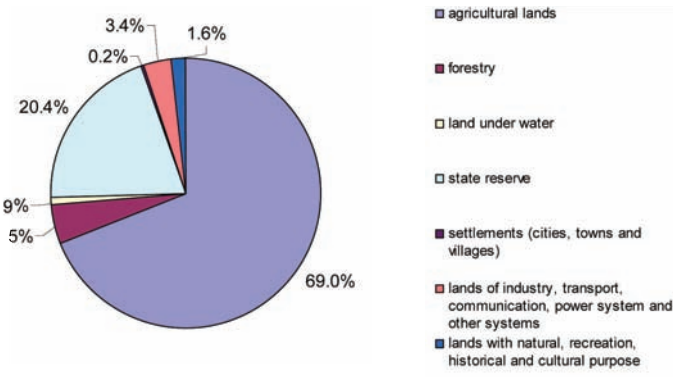


Fig. 39. Land-Use Categories in Turkmenistan

In extreme deserts conditions of Turkmenistan the vegetation, forest and plantings perform a protective function, preserve soil from deflation and erosion; serve as fodder and fuel, biological drainage, preserve settlements and agricultural fields from dry winds and dusty storms.

The afforestation and woodland restoration issues have been raised in the country since 30th of XX century, when the first forestry and nature reserves have been established.

Forests are one of the major components of environment and play the significant role in people life (Fig.40). Taking into account that data about forest state in Turkmenistan have become outdated, their inventory is necessary. Change in a total area of Forest Fund is caused by a transfer of forest to a long-term use by peasant associations for distant animal husbandry.

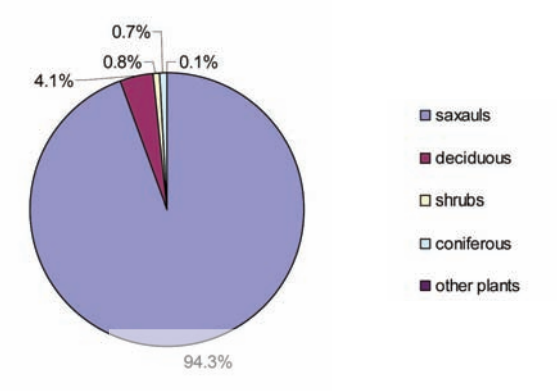


Fig. 40. Main forest types in Turkmenistan

GHG Inventory in Land Use and Land Use Change and Forestry sector (LULUCF) in Turkmenistan was conducted for the first time, and according to the new IPCC document "Good Practice Guidance for Land Use, Land-use Change and Forestry" (2003).

Though considerable errors in the given estimation which caused due to uncertainties in activity data and emission factor, the inventory has helped to estimate approximately volumes of GHG emissions and removals in this sector.

According to the abovementioned new IPCC guideline, change in carbon stocks, GHG emissions/removals was estimated for following three categories:

– Forest land remaining forest land ;
– Lands converted to forest lands ;
– Burnt biomass at fires.

Conducting the estimation of GHG emissions and removals from various sources, where it either accumulate or release, the carbon stock change was considered in above- and belowground living biomass.

On the whole in Turkmenistan the removals in LULUCF sector are approximately 800 Gg more than the emissions from this sector (Fig.41)

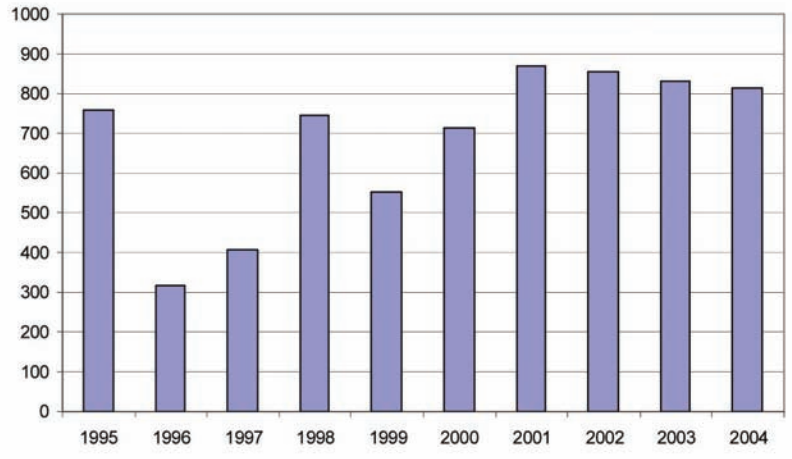


Fig. 41. CO2 accumulation in LULUCF, Gg

### 2.2.5. Waste

During the preparation of GHG Inventory in the given sector information about waste-water handling in large cities of Turkmenistan was not available; therefore the estimation was conducted only on data of solid waste disposal sites (Fig. 42).

Methane emissions in Waste sector from 1994 to 2004 have gradually increased and in 2004 they have almost exceeded level of 1994 by 59%. It was connected with population growth in the country since the accelerated rates of economic development have caused the improvement of social conditions of people life.

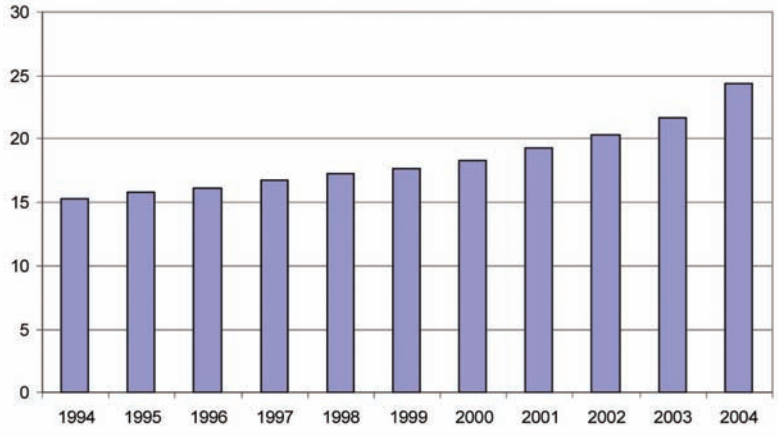


Fig. 42. Dynamics of methane emissions from solid waste disposal sites, Gg (CO2-equivalent)

## 2.3. Uncertainty Analysis

Within the framework of the preparation of the Second National Communication an attempt has been undertaken to perform the qualitative and quantitative uncertainty analysis. The comparison of emissions estimations was conducted by application of Tier 1 and Tier 2.

The analysis was done according to following documents: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories; and IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000).

When national uncertainty factors were absent, they were determined by the method on annual average emission factors according to the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000) and IPCC Guidelines for National Greenhouse Gas Inventories (2006). Concerning the uncertainty in activity data and emission factors in various sectors in different cases both qualitative and quantitative estimation have been done.

According to the uncertainty analysis on Tier 1 the uncertainty of total national emissions is equal to 28.51% from the estimated emissions sum. The uncertainty estimation was done for the emission sums of 34581.079 (1994) and 59955.096 (2004) Gg (CO2-equivalent).

## 2.4. Quality Assurance and Quality Control (QA/QC)

QA/QC procedure was conducted by experts (independent persons) and representatives of the various organisations (interested party) for each sector. In particular, accuracy of calculations was checked up by experts of the corresponding ministries and departments. Obtained results were discussed at the national workshops and expert meetings. Errors and typing mistakes in the text were eliminated.

## 2.5. Key sources analysis

The key sources analysis of greenhouse gas emissions allowed to reveal the major sources of GHG emissions, to distribute resources on priorities, to develop strategy on GHG emission reduction and to conduct their qualitative and quantitative assessment.

The key sources are those which constitute the major part of total GHG emissions in a CO2-equivalent. They should make up not less than 95% of total GHG emissions for the certain period.

According to GHG inventory for 2004, 10 key sources were revealed out of 42 analyzed sources. Their share is more than 95% in total GHG emissions.

Key emission sources (Appendix, table 7) - the enterprises of oil and gas, energy, agriculture and transport sectors. The essential GHG emissions (about 90%) occur in Energy sector from the fuel combustion, extraction, transportation and storage of oil and natural gas. With intensive agriculture development the amount of GHG emissions also increase here, which basically connected with livestock growth (3-4 times).

According to the outputs of National GHG Inventory the analysis of emissions trend in their time-series dynamics was done for 1994-2004. It allowed to determine the categories of sources which have tend different from the total emissions tendency (Appendix, Table 8).

# CHAPTER 3 CLIMATE CHANGE VULNERABILITY AND ADAPTATION ASSESSMENT

## 3.1. Climate of Turkmenistan

**Temperature regime.** High temperature variations are characterized by the most evident climate continentality during the year and per day. Despite the desert nature of the landscape, there are significant differences in climatic conditions between the northern and southern parts of the territory. The northern part, which includes Dashoguz Velayat, northern regions of Balkan and Lebap, located in the Siberian anticyclone area is characterized by severe long winters with stable frost and continuous snow cover. Summers in such regions are much shorter and less hot, with relatively even and low precipitation.

The southern part of the country is characterized by mild winters with occasional snow cover and frequent transitions from cold weather to positive values of air temperature. Conditions of warm periods are also various. Particularly the coastal zone of the Caspian Sea is recognized as having a milder climate.

During the whole year, the atmospheric circulation over the territory of Turkmenistan is characterized by frequent meridian processes. Although in the cold period of the year, they are seldom noticeable, during cold periods and interseasonal periods they become more distinguishable, and cause the weather to change followed by abrupt fall of temperature, strong winds, and precipitation. Affected by the invasion of cold continental air mass, relatively warm winters with little snow can become severe and harmful to heat-loving plants, although the cold periods last only for several days.

The differences in the temperature regime of the northern and southern territories are characterized by various conditions of atmospheric circulation in the cold and warm half-year. The relative severity of the winter period with low temperatures and infrequent thaw in the northern part of the territory is due to the progress of strong Siberian anticyclone and intensive radiation in clear anticyclone weather conditions. In the southern part of the territory, the winter temperature regime is considerably soft due to intensive cyclone activity in this period. Daily freezing weather usually does not last for a long time, only in the coldest winters, when the Siberian anticyclone is more active and subzero temperature remains for a long period. However, in such periods daily temperatures often become above zero under the significant radiation inflow.

Mean temperature in January varies from –1.6° in the west to 1.1°C in the east. Considerable short-range falls in temperature are possible up to –28°C in the east and up to –35°C in the north as well as the increase up to 12°–16° above zero. Under the average temperature of 31.4°C in July it may rise up to 40–45°C in some days. In the semi-arid zone atmospheric droughts and hot dry winds are most frequent.

The desert zone of the country is characterized by climate continentality and lack of precipitation. During the year evaporation exceeds precipitation 10 times greater; over the summer months – 20-70 times greater. In general, the climate of this zone is characterized by continuous hot summers, being cold for these latitudes winters, bigger annual and daily variations in temperature, higher air dryness and lower cloudiness.

Winds in the desert zone are weak with frequent calmness and dominant north-eastern winds. Daily wind course is typically continental: in the evenings and at nights calmness is dominated, in the daytime the wind is intensified by reaching its maximum in the afternoon.

The coldest month is January with mean air temperature varying from -3.2 to –4.8°C. At the same period, seldom temperature rise is possible up to 12–22°C during the coldest winters.

In the cold period of the year there is 60–84% of precipitation of its annual amount.

Dust storms are usually observed in the period of cold fronts.

Abnormal rise in air temperature is related to development of thermal stress.

In the warm period of the year it is likely to experience frequency of atmospheric droughts in dry and hot weather.

The winters are characterized by instability and variability of weather, particularly in the northern part of the desert, where subzero and above-zero temperatures are frequently shifted.

The summers in the desert are: long, hot and dry, the weather is stable and is recognized as dry, dusty and cloudy with high daily variations in temperature of air and soil. In the daytime, the soil surface may be heated up to 50°C and 78°C accordingly.

**Precipitation regime.** In the **northern** regions, where severe winters keep low temperatures, snow precipitation can be observed and the snow cover is stable. From June to September there is a lack of precipitation. In this period low precipitation is observed – from 2.5 to 5 mm. Precipitation in summer months is caused by cyclone activity when the level of convection reaches the level of condensation which is located at the altitude of 1.2-1.4 km. Precipitation in this part of the territory is also caused by a high level of the relative air humidity in the low troposphere layer.

Maximum amount of precipitation occurs in April (18.7 mm) and March (18.2 mm). Much of precipitation - 46.4% of the annual amount - falls in spring – from March to May. In the cold period of the year from October to February, precipitation occurs in the amount of 45.2% of the annual amount. In the warm period of the year there is low precipitation; its amount over the four months is 3.4 mm that is 8.4% of the annual amount.

In the east and south of the territory, precipitation regime is identified by invasion of the southern and western cyclones, the northern and north-western cold air mass. Maximum precipitation (64.3 mm) is observed in March. Much of precipitation is observed from December to April – 87.8% of the annual amount. In the transient period – from May to November – its amount constitutes for 10.1% of the annual amount. In the warm season, little precipitation is observed - less than 5.0 mm (1.9% of the annual amount) over 4 months.

The **western** zone belongs to the territory of Balkan Velayat. Maximum precipitation is observed in March (23 mm). Much of it is marked in autumn and spring periods (October - May) and is 86.5% of the annual amount. Low precipitation in the warm season occurs frequently – less than 19.7 mm that is 13.5% of the annual amount.

On the plain territory during the year, the maximum number of precipitation days is marked in the cold period. Maximum frequency of precipitation in the southern regions is marked in the second half of winter and in spring when the cyclone activity grows rapidly.

Much of precipitation mass falls at this period. In summer it becomes dry.

Mainly, on the desert territories precipitation events occur in the cold period of the year (5-8 days per each winter month); in summer, there is a small possibility of having them.

All **mountainous** regions are characterized by high frequency of precipitation during the entire year. It is often when rainfalls in the mountains cause mud torrents of a destructive power.

Most cases with heavy precipitation, having reached the criteria of "dangerous" and "force majeure" in all natural parts of Turkmenistan, are observed in the period from March to May. Heavy precipitation events are observed in the foothill areas. The number of days with precipitation greater than 20 mm in the foothill areas and the southern regions is 3–8; greater than 30 mm – about 3 days a year.

**Wind regime.** A wind regime is characterized by local barometric circulation regime and significantly changes when transiting from heat to cold.

In winter, desert zones of Turkmenistan have the north-eastern and eastern winds; their frequency is 38% of total number of observations in case of no calmness. It is typical for the desert and partly foothill areas of the southern parts of the country to have the north-western winds (up to 50%) along with low frequency of winds coming from other rhumbs. The Western Turkmenistan is recognized as the region with maximum frequency of the eastern and south-eastern winds, but there is no evident prevalence of one or another rhumb. It is associated with weak western ridge of the Siberian anticyclone and frequent cyclone occurrence from the south of the Caspian region and from the north-west.

Turkmenistan wind regime dramatically changes in the warm period. At this time it is typical for air mass to blow from the marginal northern latitudes of the continent to the central regions. Based on these conditions, Turkmenistan has the north-western, northern and north-eastern winds (their frequency is 35–55% of cases in July).

### 3.2. Climate scenarios

Regional climatic scenarios have been developed for Turkmenistan to assess possible climate change and its likely impacts as well as to develop adaptation measures and strategies for climate change to be prevented.

Recommended by IPCC and the National Communication Support Program (NCSP), a program MAGICC/SCENGEN version 4.1 has been used for the global and regional assessment of air temperature and precipitation amount.

Climatic scenarios have been developed for two scenarios of GHG emissions taking into account sulphate aerosols impact: A1FI – pessimistic (economic priorities) and B1 – optimistic (ecological priorities).

The SCENGEN version 4.1 database includes outputs of the 17 most developed Atmosphere/Ocean General Circulation Models (AOGCM). For plain territories of Turkmenistan experiments were performed on the accurate assessment of individual models. As a result, two AOGCM have been selected: Had300 and ECH498. Selected AOGCM outcomes were gridded to 5´5° degrees resolution. Mean climate sensitivity to GHG concentration increase in the atmosphere has been selected as well.

The region has been observed between 30° and 45° N and 50° and 70° E. This region fully covers the territory of Turkmenistan. Calculations were made for each month and season of the year. Mean value of climatic parameters was also defined for 2020, 2040, 2060, 2080 and 2100. Calculation results have provided with data on anticipated changes of air temperature and precipitation amount in the grid of 5´5°. Based on these data, after a long-term observation of 25 hydrometeorological stations of Turkmenistan, anticipated values of air temperature and precipitation amount were calculated by two-dimensional table interpolation method. Obtained values of climatic parameters have been used to estimate climate change vulnerability and impacts on different socio-economic sectors of Turkmenistan.

Being consistent with both scenarios (A1FI and B1), it is projected of atmospheric air temperature to rise over all the territory of Turkmenistan and precipitation to decrease. However, temperature and precipitation change rates as per A1FI scenario are much higher. Calculations show that by 2100 temperature is likely to increase to 2-3° (optimistic scenario) or to 6-7° (pessimistic scenario) in regard to base rate.

The following figures (Fig. 43) show changing of air temperature and annual precipitation for Ashgabat station according to two GHG emissions scenarios: A1FI and B1.

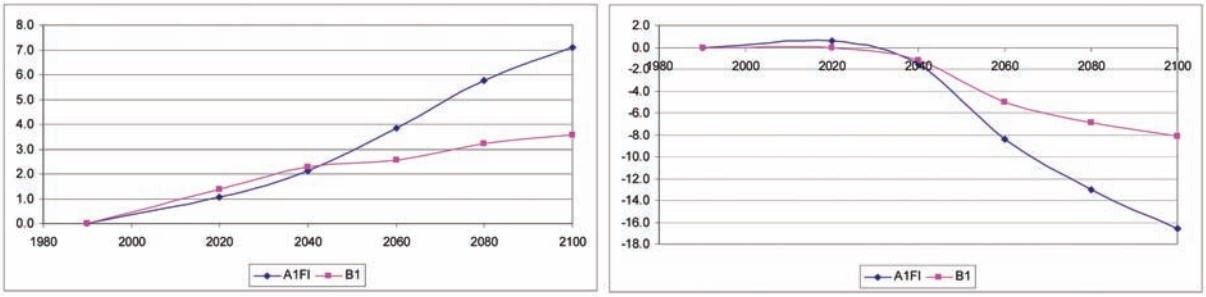


Fig.43. Annual average change of air temperature (°C) and precipitation amount (%) according to A1FI and B1scenarios for Ashgabat station

## 3.3. Climate change impact on key economy sectors

Estimated air temperature increase and annual precipitation decrease are projected to significantly affect the socio-economic development of the country in future. Mainly, it will affect activities of priority sectors of the country: human health sector, water management and agricultural sectors as well as coastal zone of the Caspian Sea.

It is of a high importance to highlight the impact of climate change on human health. Under the temperature increase of the environment, human body loses a large amount of moisture that causes a possibility of having a thermal shock.

In future, development of economy sectors and population growth is estimated to entail increase in consumption of water resources that are not in large amounts in Turkmenistan. Problems pertaining to possible climate change will affect activities of different economy sectors, especially the agriculture.

In the water balance of Turkmenistan, 90% of total volume of water resources belongs to the Amudarya river flow. As per estimations of experts of the Republic of Uzbekistan, the Amudarya flow may decrease to 10–15%, and it can affect the total volume of the water resources of Turkmenistan. Climate change may lead to local rivers flow decrease. As a matter of fact, a single failure in irrigation of cotton will lead to its yield decline by 4–6%. Consequently, income of agriculture and its related branches (refining industry) will be decreased as well as living conditions for people.

Due to scarcity of irrigated water, it is projected of degradation of arable lands

(intensive soil salinization and all types of soil erosion) and decrease and degradation of natural grasslands. Decline in pastures productivity will lead to decline in sheep-breeding production (meat and wool production will decline).

The Caspian Sea and coastal zones of Turkmenistan play a vital role in the sustainable development of the country. There is a big number of climate change assessments of future changes of the Caspian Sea level; however, due to lack of objected data about climate change and impossibility to evaluate water consumption dynamics in the basin, all projections are at high level of uncertainty. Scientific researches based on a short-term perspective agree that increased humidity in the Caspian Sea basin will remain the same in the near future and its level will be from –26.0 to –25.0 abs. m.

Climatic models, considering the water demand increase in the main river basins flowing into the sea, show that mainly the Caspian Sea level is likely to rise in the first half of the 21st century. Estimations of the river flow variation, actual evaporation in the Caspian basin under climate change impact and water demand volume show with 0.1% probability (once in 1000 years) that double concentration of $CO_2$ may cause the Caspian Sea level rise up to 1.0÷4.7 m.

Therefore, the Caspian Sea level may rise by 5 m till the mark –22 m relative to present conditions (about –27.0 m) as a result of climate change expected in the middle of the 21st century. Under these conditions chances of the Caspian Sea level rise to –25.0 m is likely to gradually grow considering projected water demand in the Caspian basin.

### 3.3.1. Water economy

Total volume of water resources of Turkmenistan is evaluated as 25 $km^3$ per average annual water content and it is generated from the surface flow of the Amudarya, Murgab, Tejen, Etrek Rivers, shallow waters of the north-eastern Kopetdag mountain slopes and small volume of ground and collector-drainage waters. 22 billion $m^3$ (88%) of the total volume of surface water belongs to the Amudarya River; the remained part belongs to the Murgab River – 1.631 billion $m^3$ (6.5%), the Tejen River – 0.869 (3.5%), the Etrek, Sumbar and Chandir Rivers – 0.354 and small rivers – 0.15 billion $m^3$ (0.6%) (Fig. 44).

The Garagum River plays a vital role in gathering and allocating the water resources. At present, its length is more than 1,300 km. The area of lands irrigated by the Garagum water is more than 1 million ha. Its water intake is located on the left bank of the Amudarya near the Mukra settlement. The annual main Garagum intake as per stated limit is 11.6 billion $m^3$. There are 115 of hydrotechnical facilities, 32 transport facilities and 3 water reservoirs with total capacity of 2.4 billion $m^3$ built along the Garagum River.

There are 130 ground water sites found on the territory of the country that at present time are partially used for household water needs. Cumulative selection of ground waters varies by year in the range of 470–670 million $m^3$/year. In addition, more than 45% of its volume is used for household water supply, about 30% - for irrigation, the remained part – for other needs (watering pastures, balneology).

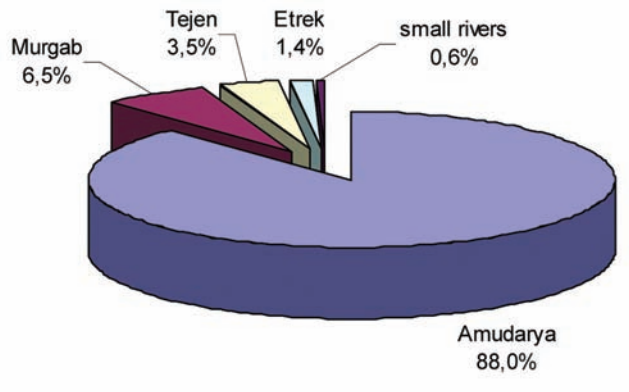


Fig.44. Surface waters of Turkmenistan

In Turkmenistan the established ground water reserves in total are 3.4 million $m^3$/day, explored – 6, and projected – 9 million $m^3$/day.

In the water balance, 2.0–2.5% of ground waters is used.

According to categories, consuming water is allocated in the following way: 91.2% of the total volume – agriculture; 6.3 – industry; 1.9 – domestic needs; 0.1 – fish industry and 0.6% – other needs.

**Current risk and vulnerability.** All rivers of Turkmenistan, except for shallow streams of the north-eastern Kopetdag slopes, are transboundary - surface waters are mainly formed beyond the country borders.

At present time almost all regions of the country are facing water resource deficit which is clearly noticeable in Dashoguz and Balkan velayats. One of the main reasons for this is the irrational use of water resources. Common reasons of this problem may be periodic shallowness of streams, big water loss, low efficiency ratio of irrigation systems, imperfection of irrigation techniques for crops and water resources record system, scarcity of efficient water saving mechanism and superfluous water resources for irrigation farming development, insufficiency of irrigated land planning.

For population needs, along with surface runoff sources, ground fresh waters are used being generated in the mountains of the Kopetdag, Bolshoy Balhan, Koitendag, in the foothill area, on the river valleys and along the waterways of great irrigation channels (due to riverbed loss). Fresh ground waters of high quality are irrationally allocated over the territory of the country. Balkan and Akhal velayats are in a big shortage of freshwater. Drinking water scarcity in Dashoguz Velayat (downstream of Amudarya) is caused not only by its shortage but also by its quality.

The rivers of Turkmenistan have increased mineralization (more than 400–1000 mg/L).

The Amudarya waters reach the territory of Turkmenistan being polluted. In Turkmenistan, it is dumped more than 4 billion $м^3$ of collector-drainage waters average mineralization of which is 2.3 (from the Uzbek side – 6.5–8.5 g/L). Total mineralization increases in the downstream and is 2200 mg/L in the Birat cross section.

Other waterways of Turkmenistan are characterized as friendly ecological meeting the water supply needs.

Data analysis according to A1FI and B1 scenarios show a possible increase of air temperature and decrease of precipitation.

*Table 1*

**Annual average air temperature according to A1FI and B1 scenarios, ˚C**

| Name of town | 1961–1990 | 2020 | | 2040 | | 2060 | | 2080 | | 2100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A1FI | B1 | A1FI | B1 | A1FI | B1 | A1FI | B1 | A1FI | B1 |
| Ashgabat | 16.4 | 17.5 | 17.8 | 18.5 | 18.7 | 20.3 | 19.0 | 22.2 | 19.6 | 23.5 | 20.0 |
| Bayram-Ali | 16.6 | 17.6 | 18.0 | 18.7 | 18.9 | 20.4 | 19.1 | 22.3 | 19.8 | 23.6 | 20.2 |
| Turkmenabat | 15.5 | 16.6 | 16.9 | 17.6 | 17.8 | 19.4 | 18.1 | 21.3 | 18.8 | 22.7 | 19.1 |
| Kone-Urgench | 12.0 | 13.1 | 13.3 | 14.2 | 14.3 | 16.0 | 14.6 | 17.9 | 15.3 | 19.3 | 15.6 |
| Serdar | 16.1 | 17.2 | 17.5 | 18.2 | 18.4 | 19.9 | 18.6 | 21.8 | 19.3 | 23.1 | 19.6 |

*Table 2*

**Annual precipitation according to A1FI and B1 scenarios, mm/year**

| Name of town | 1961–1990 | 2020 | | 2040 | | 2060 | | 2080 | | 2100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A1FI | B1 | A1FI | B1 | A1FI | B1 | A1FI | B1 | A1FI | B1 |
| Ashgabat | 242 | 243 | 242 | 238 | 239 | 221 | 230 | 210 | 225 | 202 | 222 |
| Bayram-Ali | 183 | 189 | 185 | 187 | 182 | 167 | 171 | 154 | 164 | 146 | 159 |
| Turkmenabat | 130 | 135 | 132 | 134 | 130 | 122 | 124 | 115 | 119 | 110 | 117 |
| Kone-Urgench | 118 | 119 | 119 | 117 | 117 | 110 | 113 | 105 | 111 | 102 | 110 |
| Serdar | 206 | 206 | 205 | 202 | 203 | 191 | 197 | 183 | 194 | 178 | 192 |

Altering of these parameters directly affects the water economy. Mainly, its vulnerability will be noticeable in decreasing of the flow and changing of the hydrograph of rivers.

Major factors of climate change impact on the water management are discharge of water in the rivers and accordingly, availability of the water resources as well as their allocation per economy sectors.

Studies show that temperature increase and precipitation decrease mainly will lead to total volume decrease of available water resources. As agriculture is a major water consumer in Turkmenistan, it is projected of a possible alteration of rivers flow and their hydrograph, especially flow decrease during vegetation period. This situation is becoming more pressing when it comes to a necessity of irrigation rates increasing that will entail temperature rise and transpiration increase.

Alteration of local rivers flow is estimated based on two scenarios of possible climate change and the actual data of the river catchments using regression and correlation method. The obtained results show that the annual flow of the Tejen, Murgab and Etrek rivers is likely to decrease to 5–8%. It is highly important to note that their actual flow decrease will be observed in the vegetation period.

According to SNC on climate change of the Republic of Uzbekistan, in connection to possible climate change the Amudarya water content may decrease to 10–15%.

At present the arable land of Turkmenistan is 1,696 thousand ha, and water limit for irrigation is 21,264 million $m^3$. Hence, 12.5 thousand $m^3$ (gross) is a share per 1 ha of arable land. Provided that arable land reaches 2 million ha by 2030, in accordance with Turkmenistan's policy plans, water demand for irrigation shall be about 25 $km^3$ in the event

of not conducting the adaptation measures. Turkmenistan does not have such volume of water resources; therefore, it sets conditions for necessity of conducting preventive adaptation measures.

**Water economy adaptive capacity of Turkmenistan and climate change adaptation measures.** Decrease in water resources due to possible climate change and also increased water demand for stabilizing and even increasing the scope of agricultural production stipulates to review methods of irrigation water use and to increase irrigation systems productivity by modernizing them.

Accordingly, at present time under Water Management Development Conception of Turkmenistan till 2030, there was given a priority to the water sector capacity that will enable to conduct adaptation measures to prevent climate change. The primary adaptation measures are the following:

- Improvement of the water management (transferring to integrated water management – IWM);
- Optimization of agricultural production arrangement for providing the country with necessary agricultural production, and minimization of water resources use;
- Conduction of measures enable to increase efficiency ratio of irrigation systems;
- Innovation of irrigation advanced techniques (drip, micro-spray) and enhancement of existed ones (traditional);
- Realization of irrigated land complex reconstruction (ILCR);
- Conduction of measures on used land reclamation improvement (ULRI);
- Construction of additional water reservoirs;
- Reconstruction of present and construction of new hydrotechnical sites providing water loss decrease and rational water use, etc.;
- Realization of selective works on developing drought-tolerant crops.

Under anticipated climate change, irrigation water deficit can be recovered by realization of the following adaptation measures:

*Table 3*

**Adaptation measures for recovering water deficit**

| Measure | Recover, million m³ |
|---|---|
| Irrigated land complex reconstruction for area of 280 thousand ha | 700 |
| Used irrigated land improvement for area of 400 thousand ha | 750÷800 |
| Application of advanced irrigation techniques (drip, micro-spray, siphon and tube using, etc.) | 1800 |
| Using low-mineralized collector-drainage water | 3500 |
| Using refined domestic sewage water | 300 |
| Using ground water | 400 |
| **Total** | **7450÷7500** |

However, to provide sustainable development of the water management of Turkmenistan under the climate change, it is necessary to prepare precise National Action Plan on Adaptation to Climate Change along with a list of concrete activities, deadlines of their conduction and their realization costs assessment.

### 3.3.2. Agriculture

**Sector conditions.** The agriculture of Turkmenistan plays a vital role in the economy of the country. In the last few years, 18-20% of agricultural share contributes to GDP and total volume of gross production in 2005 was more than 20 trillion manat including a crop sector – 8 (about 40%) and an animal breeding sector – more than 12 trillion manat (more than 60%) (Fig. 45).

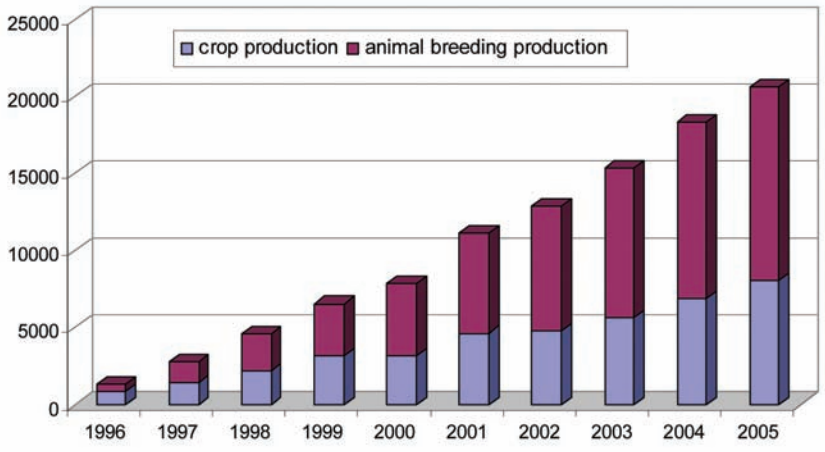


Fig.45. Agriculture GDP cost, billion manat

In 2009 total irrigated area was about 1.7 million ha. In 2005, Turkmenistan produced about 737.9 thousand tonnes of cotton and more than 3.1 million tonnes of wheat. According to the Program of Development till 2030, the country is aimed to make the irrigated area reach to 2.0 million ha.

**Climate change impact on the Agriculture sector, current risk and vulnerability.**

At present time favorable climatic conditions of Turkmenistan enable to grow cotton, cereals, vegetable, fruits, grapes, forage crops almost over all the territory of Turkmenistan; subtropical crops such as olives, pomegranates, persimmons, etc. – in the south-west.

Projected climate change in Turkmenistan will directly affect the following:

- Irrigation water demand due to transpiration intensity;
- Irrigated land reclamation;
- Agricultural crop yield;
- Vegetation period of plants, etc.

According to the agricultural regionalization of the territory of Turkmenistan, three natural climatic zones – the Kopetdag and Murgab, the downstream Amudarya and the middle-stream Amudarya were studied to determine climate change impact on provided indicators of the agricultural production.

Data analysis has enabled to determine changes of physiological demands of plants in water considering their yield capacity. These calculations have been made for major agricultural crops – cotton, wheat, lucerne, and vegetables.

*Table 4*

**Water demand of crops**

| Month | Fact | | Projection | | Balance (+ -), $m^3$/ha |
|---|---|---|---|---|---|
| | Monthly average t, °C | Irrigation rate, $m^3$/ha | Monthly average t, °C | Irrigation rate, $m^3$/ha | |
| **Vegetation period** | | | | | |
| April | 16.9 | 239 | 17.1 | 320.5 | 81.7 |
| May | 23.1 | 605 | 24.6 | 958.5 | 353.4 |
| June | 28.5 | 905 | 29.6 | 1150.2 | 245.2 |
| July | 30.9 | 1072 | 32.1 | 1176.8 | 105.3 |
| August | 28.7 | 1488 | 30.1 | 1158.9 | -329.1 |
| September | 23.1 | 1083 | 25.0 | 980.3 | -102.3 |
| October | 15.3 | 161 | 16.3 | 231.7 | 70.7 |
| **Total** | | **5552** | | **5,977** | **425** |
| **Non-vegetation period** | | | | | |
| January | 2.2 | 323 | 3.1 | 372.3 | 49.2 |
| February | 4.0 | 467 | 5.0 | 400.0 | -66.7 |
| March | 9.6 | 521 | 10.4 | 552.6 | 32.0 |
| November | 9.8 | 287 | 10.7 | 563.4 | 276.2 |
| December | 4.4 | 197 | 5.3 | 405.4 | 208.0 |
| **Total per period** | | **1795** | | **2294** | **499** |
| ***TOTAL*** | | **7347** | | **8271** | **924** |

*Table 5*

**Water demand of crops**

| | Fact, $m^3$/ha | Projection, $m^3$/ha |
|---|---|---|
| Kopetdag and Murgab | 7347 | 8271 |
| Downstream Amudarya | 5510 | 6203 |
| Middle-stream Amudarya | 6025 | 6782 |

Data provided above show that the water demand of plants is likely to increase by 2020 to 13%. Similar case is observed for all crops in all irrigated zones.

Thus, the water demand for irrigation is projected to grow.

*Table 6*

**Water demand growth of the agricultural crops according to A1F1 and B1 scenarios, % of the actual water demand**

| | 2020 | | 2040 | | 2060 | | 2080 | | 2100 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Cotton | 12.6 | 15.0 | 19.1 | 20.5 | 27.5 | 21.4 | 34.8 | 25.4 | 37.7 | 27.4 |
| Wheat | 4.2 | 5.3 | 7.9 | 8.4 | 13.1 | 9.2 | 17.9 | 11.4 | 20.5 | 12.3 |
| Lucerne | 3.8 | 5.0 | 7.9 | 8.4 | 14.8 | 9.7 | 22.2 | 12.3 | 27.5 | 13.6 |
| Vegetables | 9.5 | 12.0 | 19.7 | 20.4 | 35.9 | 23.4 | 53.4 | 29.3 | 66.0 | 32.1 |

To create favorable conditions for plants growing, a high priority is given to factors that, firstly, relate to natural climatic conditions of crop productivity zones; secondly, timely and high-quality implementation of all field works (tillage, fertilizing, planting, care, harvesting).

In this case we had a look on major agricultural crop factors (temperature regime and moisture demand) affecting vulnerability of the agriculture and water management of Turkmenistan under possible climate change.

Climate change may dramatically alter present reclamation conditions of used lands for agricultural production. With temperature increase, evaporation and transpiration will grow and this will cause irrigation rate increase demand. Expected precipitation decrease is even more alarming, as it will cause the river flow decrease of Murgab, Tejen and Etrek.

Based on long-term measurements of monthly average air temperature (1961–1990) at 5 stations (Ashgabat, Bayram-Ali, Kone-Urgench, Turkmenabat, Serdar), a composition year was modeled with consistent degrees. A number of days with critical air temperature (for cotton – more than 40°C) was determined, that directly affects decrease in yield. It is important to consider the duration of this period. If critical air temperature remains for 1-2 days, it is likely to avoid actual loss of crops.

When projecting development of such branch as cereals production (winter wheat), it is necessary to take into account that adverse impact of high temperature may vastly be noticeable in the period of sprouting and bushing out. Here, crop reverse correlation is tracked with temperatures more than +10°C. In compliance with this, it will be relevant to perform planting activities in the earlier period.

The estimation shows that the expected warming will positively affect growth and development of plants.

Assessment of possible distribution of daily air temperature indicates that critical air temperature period is possible in any of the regions; however, its possibility does not exceed 1%.

In addition, the most important factors were determined for the agricultural production:

- Increase of days with temperature more than 35°C during springs and more than 40°C – during summers;
- Accumulated effective temperatures.

The estimation has showed that two provided above factors do not cause concern in the aspect of having a negative impact on the agricultural production. The number of days with critical air temperature does not exceed allowable value and a possibility of having these days is quite low. The accumulated effective temperatures are increasing. This allows drawing a conclusion that climate change is not likely to negatively affect the agricultural production; moreover, to some extent it can be favorable (earlier planting and maybe minor decrease of vegetation days).

A bigger concern falls on the probability of the water volume reduction. It has been mentioned above that the irrigation water demand is projected to significantly grow due to enlargement of the irrigated area. However, it is necessary to consider two aspects.

Firstly, data analysis as per both scenarios A1FI and B1 provides possible air temperature rise and precipitation decrease that will directly affect the river flow volume and hydrograph.

Secondly, assumed climate change is projected to induce evapotranspiration increase and is likely to set conditions for increase of the irrigation rates. Particular attention shall be given to grassland vulnerability under climate change. Firstly, it is possible that pastures may reduce their productivity resulting in the induced livestock decrease. Secondly, it may entail a sheep productivity decrease (meat, wool, animal yield).

Assessment of climate change and its impact on the grasslands has showed their productivity to be declined in future. Despite a sufficient resistance of plants to drought and heat, it has been 1-2 years over the decade when drought has been observed in the desert followed by the grassland productivity decline. Soil drought is caused by water reserve decrease in the soil (0÷20-santimetric layer) to 4 mm.

Assessment of accumulated annual precipitation and moisture deficit shows that according to the observed scenarios, the climate change-induced grassland productivity may decline to 10–15%. It will be reflected in moisture stock decrease in the soil of 0÷20 cm layer. However, supplying additional grasslands with water and conducting complex measures on grasslands protection and recovering will enable to avoid in total decrease of used grasslands and consequently sheep-breeding will not decline.

Complex measures on the grassland protection and recovering shall include:

- Conduction of phyto-reclamation of lands;
- Planting (for the grassland protection) forage woody-bushed plants – kandym (*Callidonum setosum*), saxaul (*Halaxsilon persicum*), chogon (*Salsola sudaphyla*), saltwort (*Salsola richteri*), etc.);
- Introduction and accurate grassland rotation.

**The agriculture adaptive capacity and adaptation measures.** Alteration of separate climate components and their impact on irrigated farming activities (agriculture and water management) enable to determine trends and measures to be realized and detailed from the aspect of their components.

First of all it relates to irrigation regime of the agricultural crops that should be adapted to anticipated change of climatic conditions: daily average air temperature, evaporation, root layer condition, etc. This requires reviewing of irrigation dates and separate irrigation rates. Moreover, it is important to consider conditions defining irrigation rate value due to planned increase of the agricultural crop yield.

Along with this it is necessary to review a set of major crops in regard to their drought resistance, vegetation period duration, yield, irrigation water demand. These measures are to be conducted on the base of existing cultivars due to new ones attracted from outside but complying with abovementioned conditions and also due to intensity of selective works on new cultivars development.

The water resource decrease along with the water demand increase, to stabilize and even increase scope of the agricultural production, cause a need to review irrigation water use methods, increase irrigation system productivity due to their enhancement.

Performed studies have enabled to determine required set of measures on decrease and elimination of negative and stress situations caused by natural phenomena in the foreseeable future.

A set of such measures includes timely provision of irrigation water in the needed amount, water-salt balance control of irrigated lands, that will entail necessity to transfer lands from medium and high-saline soil categories to free-saline and low-saline soil category by complex reconstruction and the used irrigated land reclamation. Along with this, it is now necessary to start implementing measures on the agriculture and water management adaptation to new conditions to enable all agricultural and water management parameters comply with new climatic conditions in the estimated timing level.

To provide sustainable functioning of the agriculture under climate change, it is necessary to enable efficiency ratio of irrigation systems to reach 0.68÷0.70 by 2020-2030, and weighted average irrigation rate to decrease by not less than 10%. Moreover, it is necessary to attract additional water resources - the collector-drainage waters, ground freshwater and refined domestic sewage water to recover water resource deficit in the agricultural sector.

A list of primary measures on the agricultural adaptation to climate change shall include:

- Improvement of selective works on drought-resistant and high-yielding variety development of major agricultural crops;
- Optimization of the agricultural crop content and production places with purpose to minimize water resource consumption;
- Defining ways to increase efficiency ratio of irrigation systems (conduction of antifiltration activities in the canals and reservoirs);
- Introduction of the advanced irrigation techniques (micro -spray, drip-feed irrigation);
- Improving economic interrelations between the state and water consumers;

- Usage of low-mineralized collector-drainage water in the places of its generation;
- Usage of collector-drainage water along the collectors falling into Turkmen Lake of the Golden Century, etc.

As it was stated above, a set of measures on the grassland protection and recovering shall include the following:

- Conduction of phyto-land-reclamation works;
- Planting forage woody-bushed plants (kandym, saxaul, chogon, saltwort, etc.) to protect the grasslands;
- Introduction and accurate grassland rotation.

### 3.3.3. Human Health

Climate and weather conditions have always a strong influence on human health and well-being. Climate change can have a direct effect on a human (heat stress effect, death/injures during flood and storms) and an indirect effect (through active zone changing of disease vectors, such as mosquitoes, pathogenic microbes transmitted through water, water and air quality, food products availability and quality). Factual health-related consequences will be affected by local environmental and socio-economic conditions as well as a number of measures on social, institutional, technological and behavior adaptation that will be approved with object to reduce number of threats for the human health.

Potential climate change impact assessment for the human health is an important issue in the fundamental consideration of measures on reduction of GHG emissions and issues of social adaptation to climate change.

Observing climate change impact on the human health in Turkmenistan is quite challenging. The reason for this is an abrupt increase of population life standards and a rapid development of the state health care system. These and other factors of the human development lead to improvement of the human health. With this background it is difficult to identify a climate role impact on human health.

According to official data, total morbidity indicator of Turkmenistan's population has declined over the last decade from 35738.9 to 23256.8 per one hundred thousand people (Fig. 46). Morbidity of children, accordingly, has declined from 40546.2 to 26845.6 per one hundred thousand. The infant mortality over this period has declined from 42.2 to 12.1 per one thousand of children, and maternal mortality – from 99.5 to 15.5 per one hundred thousand of live-born children. The average life expectancy has increased from 64.7 to 71. There is a big progress in preventing certain diseases. Cases with respiratory disease have declined from 14106.4 to 8547.8 (Fig. 47); nervous system disease – from 1653.1 to 782.2; digestive system disease – from 3750.2 to 2162 (Fig. 48); acute intestinal infections – from 377.9 to 139.3; viral hepatitis – from 413.5 to 68.3 (per 100 thousand of people). Over the last years, in Turkmenistan cases with poliomyelitis, pertussis, tetanus and rabies have not been registered. Turkmenistan has accepted WHO declaration about malaria killing till 2015; national program on prevention of this disease was developed and approved. As a matter of fact, cardiovascular and oncologic diseases are the major reasons of mortality among adults in Turkmenistan.

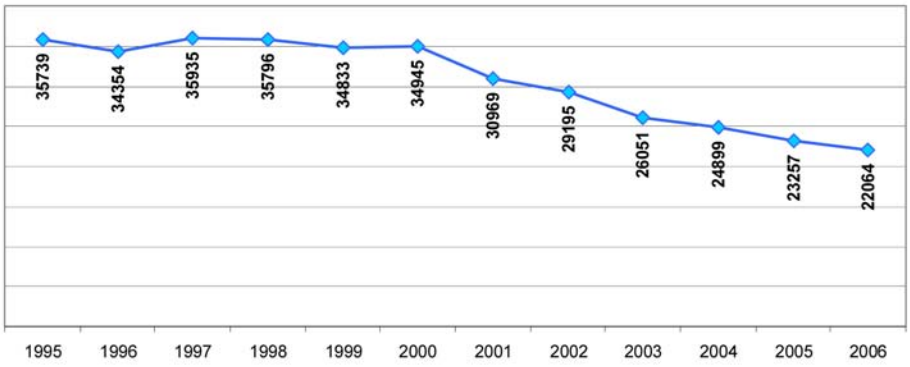


Fig.46. Total morbidity of population of Turkmenistan (per 100 thousand of people)

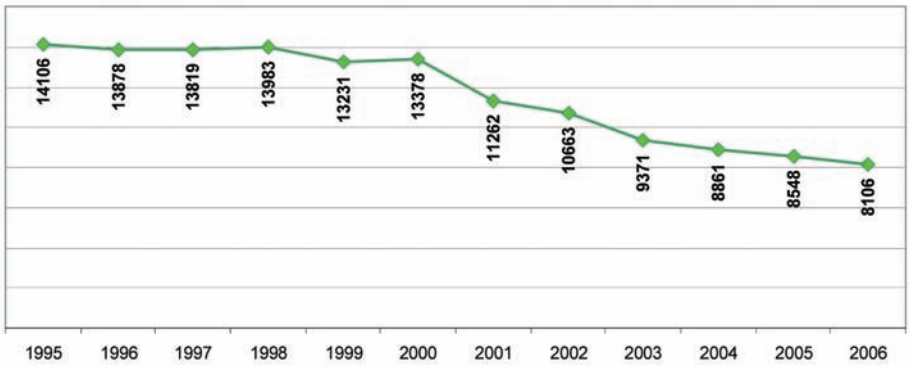


Fig.47. Respiratory morbidity (per 100 thousand people)

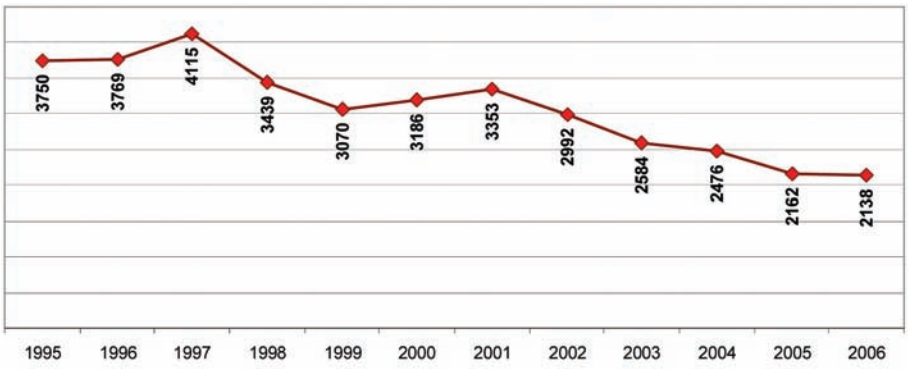


Fig.48. Digestive system morbidity (per 100 thousand of people)

One of the climate change impacts is increase of days with abnormally high temperature. In Turkmenistan under climatic-geographical conditions, high temperature along with solar insolation are the major meteorological factors causing a relative extremality. Summers in our country are recognized as hot dry weather lasting for 5 months – from May to September. These days are very hot with daily mean temperature from +22.5°C and more, and relative mean humidity – below 60%. According to data of Hydrometeorological Service of Turkmenistan, in the hottest days the temperature sometimes reaches 50°C in the shadow, and 60÷65°C under the sun. Turkmenistan among CIS countries registers soil surface absolute maximum temperatures (+77°C). In summer, the temperature of sand in the Garagum reaches 80°C. The number of hot days is projected to increase under the global warming. As per preliminary estimations, conducted under the preparation of the Second

National Communication of Turkmenistan on climate change, using MAGICC-SCENGEN program on two different scenarios, annual average temperature in Ashgabat is likely to increase to 3.575÷7.081°C by the end of the present century. Additionally, the annual average precipitation is likely to decrease to 8.1÷16.6% over this period.

Thus, severe climatic conditions may stipulate a significant stress of homeostatic systems of a human body and development of adaptive changes in the functioning of physiological systems.

Under the climatic conditions of Turkmenistan, the most frequent consequences are the following:

1. Poor health conditions caused by extreme weather conditions;
2. Poor health conditions caused by air pollution;
3. Water-borne diseases and diseases transmitted through food;
4. Transmissible diseases and diseases transmitted via rodents;
5. Mental, nutritional, infectious and other disorders.

Long-range studies of experts of the Institute of Arid Zone Experimental Pathology and physiology of the Academy of Sciences in Turkmenistan (currently is called Scientific and Clinical Physiology Center) as well as analysis of updated literature data allow to state that long staying and working under extremely high air temperature and intensive solar radiation are followed by deep morphofunctional changes in the human body. These intensive changes are of an evident seasonal nature and enable to keep a certain level of workability during the whole year including 5 hot summer months. Heat stipulates in the human body development of summer functional level in the physiological systems work aimed, first of all, to keep temperature homeostasis. However, under constant often daily high temperature of environment, human body heat exchange causes an extreme stress of heat-control systems that leads to developing of acute hyperthermia. In addition, it is essential to note that it is quite possible to reduce adverse heat effect by technology means, rational use of labor and leisure time, thirst quenching drinks as well as other methods. However, even under these conditions it's possible to have a chronic body overheating.

**Adaptative capacity and adaptation measures.** Humankind had to adapt to a hot climate since a long time and has empirically developed a series of behavioral responses and hygienic activities. They are characterized by housing and working facility constructions, laboring regime, compulsory water treatments, diet (increase of vegetable and protein food in the diet and decrease of fat, drinking tonic and vitamin drinks), clothes and headdress peculiarities, landscape building and changing the environment (planting, hydrotechnical constructions) and etc.

In addition, nowadays it is necessary to further conduct scientific studies on hot climate effects on healthy and diseased human body, investigation of rational physiologic and hygienic methods and working condition improvement means, methods of human workability increase consequently as well as labor productivity with no harm for health under tough climatic conditions of arid zone.

Physiological prevention methods from body overheating shall include specific effects aimed to increase heat tolerance ability of a human body or its acceleration to thermo-adaptation. They, mainly, include advance physical training and artificial heat adaptation and re-adaptation. Among heat prevention measures, a great emphasis is taken to a rational drinking regime and diet, drinking thirst quenching and tonic drinks (protein and vitamin containing drinks, vitamin green tea, yandack, mint with green tea decoction, cherry drinks), oxygenoprophylaxis, and wearing protection clothes. While determining a laboring and leisure regime under adverse microclimate (increased temperature), a number of issues are solved: duration of a working shift, time restrictions of staying in such conditions, setting

leisure time during a working shift, its rational use, shift works regulation and their flexible schedule (early start of work, evening shift) and etc.

Providing proper healthcare system and being able to undertake preventive responses, conducting early public awareness and informing as well as providing recommendations to public will facilitate decrease of adverse impacts.

**Vulnerability of diseased people to climate change in Turkmenistan. Climate change impact on disease emergence, course and outcome.** Climate and weather changes have an adverse impact on people with cardiovascular, lung diseases, pathology of bones and joist, perinatal pathology.

Cardiovascular, lung and bronchi diseases mainly affect people suffering from heat stress which is most probably related to potassium decrease in the cardiac muscle and increase of water vapor partial pressure of air that leads to decreasing of other gas pressure including oxygen as well.

People especially with cardiovascular diseases are affected by extreme heat. Relation of the clinical course of hypertensia, ischemic heart diseases (IHD), stenokardia, and other cardiovascular diseases to weather, its dynamics, and variations of individual meteorological factors is so evident that this problem has been solved for many years not only by cardiologists but also highly experienced physicians. Credible reverse correlation dependence has been identified between systolic pressure level, during essential hypertension, and atmospheric pressure value. People over 45 years old tend to die from IHD under high temperature effect. It is evident that the number of cardiovascular disease morbidity and mortality caused by heat stroke are likely to grow.

It is necessary also to underline cases with acute respiratory diseases and pneumonia of people living in facilities with air-conditioning during hot seasons (so called "air-conditioning" pneumonia). The increase of frequency cases of having bronchial asthma in the beginning of a summer can be connected to the increase of air allergen concentration in the atmospheric air.

Among digestive diseases, weather change most evidently affects the course of gastric ulcer and duodenum/chronic gastroduodenitis. Meteorotropic responses of some people make a disease progressive which is followed by emergence or intensity of pains in the pylorogastroduodenal, epigastric, right subcostal areas and development of dyspepsic phenomena. But, the meteorotropic responses of many people become apparent through vegetative symptomatology.

Increased temperature is an initiating agent for neuropsychic diseases. The most sensitive to weather conditions and climate change are people with neurocirculatory dystonia. In most cases, these people complain of a weakness, indisposition, unpleasant feelings in the heart zone, heart beating, short breath, dizziness, headache, sweating, emotional liability, high or low blood pressure.

**Climate change-related adaptive capacity improvement measures of the healthcare sector of Turkmenistan.** The data provided above have demonstrated that the effect of major climatic factors (high temperature and increased

solar radiation level), under climatic-geographical conditions of Turkmenistan, stimulates a development of morpho-functional changes in healthy and especially in diseased human bodies that in certain conditions may lead to having impaired health. It is reasonable to note that adaptation issues and disadaptation abnormalities in the human body under hot climate are normal, and under pathology they are still haven't been properly studied. Therefore, developing such issues is of an important aspect and shall be investigated and discussed by many specialists working in social spheres, political scientists, climatologists, hygienists and practical physicians of different areas.

In the upcoming years, under the plan of preparation to global climate change, specialists of Turkmenistan working in the area of medical climatology will have to solve the following tasks:

1. Preparation of the National Report on climate change impact on the human health assessment.
2. Assessment of high temperature on the human health in different country regions based on data analysis of monthly and daily mortality and frequency of visiting clinics.
3. Defining population groups that are more likely vulnerable to diseases due to climate change. Identifying of probable emergence of these abnormalities, obtaining expert evaluation on their number, identifying groups at a high risk, building indicators for projecting climatic impact on human health.
4. Development of prevention programs for climate change adverse effects reduction.
5. Development of new treatment methods for a host of diseases which become more progressive under affection of climate factors.
6. Investigating more rational physiologic and hygienic working conditions and developing methods of labor productivity with no harm to health under tough climatic conditions of arid zone considering decline in workability under high external temperature effect, insolation and workload.
7. Development of concrete recommendations on different aspects of population adaptation to extreme changes of weather conditions.
8. Creating database on climate change impacts on human health, possible implications and developing prevention measures for high risk groups.

### 3.3.4 Caspian Sea basin in Turkmenistan

The Caspian Sea on the territory of Turkmenistan is located in Balkan Velayat which is the largest area in the country (139.28 thousand $km^2$). The Balkan Velayat is situated in the west of Turkmenistan and occupies the Eastern coast of the Caspian Sea, the Etrek river basin, the Kurendag Mountains, the western Kopetdag and the western end of the Garagum desert.

The climate here is dry and continental. The Caspian Sea breeze has a mitigating effect on the narrow coastal belt. Winters in the north are cold and in the south – mild. Balkan Velayat is rich for raw material resources. They include oil, gas and other different raw materials for chemical production and building materials industry. In addition, Balkan Velayat is monopolist on variety of mineral wealth in Turkmenistan. This is why the region has been industrially developed.

Balkan Velayat shares about 25% of industrial production of Turkmenistan that is the highest level in the country. As compared to 2000, the industrial production scope of the region has double increased.

Fish industry in the economy of Turkmenistan doesn't play so important role. However, the fishing is intensively developed in the Caspian region. Thus, in 2005 industrial association "Balkanbalik" share was 94% of the total fishing according to State Committee of Fishing Industry.

The Caspian Sea is the largest closed lake in the world. Its level is much lower than the level of the world ocean. At present it is about –26.5 abs. m. The total Caspian coast length is almost 7,000 km; the coastline on the territory of Turkmenistan – 1,200 km.

**Current Caspian Sea level.** Systematic observations of the Caspian Sea began in 1837. In the second half of the 19th century, the annual average values of the Caspian Sea level were marked from –26 to –25.5 abs. m and had a tendency to decline. This tendency continued in the 20th century. From 1929 to 1941 the sea level vastly declined (almost for 2 m: from –25.88 to –27.84). Afterwards, it continued to fall and having declined to about 1.2 m, in 1977 it reached the lowest over the observational period mark (–29.01 abs. m) Later the sea level has begun to notably increase and having risen up to 2.35 m by 1995, it reached – 26.66 abs. m. In the following 4 years the average sea level had declined almost to 30 cm, having reached –27.00 abs. m in 1999.

In the following years there weren't any certain changes in the sea level, only insignificant increase or decrease was observed. Over 2000–2006 the average sea level was more or less stable and in 2006 it was –26.5 abs. m.

Long-range alteration of the sea level can be illustrated based on instrumental long-term observation of the Turkmenbashi station (Fig. 49).

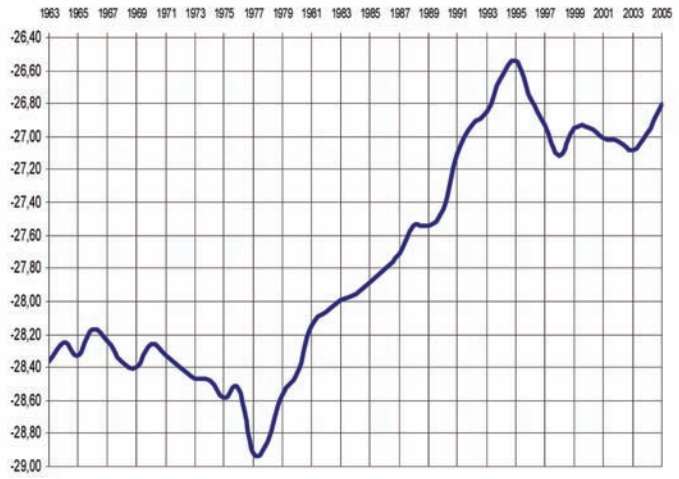


Fig.49. The Caspian Sea level change according to Turkmenbashi station observations

**Caspian Sea level variation causes.** Current studies of the Caspian Sea level variation causes are aimed mainly for development of two concepts – geological and climatic.

Among most of studies the key task is to work out the water balance equitation and analysis of its components.

The Caspian water balance analysis shows that the major defining factor for all evident changes of the Caspian level (fall in the 30's of the 20th century and in 1971-1977, rise – in 1978-1995) is cumulated inflow of the rivers into the sea that also greatly depends on climatic indicators of the catchment basin of these rivers. The major inflow of the Caspian Sea is the Volga River. Along with the river inflow, long-term sea level variations are affected by precipitation and evaporation, but their impact is less significant.

**Climate change impact on the Caspian Sea water balance.** Possible change projections in the annual volume of the Volga River inflow to the Caspian Sea for different climate change scenarios performed using a water balance model have showed that by the middle of the 21st century it is likely to have annual inflow increment of the Volga to 5-10% (Fig. 50).

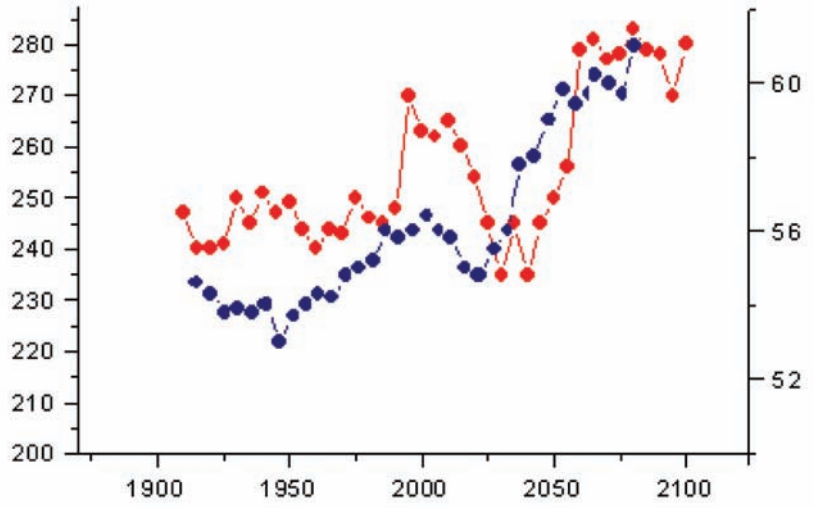


Fig.50. Actual and projected indicators of the Volga annual inflow ($km^3$/year) and precipitation level (cm/year)

General circulation model-based estimations have identified small changes in precipitation level of the Caspian Sea basin: from 4-8 to 52 mm, changes in the annual average evaporation volume with regard to changes in the air temperature – 180–239 mm. In this case, the actual evaporation (evaporation minus precipitation) may increase to 158–243 mm under anthropogenic climate change.

At present, there are many of the Caspian Sea level change assessments with future projections; however, due to lack of credible climate projection and impossibility to provide definite evaluation of water consuming dynamics in the basin, all projections are of a great uncertainty.

In terms of projecting for a short-term period, scientists conclude that increased humidity in the Caspian basin will remain unchanged in the nearest future and the sea level will be in the rage of –26.0 to –25.0 abs. m.

At the end of the 21st century, the sea level is projected to be from –20 to –45 abs. m according to two scenarios. Only two models project the sea level rise – CNRM-CM3 (A2 and A1b) and CSIRO-MK3 (for A2). CNRM-CM3 model, projecting the sea level rise to 5 m, provides the greatest value of evaporation decrease from the sea surface (–30%). CSIRO-MK3 model, which also projects a slight sea level increase, provides with negative values of the surface evaporation. The greatest sea level fall which is up to 20 m by the end of the 21st century is projected by MIROC3 model based on a vast evaporation increase in the Caspian basin.

The national experts have constructed climatic scenarios for Balkan Velayat based on the greenhouse gas emissions scenarios A1FI and B1 by the MAGICC/SCENGEN complex program.

Analysis of expected air temperature has almost the same positive departure from the basic temperature at the observed stations for both scenarios until 2020 and more evident increase of the annual average temperature for A1FI scenario until 2060.

Precipitation model values, estimated as per two scenarios for 2020 and 2060, are similar in meaning to climatic data of 1960–1990 basic period under a slight negative departure from the basic values.

Based on HadCM2, CGCM1, ECHAM models, scientists have obtained assessment of future climate change for the Caspian region by 2050. All three models provide evidence for temperature rise and the sea surface evaporation rise by 2050 in the Caspian zone

of Turkmenistan; in addition, the ECHAM model is projecting a slight change in the air temperature to 3.4°C.

The assessment results of the sea surface evaporation change vary in values for all models. Thus, the HadCM2 model shows only a slight evaporation increase in the Caspian basin of Turkmenistan whereas the ECHAM model projects a significant increase of the evaporation ratio.

**Assessment of natural resources and the region economy vulnerability to climate change.** The Caspian Sea has unique in the world reserves of sturgeon fish; its water area is actively used for bioresources farming and development. The Caspian shallow waters provide a great place for nesting, wintering and swimming birds stay during their flight. The main part of the Turkmenbashi Bay is on the territory of Khazar, natural reserve opened in 1932. Almost 85% of total reserve area is occupied by water and 15% - by land. Protection of migratory birds wintering here is the major tasks of the reserve. Birds fly to the bay as it is shallow and its bottom is covered with vegetation which is a source of feeding for them. Among all birds inhabiting along the eastern coast of the Caspian Sea, 80% of them stay for winter in the reserve for a period of 5 or 6 months. There are more than 10 million species that migrate and about 500 thousand species constantly dwelling in the reserve. The reserve is inhabited by many species of birds and animals some of which are endemics and are under protection.

The climate of the Caspian Sea has an evident influence on the biodiversity of the whole region. The atmospheric precipitation availability is followed by an active growth of vegetation facilitating increase of representatives of fauna. And vice versa, long droughts stimulate abrupt decrease of species and being consistent with anthropogenic factor (overgrazing) are followed by desert land degradation. As air moisture decreases, condensation moisture formation in the sand areas decreases as well that worsens delivery of ground waters and providing the desert vegetation with moisture.

It is difficult to foreseen climate change impacts on the biodiversity of the Caspian Sea due to lack of specific models. If the climate of the region becomes hotter and drier due to precipitation decrease in the river basin, a swampland area is likely to decrease with a limit in flow and increase in evaporation. This, consequently, will cause decrease of areals, possible spotted salinization increase and food chain alteration. If the climate becomes more humid and cooler, there is a chance for increasing pollutants coming to the Caspian Sea as a result of the sea level rise and polluted land flooding as well as from rivers (for similar reasons).

According to projections of some climatic models, the climate of the Southern Caspian zone will be hotter and drier, the Northern – more humid and colder especially in the Volga catchment basin. Ice cap changes of the Northern Caspian zone will negatively affect a population of seals as reproduction pattern may change as well. Changes in water temperature in all Caspian zone may dramatically impact on phytoplakton productivity and species predominance. Climate change and other factors can cause algae flowering. This will influence all plankton-feeders first of all zooplankton and then pelagic fish species, such as sprat. Even slight changes in the sea level may cause serious changes in benthic communities of the shallow and coastal zones. Decrease of the benthic invertebrates at this zone will negatively affect a population of sandpipers and other species inhabiting the coastal shallow waters.

The sea transgression may seriously harm flora and fauna of the Caspian area. As a result of the coastal zone flooding, the sea can be polluted with oil products, pesticides and other toxic substances having a toxic effect on hard roe, larva and fry, spawning area and destroying a nutritive base. As a consequence, sturgeon population and other valuable fish species can decrease in number.

The Caspian Sea level rise-induced flooding of the large coastal zone has already caused the economic and social damage. A sudden increase of the Caspian Sea level has put many settlements, industrial and cultural facilities in a risk for further existence.

Assessment studies of the sea level rise impacts on socio-economic conditions have been conducted in the framework of the Caspian Ecological Program. Potentially flooded regions were projected according to three assumed stages of the sea level rise: (–26.0 m), +2m (–25.0 m) and +5m (–22.0 m).

Compared to other Caspian countries, possible sea level rise impact on the population and agriculture of the coastal zone of Turkmenistan is rather small. Almost all the territory of the Western Turkmenistan is occupied by deserts due to dry climate and this is the reason why such important land use types as non-irrigated and irrigated lands and gardens are not developed. Deserts, except for the coastline of 1035 km length, are useless for settling and living. The sea level rise to 5 m may flood a village Chikishlar (Esenguli region in the south of Turkmenistan) with population of about 1258 (2001 data).

The most negative consequences of the possible sea level rise may be reflected on Khazar peninsula (former Cheleken) in the middle of the coast of Turkmenistan. If the sea level rises to 5 m, present Khazar peninsula may be flooded by the waters from the bays: the Turkmenbashi Bay – from the north and the Turkmen Bay – from the south. Nevertheless, Khazar town would not be flooded but the peninsula itself may become an island separated from the continent by about 2 km long sea channel.

Over the last decade Western Turkmenistan has become one of the industrially developed centers of the country. The industrial facilities mainly in the oil and gas sectors are located in the cities of Balkanabat, Khazar, Turkmenbashi, Garabogaz (Bekdash), and Gumdag. The sea level rise may cause flooding of oil and gas pipelines that were extended to and along the coast, and oil and gas production may be followed by soil pollution on the Khazar and Ekerem coasts.

**Climate change adaptation.** The President of Turkmenistan has established several decrees such as "On measures on ecological fundamental improvements of the Caspian Sea basin" (1991), "On water supply improvements for Balkan and Lebap settlements" (1995), to improve ecological and prophylactic-epidemiological conditions of the Caspian zone and provide favorable conditions for living.

**Recommended measures for reducing climate change adverse impacts.** Solving socio-economic and ecological problems related to climate change in the Caspian basin and as a consequence to the sea level variations, requires a proper up-to-date preparation. Some of the problems are long-term and require big financial and material costs. Nevertheless, to mitigate extreme cases which can occur during a short period, it is necessary to conduct measures in advance based on the analysis of possible scenarios of climatic conditions and consequences change.

The Caspian Sea level rise-related measures must follow these goals:

- Prevention of contaminants drop to the sea from flooded facilities;
- Protection of the most important coastal facilities.

In order to prevent the coastal infrastructure damage, it is necessary to conduct measures on protecting the following major socio-economic facilities:

- Balkanabat – Khazar highway and the roads extending to the center and around the Esenguli etrap
- Sea port of Turkmenbashi;
- Living facilities at Chikishlar, Esenguli and in other small settlements;
- Freshwater basins of the Etrek river (mainly for fish breeding);

- Freshwater plant at Esenguli;
- Industrial facilities located on the coast, mainly oil and gas facilities.

The sea level drop is likely to cause a lot of serious problems stipulated by the coastline removal from port constructions and other communications related to sea transportations. In order to be prepared to solve these problems related to the Caspian Sea level drop, it is recommended that the following short- and long-term measures are conducted:

- Preparation of the port constructions for possible coastline removal;
- Preparation of drilling units to be operated on the sea shelf under new c.onditions

**Recommendations for future studies on adaptation.** Activities conducted under the Caspian Ecology Program and preparation of the Second National Communication of Turkmenistan on UNFCCC have initiated assessment works of potential damage related to a sudden sea level rise due to climate change but there are difficulties and gaps to obtain this information.

For sustainable development of the coastal zone of Turkmenistan due to climate change, the following activities are offered:

- Construct scenarios of developing events under the sea level change for a middle-term period (25-30 years) considering international and regional knowledge of experts on climate change impact;
- Perform economic evaluation of possible damage as per each scenario including environmental, cultural and domestic damage;
- Study knowledge and works of international projects on adaptation measures development for bays and ports; develop conceptual models and plans on selected area adaptation on the Caspian coast of Turkmenistan.

As it has been mentioned, among different sea level change factors, there is a climatic background. According to data of Intergovernmental Panel on Climate Change (IPCC), the average global sea level in the last century rose to 10–20 cm. Speeding rate of such increase is 1-2 mm per year that is 10 times more than it was observed during the last 3000 years. Being consistent with IPCC, the average sea level will rise to 9–88 cm by 2100 that will be stimulated by fresh water inflow due to melting of glaciers and ice cap. Thus, the Caspian Sea will have an additional flow due to global warming. The present level of the sea is dependent on the water balance components change; therefore, at present time it is essential to consider also global climatic changes while projecting changes in the water regime. This will enable to ensure present plans of the Caspian zone development, and also, develop measures on adaptation and mitigation of adverse climate change impacts.

# CHAPTER 4. ASSESSMENT OF MEASURES TO MITIGATE CLIMATE CHANGE

## 4.1. Current energy use tendencies

In Turkmenistan, as a result of the real sector development and the demographic growth, there has been formed the upward tendency in using of fuel-energy resources.

In 2000, according to the experts' assessment, the use of primary and secondary energy resources made 19.8 million tons in oil equivalent. In 2007, this value rose to 30.4 million tons or 1.5 fold.

In 2000-2007, the growth of fuel-energy resources (FER) accounted for 148.7%. In 2007, the share of internal use accounted for 39% of total FER output, in 2000 - 38%. Thus, despite the intensive growth in FER use by the domestic market, the FER production remained to be export-oriented. At the same time, just due to increase of gas export there was provided around 90% of accretion of absolute volume of the energy resources export. The share of crude oil accounted for 3%, oil products - 6.7%, electric power - 0.3%.

Over the period under review, the domestic use of oil increased notably (152%), mainly owing to upgrading of Turkmenbashi Refinery producing light-oil products of European standard. In 2007, the share of oil in the internal use accounted for 49.5%, in 2000 - 29%. The larger portion of oil products was exported.

Gas fuel is most important in the structure of FER consumption. In 2007, it accounted for 58.5% of total energy use, or 1.6 fold growth against the level of 2000.

The main reason of gas use growing was the 44% increase of electric power production, as the natural gas as the most environmentally safe fuel of primary energy resources was used in electricity production. In 2007, over 13% of produced electric power was exported.

In spite of absolute growth in FER use, the GDP energy intensity index at PPP lowered by nearly 30% in 2007, compared to 2000 and accounted for 0.51 toe/US$. This result was based on advanced dynamics of 2.3 growth of GDP at PPP.

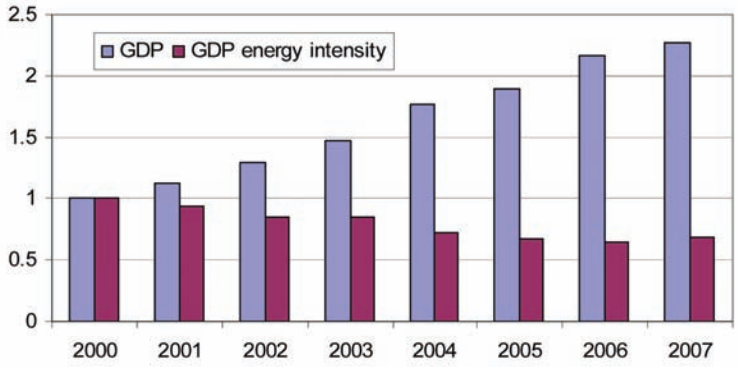


Fig.51. Dynamics of GDP production and GDP energy intensity in relation to the level of 2000

Due to notable decline in GDP energy intensity index at PPP, the favorable indicator of average annual energy use elasticity accounted for 0.51 in 2000-2007.

In 2000-2007, the end use of energy increased more moderately than the general energy use. In 2007, without taking into consideration the losses of primary and secondary energy resources in transporting networks, as well as resources used as a raw material for production processes, 13793.2 thousand toe of FER was consumed in the socioeconomic sphere of Turkmenistan. Compared to 2000, the volume of FER use increased by 22%. In 2000, the share of end use of energy in the total energy volume accounted for 57%, while in

2007 - 45.3%. This decline was mainly connected with high growth in crude oil refined into various types of oil products with higher value added.

The most intensive consumer of FER in the real sector is the industrial production, its share accounted for 37% of primary and secondary energy resources consumed in 2007.

The households are the biggest consumer of FER in the country. In 2007, its share in end use of FER was 38.5%. The positive moment was the move to reduction of this indicator by 41.6% compared to level of 2000.

For the agriculture, FER consumption accounted for 11.7% of the final consumption volume, construction - 1.5%, transport - 8%, other branches - 3.6%.

The share of **gas** in the end use pattern of FER was about 74% in 2007. Gas consumption increased by 19% within 7 years. The industrial production consumed 44.5% of gas, households - 45.1%. In 2007, the gas consumption by industrial production increased by 29%, households - by 7%, compared to 2000. In industrial production gas consumption 80-85% fell to power engineering.

Higher growth rate of gas consumption (145%) formed in the agriculture, mainly due to intensive development of vegetable growing and animal breeding at private farms (greenhouses, heat for cattle-farm buildings). In 2007, the share of the agriculture in total gas consumption accounted for 5%.

The share of motor fuel – **gasoline -** in FER consumption of Turkmenistan accounted for 11% in 2007. Over 7 years, gas consumption increased by 57%. The major gasoline consumers were the transport, agriculture and households – 29%, 26% and 32.5 %, accordingly.

Consumption of **diesel fuel** accounted for 9% of FER consumption in 2007. The main consumers of diesel fuel were agriculture - 40%, transport - 47% and construction - 8%. In 2007, the higher growth rate of the fuel consumption - 176%, compared to 2000, formed in the transport branch, mainly due to booming growth of the economy and expansion of transit transportations through Turkmenistan. The growth of freight turnover accounted for 144 %.

In 2007, end use of **electric power** increased by 38% compared to 2000. Its share in FER consumption was 7%. The major consumer of electric power was the industry that consumed 37% of this secondary energy carrier. The highest growth rates of electricity use accounted for 158%, in the agriculture, mainly due to intensive construction of residential buildings in rural areas and growth of entrepreneurial activity within the households. The total electricity volume used in the agriculture included the productive and non-productive use. People in cities and towns consumed 20% of total used electric power, including lightning in human settlements. In 2007, the share of households in the end use of electric power accounted for over 30%.

*Table 7*

**Electricity demand and supply balance, million kW**

| Balance | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| Generation | 9943.4 | 10614.3 | 10707.2 | 1092.0 | 12054.2 | 12936.7 | 13883.4 | 14771.9 |
| Import | … | … | … | 184.1 | 0.4 | 0.4 | 0.4 | 0.3 |
| Consumption | 8014.5 | 8238.5 | 8769.3 | 8898 | 9301.1 | 9926.7 | 10397.1 | 10871.9 |
| *Industry* | 3445.5 | 3664.2 | 3766.4 | 3903.6 | 4040.3 | 4124.5 | 4309.2 | 4039.8 |
| *Construction* | 106.8 | 110.7 | 217.9 | 178.8 | 238.7 | 226.2 | 187.4 | 220.4 |
| *Municipal services* | 1563.9 | 1520.5 | 1795.4 | 1622.2 | 1697.6 | 1976.9 | 2184 | 2250.6 |
| *Agriculture* | 1818.4 | 1867 | 1975.2 | 2139.1 | 2096.8 | 2293.9 | 2411.6 | 2679.4 |
| *Transport* | 284.8 | 252.7 | 391.8 | 374.8 | 424.9 | 511.7 | 503.7 | 724.4 |
| *Other* | 795.1 | 823.4 | 622.6 | 679.5 | 802.8 | 793.5 | 801.2 | 957.3 |
| Losses | 1035.3 | 1313.6 | 1279.9 | 1504.5 | 1605.7 | 1690.9 | 1878.5 | 2031.2 |
| Export | 893.6 | 1062.2 | 658 | 701.6 | 1147.8 | 1319.5 | 1608.2 | 1869.1 |

The growth of electric power consumption induced the increase of $CO_2$ emission. However, due to high economic growth there formed the downward trend of the carbon intensity indicator.

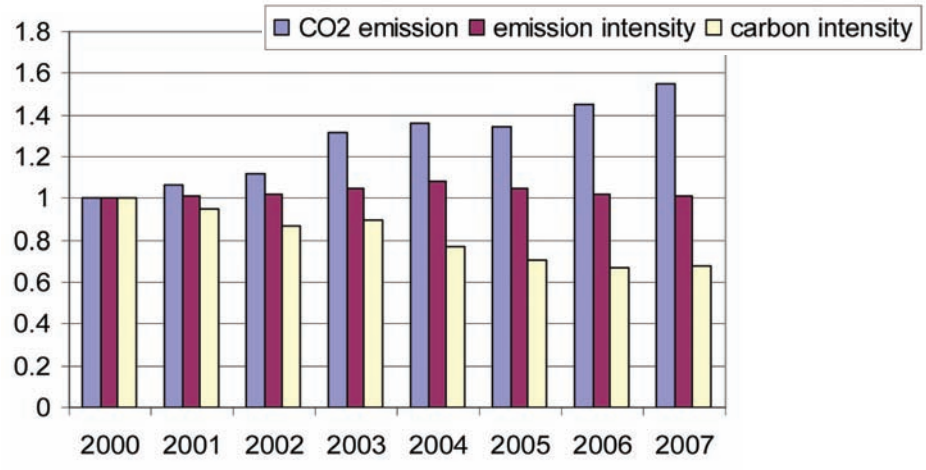


Fig.52. Dynamics of $CO_2$ emission, emission intensity and carbon intensity compared to 2000

## 4.2. Modeling of energy use until 2030

### *4.2.1. General assumptions*

The energy use volumes in Turkmenistan until 2030 have been estimated by two scenarios of the economy development – moderate (reference scenario) and innovative-active.

**The first (moderate) scenario** contemplates increase in use of energy resources according to the needs of social and economic development of the country, while ***the* second (innovative-active) scenario** is oriented on energy conservation in all economic branches and in social sphere based on establishing the legislative framework in the country to develop and realize necessary measures.

The macroeconomic forecast under the first scenario was made in view of new approaches to management in the socioeconomic sphere of the country in 2007-2008. This new course was connected with high growth of the economic potential of Turkmenistan based on market reforms and structural transformations in the economy.

Within the period under review, a big number of national projects were launched, agreements on participation in interstate projects were concluded and course on market reforms deepening was declared. Present-day realities created the need to update the National Program "Strategy of economic, political and social development in Turkmenistan until 2020" (2003). Also, a national strategy of President of Turkmenistan on new revival and radical reforms until 2030 was at the stage of development.

Currently, the average annual growth rate of real GDP is estimated as 8-9% per year for the period of 2008-2030. The other guiding line of development of the country is the expansion of non-state sector of the economy that should occupy 70% of GDP by 2030.

The guidelines of socioeconomic development of Turkmenistan until 2030 involve also the target programs, large-scale national projects, revised and new laws, regulatory acts and programs. The following documents are a part of them:

1. The development program of the oil-and-gas complex in Turkmenistan until 2030 (2006). It envisages a rapid growth in extraction and refining of oil, production of gas and development of diversified routes for gas export to the world market.

2. The national program of President of Turkmenistan on improvement of social and living conditions in rural areas, settlements, towns of etraps (administrative districts) and in etrap centers until 2020 (2007). Along with large-scale construction projects in the social sphere the program stipulates the construction of power transmission lines, roads, lines of communication, water and gas pipelines, sewerage network. The economic development of the regions will be a prerequisite in developing their productive forces.
3. The state plan of development and rehabilitation of the construction complex in Turkmenistan for the period of 2008-2010. It assumes growth in productive potential of the domestic construction industry and industry of construction materials to reduce in future the share of import of construction services of foreign companies as well as of construction material the production of which from local mineral resources is quite possible.
4. The revised laws of Turkmenistan "About foreign investments" (2007) and "About hydrocarbon resources" (2008). These legal documents stipulate expanding of privileges and guarantees for foreign investors.

The Conception of industrial-innovative development of Turkmenistan is being developed now. Upon approval of this Conception, there will be developed a program defining a legislative model of national innovative system establishment.

The future of the economy of Turkmenistan is also determined with a number of other projects:

1. Construction of the transnational railway "North-South" to connect Turkmenistan with European countries, Russia and Kazakhstan and to open the gates towards Persian Gulf. The construction started in territory of Turkmenistan in 2008 in view of advantageous geographic-economic opportunities of Turkmenistan. The project stipulates upgrading of the transport logistics for the export and import freight traffic in order to expand advantageous transit transportations.
2. Construction of Trans-Afghan gas pipeline designed for supply of 33 billion $m^3$. Afghanistan, Pakistan and India as well as many other countries are interested in the project. The leading partners in developing the project feasibility study are the Asian Development Bank and the UK Company "Penspen".
3. Creation of Trans-Caspian route to deliver natural gas from Turkmenistan to Europe.

In the downstream industries the course is set for rapid increase of technological potential of the chemical industry and the industry of construction materials. Development of oil refining, cotton-processing and food production complexes continues to be of high priority, with deepening of diversification of product mix. Hence, in the industry, the branch and production components are expanding as a natural result of achievement of a higher economic potential of the country. The process is based on combination of the export-oriented and import-substitution directions.

Current realities and new directions of development of Turkmenistan show that the country has entered the phase of active complex management of natural resources, which is characteristic for the developing countries for achievement of higher industrialization level (ground and water resources, minerals, biological diversity, recreational resources, geographical closeness to developed countries, etc.). The process is undoubtedly connected with intensification of market relations, i.e. with movement to prevalence of non-government sector in the production of goods and services.

As a rule, the economic growth in developing countries depends on the position of industrial branches. The experts' assessment based on branch selective trends in development of industrial production allows to project that in 2020-2025 the main types of

non-hydrocarbon raw materials including hydro-minerals from the brine of Duzlybogazgol Gulf will be actively involved in the industrial turnover. Additionally, the main volume of non-foods produced by the agricultural sector will be processed into finished products. The gas-chemical branch will enter a new stage of development that assumes production of wide range of secondary energy carriers, including the environmentally safe fuel types. The time period after 2025 is envisaged as the completion of a production-branch structure in the industrial sector up to organic integrity between the available hydrocarbon/non-hydrocarbon resources and the level of output with additional value added. At the same time, by 2030-2035 the growth opportunities for the industrial export-oriented model based on the advantages of natural potential of the country will come to end.

From the experience of the developed countries it is clear that development of the manufacturing sector (industry, agriculture, construction) is followed by advance growth of the whole service sector of the economy representing transport, communication, finances, retail and wholesale trade, health services, education, science, scientific services and tourism. In this connection, in a long-term period, there may be expected further change of the GDP structure expressed in declining of a share of the manufacturing sector and increasing of the non-productive sector. In such situation, the national innovative system begins to form as a primary factor to support high rates of the economy development and stability in conditions of globalization and cyclic world crises of overproduction. In this regard, the education system development course being formed in Turkmenistan and the drafting of documents on industrial-innovative development are aimed at preparing for the change of stages of socioeconomic development until 2030.

Progressive development of the economy of Turkmenistan with changes in branch proportions will liquidate in future its dependence on price fluctuations at world energy market. In this regard the title "moderate" of the first scenario is correct only in relation to the second "innovative-active" scenario. Given the energy efficient technologies and equipment of the fifth and sixth technological levels are already imported from the developed countries to Turkmenistan the first scenario also has the features of energy conservation development. The main distinction of the second scenario is the imperative energy conservation development in all social and economic spheres assuming a shift from the moderate evolutionary process to impetuous energy efficient development.

### 4.2.2. Moderate scenario

According to experts' estimations, the average annual growth of GDP at PPP in Turkmenistan will account for 5.9% in 2007-2030. The economy growth will post 8.4 fold compared to 2000. In 2030, the GDP at PPP per capita will account for US$30 thousand, the level of the developed countries (Annex, Table 9).

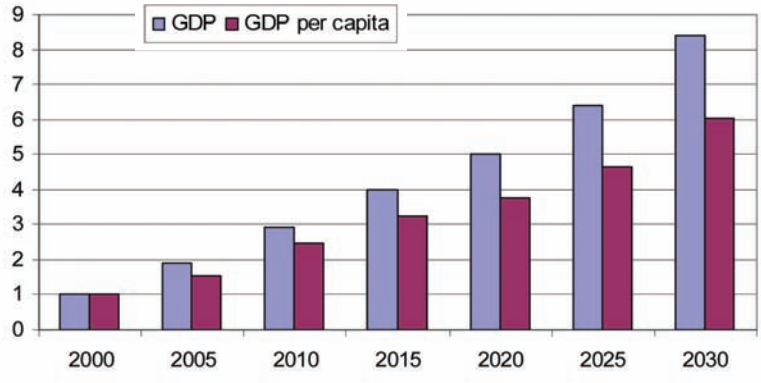


Fig.53. Dynamics of GDP and GDP per capita compared to 2000

By the end of the forecasting period there will emerge the parity of manufacturing and service sectors in the economy structure (Annex, Table 10).

Despite intensive development of the manufacturing sector, agricultural production, construction and service branches, the oil-and-gas complex will continue to play a leading role in the economy. According to the oil-and-gas complex development program until 2030, the extraction of natural fuel resources will make 319125 thousand tons in oil equivalent by 2030, or will rise 4.6fold compared to 2007. In 2030, the amount of oil extraction will increase 11fold, gas extraction - 3.5 fold. Such high rates of oil extraction are based on rich resource potential and anticipated large investments (including foreign investments).

The program stipulates large-scale development of the oil refining industry. In 2030, the refined oil volume will increase 4.8 times compared to 2007.

To preserve the energy independence of the country the 3.4 fold increase in electric power generation is assumed.

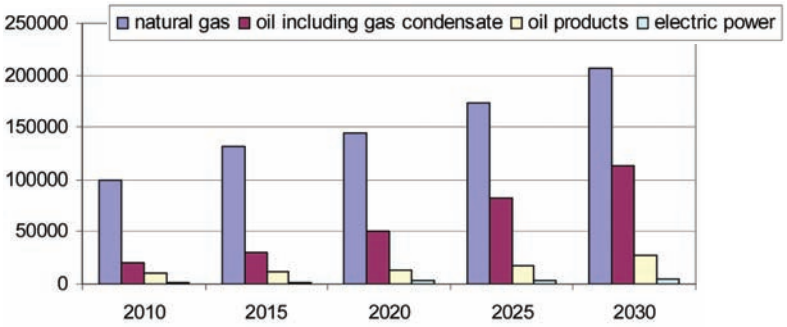


Fig.54. Production of main fuel and energy resources, thousand toe

Total volume of primary and secondary energy sources produced by 2030 will make for 351720.5 thousand tons in oil equivalent or 4.5 fold increase compared to 2007. The production pattern by energy carrier types will change significantly. In 2030, the share of crude oil use will increase to 32% compared to 12% in 2007, and the share of gas will decrease to 59% compared with 71%.

In 2030, the use of primary and secondary energy sources will equal to 85513.8 thousand toe, that is 2.8 times higher compared to 2007.

The orientation on manufacture of products with high value added in the fuel complex will condition the increase in future of oil refining share in total domestic consumption of energy resources. In 2030, it will account for 46% compared to 29% in 2007. Such tendency is the peculiarity of development of the national economy aimed at using the rich hydrocarbon potential. In 2030, the oil refining share in the volume of absolute growth of domestic energy consumption will exceed 55%.

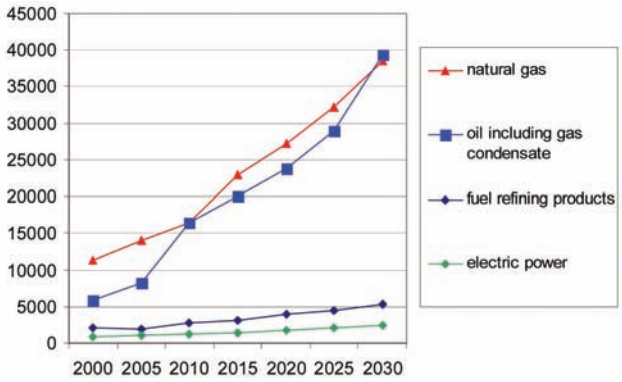


Fig.55. Consumption of fuel and energy resources, thousand toe

In 2030, in spite of absolute increase in FER consumption, the index of GDP at PPP energy intensity will lower by 23.5% compared to 2007, making 0.39 toe/$US (Annex, Table 11). It will be connected with increase of the non-energy efficient servicing branches contribution to the value added and with further process of economic potential formation based on the fifth and sixth technological levels.

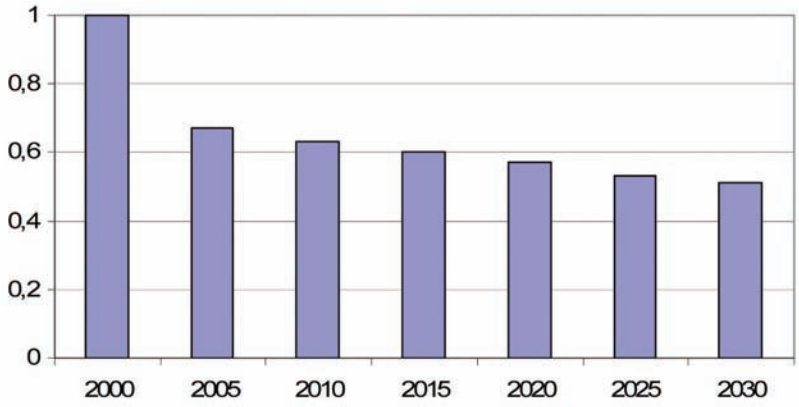


Fig.56. Dynamics of GDP energy intensity compared to 2000

Elasticity coefficient is one of the parameters reflecting effects of economy development on energy use growth. It is determined as a ratio of FER use growth rate to GDP-PPP growth rate. According to the projected volumes of FER use and economy growth under the moderate scenario, the elasticity coefficient changes from 0.74 to 0.88 per five-year intervals. It reflects strong dependence of energy use growth rates on the economy growth rates. High elasticity in 2010 (0.88) and in 2030 (0.87) stems from intensive increase of oil refining output. Hence, in 2010 this output will increase by 41% compared to 2005, and in 2030 - by 36% compared to 2025.

In 2030, the FER end use will reach 29285 thousand tons in oil equivalent, having doubled compared to 2007. In the long view, the share of final consumption in total FER use will decline further (34%), due to intensive export-oriented development of the oil refining branch.

Enhanced diversification of the industrial processing sector will lead to higher demand for energy resources in this sector. In 2030, its share in total final consumption will increase to 42%.

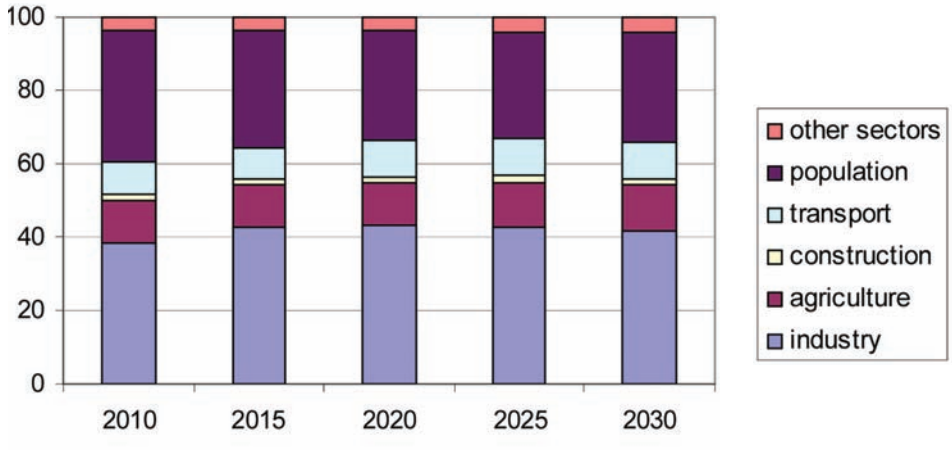


Fig.57. Final consumption of fuel and energy resources by sectors in 2010–2030, %

In the long-term, the share of energy use by households will diminish, primarily due to high rates of the economy development. By end of the forecasting period the share of households in FER use will account for 30%, while the shares of other productive and non-productive branches will not change importantly.

In 2030, the final **gas** consumption will increase 2.1 fold compared to 2007. In 2010-2030, its share in FER end use will rise from 89% to 91% compared to 74% in 2007**.**

The industry, mainly the power engineering, will remain to be the most intensive user; the demand for electric power will increase 2.4 fold compared to 2007. The biggest consumption will be in 2011-2015, owing to expanded development of energy-intensive branches such as construction materials production (cement, glass, super-thin basalt fibers) and chemical industry. In 2030, gas consumption in the industry will account for 51% compared with 44.5% in 2007. However, in 2016-2020 the growth rates of gas demand will go down in connection with modernization of power engineering, installation of cogeneration plants.

In 2007-2030, gas consumption in the agriculture will increase 2.7 fold, due to industrialization of animal breeding and vegetable growing branches, as well as due to realization of National Program on improvement of social and living conditions in rural areas.

Gas consumption by households will drop to 35% in 2030 compared with 45% in 2007, as a result of development of autonomous heat supply system for residential buildings.

In the forecasting period the **gasoline** use volume will double. Higher growth rates (2.4 fold) of this indicator will come from increase of quantity of private cars. Commercial motor transport as the most intensive consumer of fuel will use 35% of gasoline in 2030. The growth of gasoline consumption in the agriculture will slow down, due to concentration of agricultural production (cooperative societies) and modernization of agricultural machinery fleet. The share of the branch will account for 26.5% in total gasoline consumption in 2030.

In 2030, **diesel fuel** consumption will increase 2.1fold in a result of high rates of economy development and expansion of large-tonnage transportations. In this regard, in 2030, the diesel fuel consumption by transport will increase 2.3 fold compared to 2007. However, after 2020 the growth rates of diesel fuel use will become slower because of conversion of the railway transport to electric operation. The share of agriculture will drop to 35% because of modernization of the agricultural machinery fleet. Diesel fuel consumption in the construction industry and in communication sector will increase as a result of intensive development of regions in the country.

The **electric power** consumption is forecasted to grow and reach 2167.3 thousand tons in oil equivalent in 2030, showing the 2.3 fold growth compared to 2007. The rapid growth of consumption will be in transport - 4.8 fold, and therefore its share in total electric power consumption will increase to 14% compared with 6.6% in 2007. This growth will come from development of pipeline transport systems (oil and gas pumping over) and railway electrification. Consumption by the industry and agriculture will increase twice; their development will be based on importing of energy efficient and resource saving technologies. The doubled increase of electric energy consumption by households will be connected with the population growth, with active purchase of household appliances, improvement and expansion of housing conditions. After 2015 the light-emitting diode lamps are expected to be widely used, which will constrain the growth of electricity consumption by households.

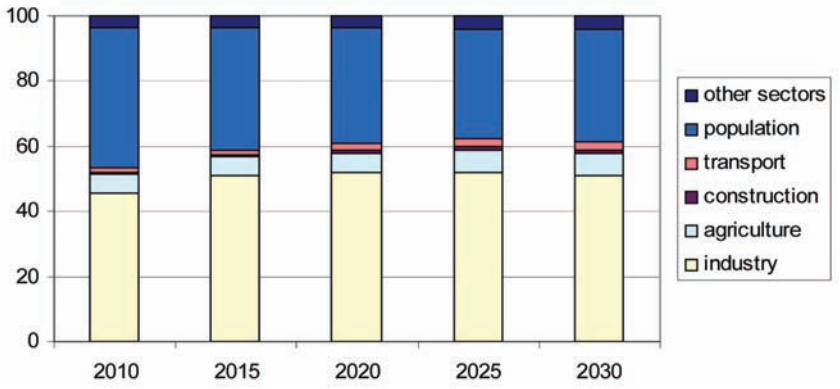


Fig.58. Natural gas consumption by sectors in 2010–2030, %

The GHG emission volumes under the moderate scenario within a period until 2030 have been estimated in accordance with the forecasting volumes and structure of FER . By end of the long-term period, the GHG emission will make 287173.1 $CO_2$-eqv tons, or increase more than fivefold compared to 2000 and 3.3 fold compared to 2007. As a result of high growth of the economy, the carbon intensity factor will decline and account for 0.0013 or 61% in 2030 compared to 2000.

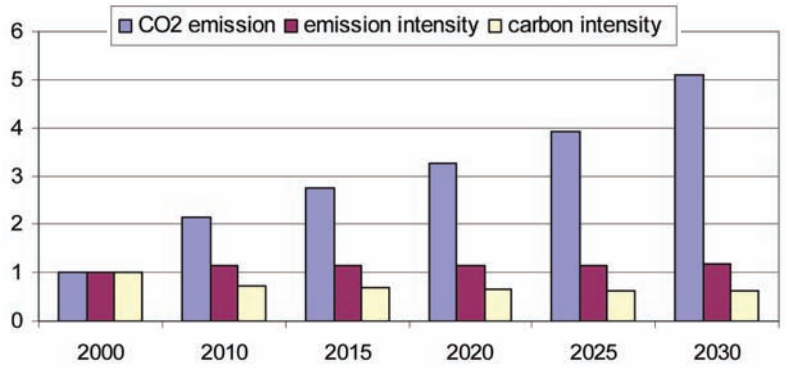


Fig.59. Dynamics of $CO_2$ emission, emission intensity and carbon intensity compared to 2000

### 4.2.3. Innovative-active scenario

This scenario of economy development is based on increase in energy use efficiency by all economic branches that would lead to decline in energy consumption per unit of GDP. In other words, it would be beyond the historical utmost of contingency of GDP growth and domestic energy use growth as it is seen from the moderate scenario.

Realization of the innovative-active scenario will require higher rates of technological and social developments. These processes should be preceded by formation of adequate institutional and organizational policies, practices and relevant legal framework. In view of development and introduction into economy management of energy conservation measures, the results of the energy conservation policy will come out after 2015. In this regard, for the period until 2015 the parameters of economy development, energy use, GHG emissions under the moderate scenario and the innovative-active scenario are similar.

The declining rates of GDP energy intensity under the innovative-active scenario have been assumed to increase by time series (Annex, Table 11). For 2016-2020 the average annual declining of energy use will account for 1.5%, for 2021-2025 - 2.0%, for 2026-2030 - 2.5% (compared with energy use under the moderate scenario). Such rates have been assumed in

accordance with the international best practices and are achievable in Turkmenistan due to its increased economic potential.

World experience also proves that active energy conservation policy generates higher economy efficiency as a whole. When producing and applying innovative energy-saving technologies, the specific material costs diminish and in this way there appears opportunity to increase financing for scientific elaborations, marketing researches, improvement of production management system, in other words, the demand is reoriented on service branches. Further sustainable development of the financial sphere will promote re-distribution of finances flows and increase of service sphere investment. It will lead to higher growth of gross value added in service branches compared with growth of gross value added in manufacturing branches. Expansion of services in energy saving area will promote development of production of domestic technologies and equipment, which can subsequently be exported abroad.

In view of the nature of active energy conservation policy under the innovative-active scenario, the acceleration of structural developments in the economy and of average annual growth of GDP is anticipated (Annex, Tables 9 and 10).

In 2030, the national economy development indicator will increase 9.6 fold compared to 2000. In 2007-2030, average annual growth of GDP at PPP will account for 6.5%. By end of the forecasting period the GDP per capita will equal to US$34 thousand. In 2030, the economy structure in Turkmenistan will come up closely to the economy structure of the developed countries where the service sector occupies notable positions. Under the innovative-active scenario the share of the service sector will account for 58%.

Changes in the economy structure based on active energy saving policy will result in energy use reduction being a main force to mitigate climate change. Hence, in 2016-2030, total energy use under the innovative-active scenario will decrease by 5% compared with the same parameter under the moderate scenario. In 2030, the GDP energy intensity will make 0.32 toe/US$ or decrease by 18% compared with the same parameter under the moderate scenario (Annex, Table 11).

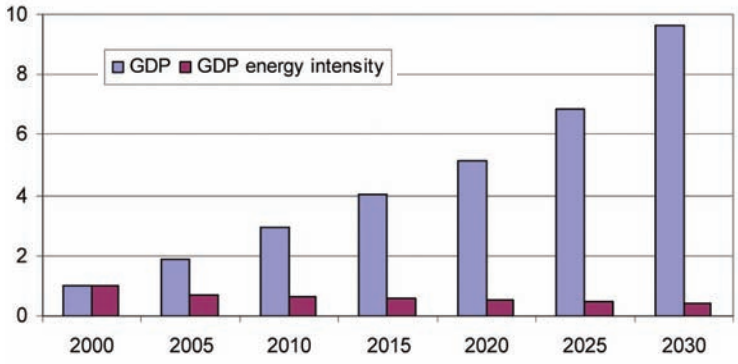


Fig.60. Dynamics of GDP energy intensity and production compared to 2000

Progressive organizational improvements in development of the energy supply system in the country will be effective in adequate GHG reduction, thus improving air quality in the country and regions, decreasing harmful impact on people's health, on animals, plants and ecosystems. In 2030, the parameter of carbon intensity under the innovative-active scenario will equal to 0.0009 $CO_2$-eqv tons or fall by 40% compared to 2007 (Annex, Table 12). In this way, the highest diversification of the economy and the optimal employment owing to high development in the sphere of services are achievable. In general, it conforms to the sustainable development model.

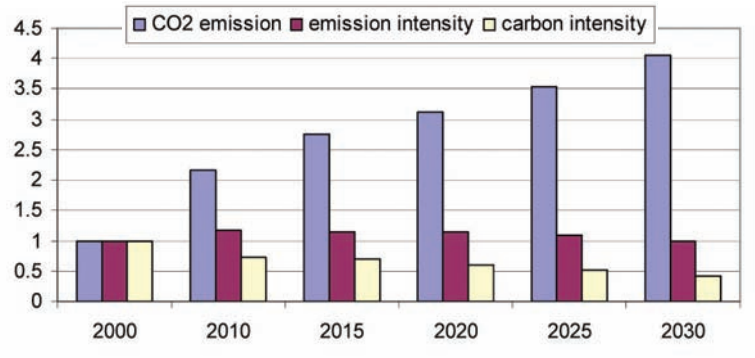


Fig.61. Dynamics of $CO_2$ emission, emission intensity and carbon intensity compared to 2000

The national policy to mitigate climate change will be effective if a comprehensive set of tools and practices regulating the energy saving process is applied. This set should be developed during 2010-2013 to generate reserves for realizing the innovative-active development scenario by 2015. Such set of national tools and measures should include:

- the strategy of energy-saving-based development of Turkmenistan until 2030. The document should declare the "clean development" priority in socioeconomic progress of the country and the priority directions to mitigate industrial impact on climate change;
- the complex national program of energy saving in Turkmenistan until 2015. It should reflect priority directions and practices to achieve energy effective use in housing and public utilities, in industry, budgetary sphere, agriculture, transport, fuel-energy complex. Similar programs should be developed for the country's regions;
- the national development program of renewable energy sources in Turkmenistan until 2020. It will stipulate adequate measures on applying power engineering units using alternative energy sources in various economic branches of the country;
- improvement of energy tariff policy in the energy sector aimed at applying gradually the market pricing principles to all types of energy sources in real sector of the economy;
- improvement and elaboration of legislation on energy-saving-based development. The main legal act in the sphere should be a law of Turkmenistan on energy saving aimed mainly at forming energy saving behaviors. The law will regulate administrative actions in case of irrational use of FER, privileges to realization of energy saving measures, and financial and economic mechanisms of governmental support to energy conservation. To adopt an adequate legislation the following steps should be taken:
- development of laws "On energy industry", "On technical regulation of energy supply systems", "On alternate and renewable energy sources", etc.;
- improvement of infrastructure for registration and monitoring of energy consumption:

1) to develop and apply within the national statistics the fuel and energy balance sheet of the country as the most important tool to monitor efficiency of national energy supply systems and forecast development of the social and economic sphere;
2) to enhance the powers of the State Energy Inspection of Turkmenistan to supervise implementation of work on saving of FER and decrease of their consumption per unit of output (works, services).

## 4.3. Measures to mitigate climate change taken in key economy sectors

### *4.3.1. Power engineering*

#### *4.3.1.1. Measures to mitigate climate change taken in 2000-2007*

The power engineering industry of Turkmenistan is one of the key economy branches. Implementation of the national economy programs and plans on acceleration of the socioeconomic development largely depends on this branch development, which over the period of Turkmenistan's independence has notably contributed to the energy security of the country.

The electric power supply system of Turkmenistan consists of 8 thermal and 1 hydro power stations. The system is connected to the Joint Electric Power System of Central Asia and exports surpluses of electric power. The power stations use as a fuel the natural gas supplied from the nearest gas fields. Black oil and diesel fuel from the Turkmenbashi and Seydi refineries are used as a reserve fuel in the stations.

In 2005-2007, the growth of electric power production accounted for over 7%, export increased annually by 15%. Generation of electric power increased by more than 30% compared to 2000.

In 2000-2007, the electricity consumption was permanently growing in Turkmenistan. In 2007 it increased by 36% compared to 2000. The intention to preserve growth for the next 10-20 years has determined a gradual change of the generating capacities structure. Due to deactivating of old equipment and putting of new ones into operation during 2000-2007, the economy needs in electric power have been completely satisfied, and new opportunities for export of electric power to neighboring countries have appeared.

In 2004-2007, there were completed a number of large-size projects in the power engineering. This fact promoted a sustainable and reliable operation of the electric power supply system of Turkmenistan, a reduction of share of old fixed assets, an increase in efficiency of electric generating capacities and also promoted energy conservation and GHG emission reduction.

*Table 8*

**The largest projects on energy saving in the power engineering industry 2004–2007**

| Year of putting into operation | Project |
|---|---|
| 2004 | Installation of three gas-turbine units each of 42 megawatt capacity in Balkanabat power station |
| 2004 | Replacement of 50 megawatt outdated steamed turbine for 123 megawatt new gas-turbine unit in Abadan power station |
| 2005 | Removal of turbine #3 with capacity of 50 megawatt that had worked over 40 years, in Turkmenbashi power station |
| 2006 | Reconstruction of power production unit # 2 in Mary power station |
| 2006–2007 | Commissioning of Ashgabat and Dashoguz power stations with 254.2 megawatt capacity each |

Thus, in 2007, the structure of electricity generating capacities changed significantly compared to 2000. In 2000, the available capacity of steam and gas turbine units accounted for 85.9% and 14.1% accordingly, in 2007 - 73.6% and 26.4%. About 29% of the available capacities were of less than 10 years age, and about 25% of them were over 30 years age.

Nevertheless, in 2000-2004 the obsolete and old equipment at the thermal power stations conditioned the increase in average specific fuel consumption by 6.5% per year. Energy efficiency of the electric power generation rose by 30% in 2000-2007.

In 2005-2007, the energy consumption for own needs decreased by 9% compared to 2000. In 2007, this indicator for the steam turbine units accounted for 6-14%, for the gas turbine units - 0.2-2.2%. Realization of the abovementioned projects allowed the saving of natural gas in volume of 485 million $m^3$, and the reduction of GHG emission by nearly 1 million tons in $CO_2$ equivalent in 2004-2007.

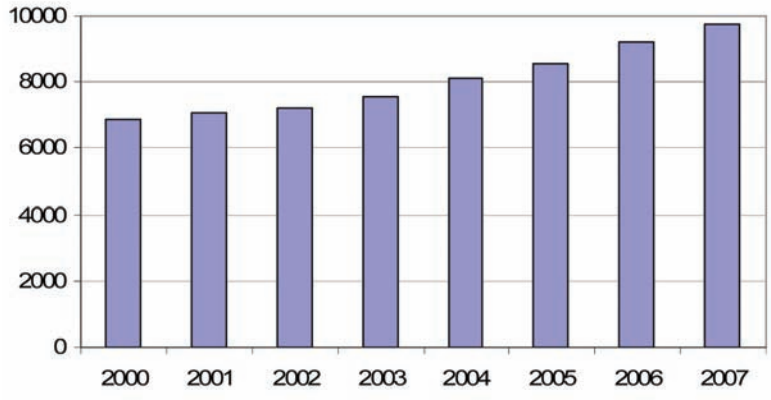


Fig. 62. $CO_2$ emission from power engineering in 2000-2007, Gg

It should be noted, that despite the energy efficiency increase at the power stations due to application of modern technologies, the total amount of GHG emission connected with electric power production continues to grow.

### 4.3.1.2. Measures to mitigate climate change until 2030 under the moderate scenario

This scenario assumes growth in electric power use for the needs of social and economic development of the country in accordance with the national programs. Decrease in GHG emission from the power engineering under the scenario will happen mainly due to taking of technological measures on effective use of organic fuel and reduction of energy losses.

The priority direction of the branch development is to set the up-to-date electric power supply system in view of the dynamic social and economic development of the country and realization of large-size programs of development of Ashgabat and the administrative regions of the country. According to the planned growth of the economy, the electric power production will rise to 31.57 billion kW/year by 2020, and threefold by 2030 compared to 2007. In this regard, the annual growth of electric power generation until 2020 is forecasted as 6.5%. Its domestic use in 2020 should reach 20 billion kW and export - up to 115 billion kW. It is assumed in this connection the rapid growth of investments, which would allow increase the introduction of new electric generating capacities almost twice.

New capacities will be introduced by installing maneuverable supplies based on gas turbine units. It will ensure more reliable functioning of the joint energy system of the country and more efficient operating of steam turbine equipment in the power stations. Therefore, the fuel consumption for generating electric power will decline, and its cost price and GHG emission will decrease.

In Turkmenistan, the electricity generating supplies growth is also anticipated due to construction of up-to-date electric power units, reconstruction of available electric power units with new efficient equipment, construction of power transmission lines. As a result, the possible increase in electricity supply capacities will make 733.4 megawatt by 2020; and 2.5 gigawatt in 2020-2030. In this way, the total capacity of power stations in Turkmenistan will increase up to 4075 megawatt by 2020; up to 6 gigawatt by 2030.

Within the nearest years, the infrastructure of the branch will be replenished with two new power stations - in Ashgabat and Avaza settlement, and each station will have the 254.2 megawatt capacity. Electricity supply by Balkanabat power station will increase, the largest power station of the country in Mary will be modernized. In Ashgabat, 18 sub-power stations are supposed to be built, and overhead transmission lines are planned to be replaced for cable grids. In Avaza, 15 sub-power stations will be constructed. Additionally, it is planned to construct new electric power units, electric grids and modernize the existing ones to cover all the human settlements of Turkmenistan.

The intended capacity growth in the branch will open new opportunities to establish diversified export routes of the Turkmen electric power. In the long view, the significant growth of electricity export to neighboring countries, as well as to Pakistan, West Europe is envisaged.

*The main strategic development policy of the branch until 2030:*

1. Construction of power stations equipped with up-to-date devices and units with application of new technologies and scientific achievements;
2. Reconstruction of steam turbine units operating over 20 years;
3. Reconstruction of gas turbine units with application of utilizing boiler and steam turbines;
4. Construction of new power stations with application of the steam-gas combined cycle.

In accordance with experts' estimations, increase in efficiency of power stations under the strategy may lead to total energy conservation of 35 billion $m^3$ of natural gas and to reduction of GHG emission - 67.5 million tons in $CO_2$ equivalent in 2010-2030 or 1.6 billion $m^3$ and 3.21 million tons in $CO_2$ equivalent per year accordingly.

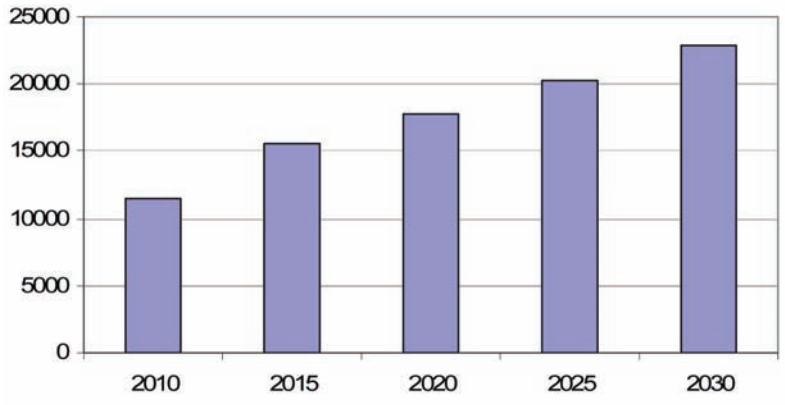


Fig. 63. GHG emission from electric power generation in 2010–2030 under the moderate scenario, Gg $CO_2$

### 4.3.1.3. Measures to mitigate climate change until 2030 under the innovative-active scenario

The scenario envisages development of adequate legal acts and taking of special measures on energy conservation.

In addition to technological measures on energy conservation under the moderate scenario, this scenario suggests broader application of cogeneration to produce electric power and heat in the meantime, optimization of operating regimes of the power supply system to decrease electric power losses while distributing and transmitting. For the electric power supply system of Turkmenistan the decrease in total electric power losses by 3-5% is actually possible.

Climatic conditions of Turkmenistan are extremely favorable to use renewable energy sources for production of electric power, heat and cold.

**Solar energy potential.** Within a year there are about 300 sunny days, the average annual sunlight intensity equals to about 700-800 W/m$^2$. It is equivalent to energy flows of 2000 kW/m$^2$ per year to 1 square meter of land surface. The annual energy potential of the solar energy is estimated to be 110 billion tons of conventional fuel.

Modern technologies on conversion of solar energy to the heating and electric one can be widely used for the heat and electricity supply to autonomous consumers.

**Wind energy potential.** The wind regime of Turkmenistan is the most appropriate in the west and north-west areas of the country where the wind speed exceeds 4 km/s. In the north coast of the Caspian Sea basin the specific wind capacity is quite high and equals to 110-135 W/m$^2$. High level of wind energy potential is typical for the Balkhan-Kopetdag corridor - over 150 W/m$^2$.

In general, the wind energy potential can be estimated as 5.5 billion tons of conventional fuel per year.

The wind energy-based power engineering equipped with up-to-date technologies is quite reliable source for energy supply in many countries. Small-size wind energy-based units and power stations with some megawatts capacity are produced in different countries and applied for electric power production both in the common energy system and in stand-alone power stations.

**Hydro energy resources** of the country consist of large and small trans-boundary rivers - Amu Darya, Murgab, Tedjen, Atrek, as well as 20 small rivers running down from the northern slopes of the Kopet Dag Mountains. The biggest waterway in the country is Amu Darya. It runs over the level land boundary territory of Turkmenistan. The artificial Garagum River begins from the Amu Darya and also runs over the level land territory. Construction of hydroelectric power stations at these rivers is economically inadvisable in Turkmenistan. Construction of hydroelectric power stations at other rivers (Murgab, Tedjen, Atrek) is

economically unjustified as these are shallow water rivers. Water turbines with 0.5-2.0 kW capacity built on small rivers running down with high speed from mountains can be applied to supply electricity to remote consumers.

The first power station of Turkmenistan – Gyndukush hydro-power station, the active museum

**Geothermal energy.** Thermal waters in Turkmenistan are considered to be applied in three ways: medical, chemical and power engineering.

The prospects of profitable use of the thermal underground water are determined by the temperature distribution character at 3000 meters depth, which reflects unique geothermal conditions in separate areas of Turkmenistan. By type of geothermal regime there are areas corresponding to certain geotectonic elements: Karakum (epigercinal platform), Kopet-Dag (orogeosynclinal) and Western-Turkmen (intermountain geosynclinal area). Within these areas, the temperatures at 3000 m depth equal to 80-110°C.

Thermal waters of 33-49°C at spill, mineralization of 3-15 g/l and water flow speed of 5-50 l/s can be applied for heating of buildings, greenhouses and other economic facilities.

The innovative-active scenario should stipulate the creation of mechanisms focused on strengthening of role of the state in development and realization of laws and programs concerning energy efficiency and energy saving, launch of mechanisms inducing energy saving. The world experience proves that additional economic incentives and sanctions are necessary to implement an effective policy of energy saving and to motivate energy producers and consumers. Thus, to reduce GHG emission intensively through increase in energy saving and energy efficiency of the electric power industry, the following measures are necessary:

1. To develop legal framework to implement energy saving policy and system of economic incentives;
2. To apply new advanced technologies for electric power production and distribution;
3. To improve the system of electric power registration at producers and at consumers;
4. To increase the role of renewable energy sources in the energy balance of the country;
5. To carry out GHG inventory annually in the power engineering.

In addition to the moderate scenario, the realization of the above mentioned measures will allow to save natural gas on average 0.9 billion $m^3$ per year and reduce GHG emission up to 1.7-1.8 million tons in $CO_2$ equivalent per year.

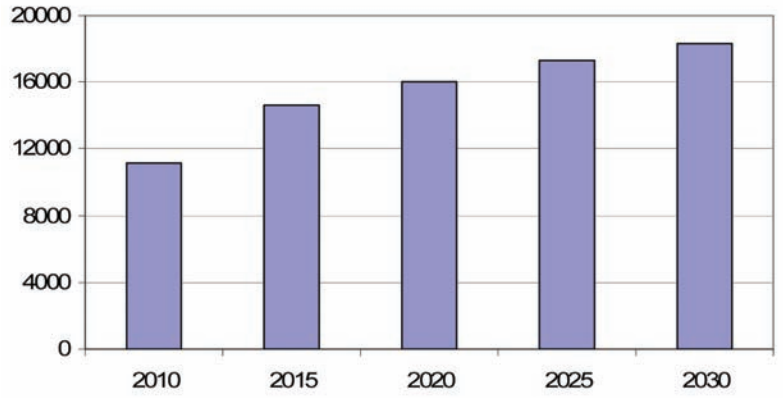


Fig.64. GHG emission from electric power generation in 2010–2030 under the innovative-active scenario, Gg $CO_2$

The projects listed below to mitigate climate change suggest reducing of GHG emissions in total by 1.7-1.9 million tons in $CO_2$ equivalent per year:

1. Using of heat from gas turbines of Ashgabat power station to supply heat to Ashgabat;
2. Using of heat from gas turbines of Akhal power station to supply it to greenhouses of vegetables and fruits growing;
3. Applying of closed-cycle cooling towers to cool circulating water in Avaza power station;
4. Conversion of gas turbines of Turkmenbashi Refinery to the steam-gas combined cycle
5. Using of steam heat in Avaza power station to produce distillates (thermal evaporators);
6. Installation of gas expansion units at the gas-distributing station in Mary power station;
7. Installation of gas expansion units at the gas-distributing station in Turkmenbashi power station;
8. Construction of 400 kilovolt power transmission lines from Mary power station to 400 kilovolt sub-power station in Serakhs (Iran) and construction of open distribution unit with 400 kilovolt transformer in Mary power station;
9. Construction of 400 kilovolt power transmission lines from Balkanabat power station to 400 kilovolt sub-power station in Gonbat (Iran) and construction of open distribution unit with 400 kilovolt transformer in Balkanabat power station (Balkanabat);
10. Construction of 500 kilovolt power transmission lines from the sub-power station in Gurtly (Ashgabat) to the sub-power station in Goturdepe (Balkanabat);
11. Construction of 220 kilovolt electric transmission lines from Mary to Serkhetabat;
12. Construction of 500 kilovolt sub-power station in Dashoguz;
13. Construction of 500 kilovolt power transmission lines from East sub-power station (Ashgabat) - 500 kilovolt open distribution unit in Mary power station (Mary):
14. Applying of energy saving technologies in the street lightning system in Asghabat;
15. Applying of combustion catalysts REDUXCO in boilers of power units in Mary power station;
16. Creation of 5 megawatt network of solar energy-based livestock ponds at natural pastures;
17. Construction of energy conservation "solar houses" for rural area with saving up to 10 megawatt;
18. Construction of 10 megawatt wind energy-based power station in Balkan velayat for electric power production in small settlements.

In the long view, the energy conservation-oriented projects will be the core of the development program of power engineering industry in Turkmenistan. Most important projects will be included to the annual investment programs. To implement a part of the projects the Clean Development Mechanism (CDM) of the Kyoto Protocol can be applied.

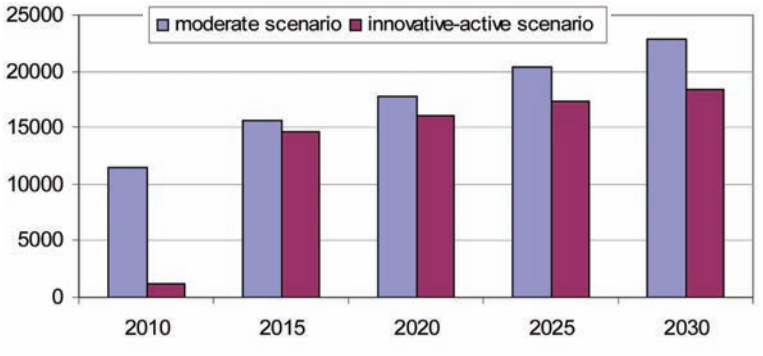


Fig.65. GHG emissions under the moderate and innovative-active scenarios in 2010–2030, Gg $CO_2$

The moderate and innovative-active scenarios anticipate limitation of GHG emission in the power engineering in 2010-2030. GHG emissions will grow under both scenarios: under the first scenario - 2 fold; under the second one - by 55-60%.

### 4.3.2. Oil-and-gas complex

### 4.3.2.1. Measures to mitigate climate change taken in 2000-2007

Majority of energy resources in Turkmenistan are concentrated in the oil-and-gas sector. The most important of them is natural gas with its reserves much greater than the other important hydrocarbon resource - oil. By the proved gas reserves the country is the second after the Russian Federation in the CIS countries.

**Gas industry.** Extraction, preparation and transportation of natural gas in Turkmenistan are implemented by the State Concerns "Turkmengas" and "Turkmenoil". Gas-transport entities of "Turkmengas" serve over 8000 km of gas pipelines and 5 compressor stations (CS) with total capacity of over 700 megawatt.

"Turkmengas" operates the gas pipelines supplying gas from the east and west regions of Turkmenistan through Uzbekistan, Kazakhstan to Russia. Total length of the available pipelines is 7 thousand km without taking into account pipe-bends. The pipeline system was constructed within the period of 1962-1997 and includes the gas pipelines Turkmenistan (Deryalyk) - Europe (Central Asia - Center CAC 1,2,4) and Turkmenistan (Garabogaz) - Europe (CAC-3). The Concern "Turkmenoil" operates the export gas pipeline Korpeje - Kurtkui constructed in December of 1997.

In 2000-2007, a number of projects on development and reconstruction of available gas-transport grids were implemented in Turkmenistan. In 2007, the project on modernization of Turkmen sections of the gas-supply system supplying gas towards north was completed. The main part of the project was the construction of loop pipelines and line compressor stations.

Within the program on reconstruction of the gas pipelines Turkmenistan (Deryalyk) - Europe 160 km loop pipelines, 90 megawatt liner compressor stations (CS) "Yilanly" and "Deryalyk" were constructed in 2001-2007.

In 2001, the 43 km loop pipeline of 1420 mm diameter was put into operation within the pipeline CAC-4.

In 2003, the unit of gas compression and preparation with the efficiency of 20 billion $m^3$ per year was constructed in the natural gas field Dovletabad-2.

In 1998-2003, the units of gas desulphurization and glycol injection dehydration were modernized in Dovletabad-3 and Northern Bailugly natural gas fields. To guarantee export of Turkmen high quality natural gas the unit of gas dehydration in the CS "Deryalyk" was put into operation. All the new units are equipped with up-to-date advanced technologies of the companies "Pall GmbH', "Zulzer Hemtek" and "General Electric".

In 2004-2005, the company PII Pipetronix GmbH (Germany) under the service contract with "Turkmengas" performed diagnostics of 3000 km gas-main pipelines Naip - Deryalyk and Dovletabad - Deryalyk with in-tube defect detectors. It allowed decreasing in numbers of major repairs, providing reliability of the gas-transport system in Turkmenistan, as well as limiting methane emission into atmosphere for a long-term period.

In 2007, the booster compressor station (BCS) with 98 megawatt capacity was constructed in Dovletabad-3 natural gas field. Currently, additional capacities for gas extraction, preparation and transportation are created. Such type of work is carried out at the gas fields Garrabil – Gurrukbil group, Bakja, Zeakly - Derveze, Yashlar - Gunorta-Yolatan zone, etc.

To supply larger volumes of gas from the Odjak-Naip fields group the BCS and units of gas preparation are planned to be put into operation within next years. The 2nd turn BCS construction in the gas fields Dovletabad-2 and Malay is stipulated too.

**Oil industry.** The oil extraction work is mainly performed by the State Concern "Turkmenoil" in the west of Turkmenistan. In 2000, Government of Turkmenistan concluded the production-sharing agreement (PSA) with several foreign companies. Since coming into force of PSA the oil extraction has grown threefold.

In all oil-fields, where the Concern's enterprises of oil and gas extraction operate, great efforts have been made to stabilize the increase in oil extraction. For instance, over the years of Independence a number of new high tech facilities have been erected at Goturdepe and Barsagelmez oil-fields - units of low-temperature gas separation, booster-pump stations, gas-compressor stations, skid-mounted compressor stations, hundreds kilometers of collectors, pipelines, blowing lines at crude oil collectors. Increase in oil extraction is achieved owing to new oil-well drilling, rehabilitation of inactive wells, and application of new technologies for intensive extraction. There widely applied the technologies of activating the bottom-hole formation zone, transfer of wells to gas-lift and mechanized ways of oil extraction, kick-off of the second borehole, screw way of oil extraction, separate operation of oil bores, gas-lift under high pressure. These actions promote the improvement of oil-recovery out of layers and intensify extraction. Nowadays, compressor stations become an important part of the oil and gas extraction infrastructure.

Over a few years a number of new gas-compressor stations have been constructed at the oil-gas fields with the help of foreign specialists. "Serdar" compressor station in Barsagelmez oil field and two skid-mounted compressor stations are among them. Also, two skid-mounted compressor stations and the gas-compressor station with capacity of 12 million $m^3$ per day have been put into operation in Goturtepe oil-gas field. These stations have modern turbo-blower units and high-efficiency centrifugal compressors.

In 1990-2007, the fleet of lifting equipment was completely renewed. While implementing capital repair of wells, the new technologies of flexible pump-compressor pipes were tested for further using, it allowed reduce repair period twice and improve quality of work.

In 2006, construction of the oil-main heat-insulated pipeline Korpeje-Balkanabat was finalized. In Korpeje oil field, where the pipeline begins, the oil-transfer complex was put into operation. Currently, crude oil is only piped to the Turkmenbashi Refinery, which is cost effective and environmentally safe.

In the southwest of the country the booster-pump stations, oil-gas main pipelines, all infrastructures in oil extracting Keymir and Akpatlavuk oil-gas fields were constructed. In Ekerem the oil-loading terminal that facilitates, accelerates and secures tanker loading for export was reconstructed.

Since 2000, the Gundogar-Cheleken oil field is developed by the consortium "Khasar". The significant achievement of such cooperation of "Turkmenoil" with a foreign company is the transfer of effective technologies and advanced experience to the Concern's entities and personnel.

Enhancement of productive capacities and upgrading of infrastructures in the oil branch continued in 2007. Launch of the gas-lift compressor station in Goturdepe and oil-transfer station by the company Dragon Oil under the project "Cheleken" became the especial significant event of that year.

Until recent time, the petroleum gas emissions from oil-field sites happened due to insufficient readiness of the infrastructures for oil gathering, preparation, transportation and refining as well as due to absence of consumer. For the time being, after putting into operation of the compressor stations in Goturdepe, Barsagelmes, Belek and reconstruction of gas-lift systems the greatest amount of petroleum gas is utilized.

In 2006, "Korpeje" compressor station was put into operation to recycle and transport petroleum gas to the gas-main pipeline Turkmenistan-Iran. The amount of recycling petroleum gas by the station made 2.6 million $m^3$ per day. Petroleum gas earlier flared is delivered to the compressor station from the booster-pump stations "Southern Gamashlaja", "Korpeje-1" and "Korpeje-2.

**GHG emission from the oil-and-gas complex in 2000-2007.** The operation of the oil and gas enterprises is inevitably accompanied with methane emissions, mainly because of inappropriateness of production processes, obsolete equipment and techniques. Despite the large-scale re-equipment, the enterprises of the oil-and-gas complex still remain the main sources of GHG emission at all stages of oil and gas production, from geological survey to processing, transportation, storing and consumption of hydrocarbons.

GHG emissions from the complex include all emissions from extraction, refining, transportation, storing of oil, natural and petroleum gas as well as from their burning if they are not connected to secondary energy production. Additionally, they are the emissions from flaring of natural and petroleum gas, technological emissions, emissions from repairing processes and from accidents.

In 2000-2007, GHG emissions from the oil branch exceeded those from the gas branch. However, the GHG emissions from the gas branch increased faster and accounted for over 200% in 2007 compared to 2000, while the growth in emissions from the oil branch was 9-10%. First of all, it was connected with sharp increase in extraction and transportation of natural gas for export.

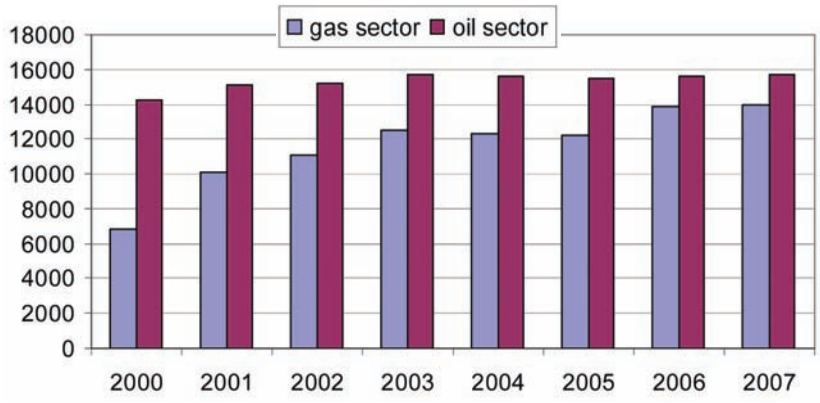


Fig.66. GHG emissions from the oil-and-gas complex in 2000-2007 (shares of oil and gas industries), Gg $CO_2$

### 4.3.2.2. Measures to mitigate climate change until 2030 under the moderate scenario

Underlying principles of development of the oil-and-gas branch of Turkmenistan are incorporated in the National Program of President of Turkmenistan "Strategy of economic, political and cultural development of Turkmenistan until 2020" and in Program of development of the oil-and-gas complex of Turkmenistan until 2030. According to these documents, priority measures on development of the gas branch of Turkmenistan are the accelerated development and putting into operation of oil and gas fields explored and prepared for development, large-scale application of new techniques and high technologies.

In 2030, in Turkmenistan gas extraction will increase to 250 billion $m^3$, oil - to 110 million tons. The gas pipeline system Central Asia - Center (CAC) is planned to be completely reconstructed by 2011 to provide larger export of Turkmen gas towards the north.

The development program of the branch stipulates the oil refining up to 20 million tons by 2020, up to 30 million tons - by 2030. It will come about through the further modernization, increase of capacities at Turkmenbashi and Seydi refineries.

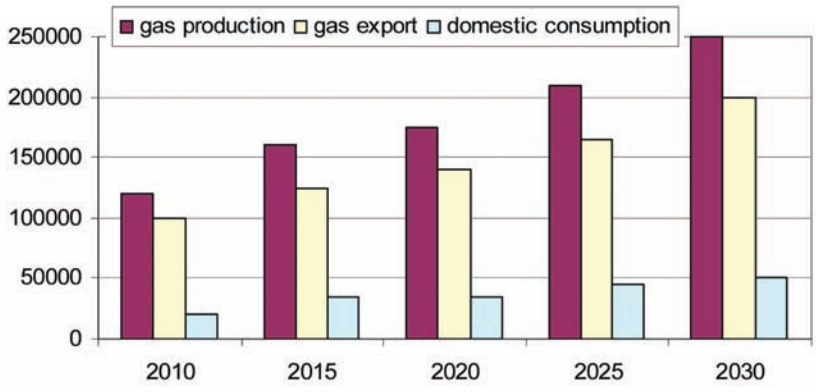


Fig.67. Gas extraction, export and domestic consumption until 2030, million $m^3$

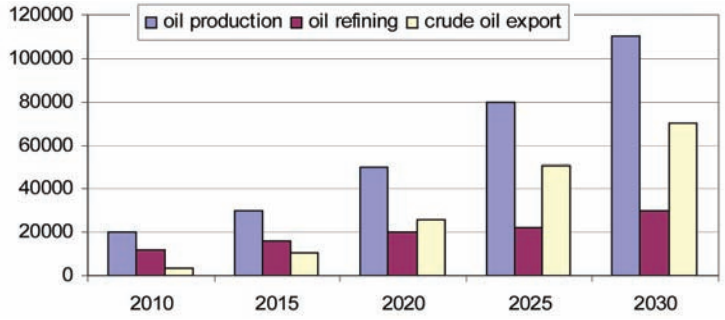


Fig.68. Crude oil extraction, refining and export until 2030, thousand ton

New compressor stations will be constructed at oil-gas fields to contribute to petroleum gas recovery. This is gas-lift compressor station "Keymir" that will collect petroleum gas in amounts of 960 million $m^3$ per year under overpressure 0.25-12 mega Pascal and supply it to the gas-lift system of Keymir oil field. Excessive gas will come to the gas-collector in Keymir oil field, and through the unit of complex gas preparation in Akpatlavuk will be supplied to the export gas-main pipeline Turkmenistan - Iran. The amount of extracted petroleum gas subject to utilization will make 600 million $m^3$ per year, in Akpatlavuk - 360 and Keymir - 240.

The second compressor station to be constructed will be "Khazar" with the rated capacity 2.0 billion $m^3$ per year. The station is intended for collection of petroleum gas under the overpressure 0.25-2.5 mega Pascal and supply of it to "Goturdepe" compressor station through the 75 km gas-main pipeline Khazar - Goturdepe.

Priority measures on development of oil-gas transport infrastructure are the reconstruction of the operating oil-gas transport system, expansion of oil-gas main pipelines for domestic supply of Turkmenistan, construction of new pipelines for export of hydrocarbons to foreign markets. Further, the priority aim of development of the oil-and-gas branch will remain to be the increase in technological and economic efficiency of production cycle as a whole: geological survey, exploration, development of oil-and-gas fields and transportation of hydrocarbons.

Rapid growth in the oil-and-gas production will require applying of innovative science-based approaches with a view of increase of energy efficiency of the oil-and-gas complex. It is obvious that the main measure to solve the problem will be application of up-to-date technological processes.

Estimations under the moderate scenario are based on the volumes of oil and gas extraction, transportation and refining in accordance with the development program of the oil-and-gas complex until 2030. Additionally, priority measures on development of oil-gas-transport infrastructure are taken into account.

GHG emissions under the moderate scenario may reach 115-120 million $CO_2$-eqv tons in 2030 or on average 85-87 million $CO_2$-eqv tons per year in 2010-2030. Thus, the emissions can increase more than 3.5 fold compared to 2007.

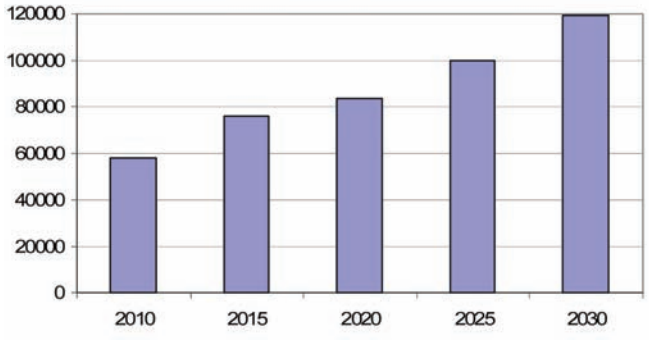


Fig.69. GHG emission from the oil-and-gas complex in 2010-2030 under the moderate scenario, Gg $CO_2$

### 4.3.2.3. Measures to mitigate climate change until 2030 under the innovative-active scenario

The GHG emission forecast under the second scenario assumes significant increase in energy efficiency and energy saving over the whole production cycle: geological survey, exploration, development of oil-and-gas fields, and transportation of hydrocarbons.

It should be noted that this scenario means more intensive restriction of growth of the GHG emission from the oil-and-gas complex until 2030. GHG emission can be reduced by 23-25% compared to the moderate scenario by the end of the forecasting period.

Development and realization of measures on energy saving in the gas industry will allow decrease consumption of natural gas for own needs. The main way to reduce gas use for maintaining of gas main pipelines is gradual replacement of low-efficient gas-pumping units for new up-to-date ones with increase of efficiency to 37-39%, and in the long view - to 42-43%, as well as application of gas-pumping units operating due to gas pressure difference in gas-distribution and gas-transport networks.

Additionally, to reduce GHG emission, the innovative-active scenario suggests the measures aimed at decreasing in constant and incidental emissions from production processes of the gas industry within 3-5 million $CO_2$ tons per year. Some of these measures are to apply non-fire method of branch cutting-in, methane recover while testing oil and gas wells and acid gas recover from torches of large-size gas fields.

Reconstruction of the gas-transport system will promote reduction of GHG emission up by 4-5 million $CO_2$ tons per year. To detect and liquidate methane leakages at due time it is necessary to develop and organize monitoring system of methane leakages from the gas-transport system, which will create the necessary prerequisites for GHG reduction by over 0.5 million $CO_2$ ton per year.

The projects on energy saving offered in the innovative-active scenario for the gas branch:

1. Decrease in methane leakages from gas-main pipelines owing to application of SKDA system;
2. Decrease in gas leakages from low and average pressure gas-distribution networks in Ashgabat and all velayats of Turkmenistan;
3. Increase in efficiency of electric power consumption by electric motors of gas pumping units of the Association "Turkmentransgas": the gas compressor stations - Karakumskaya, Shatlyk, Cholluk, Deryalyk;
4. Introduction of gas-turbine units to gas compressor stations of the Association "Turkmentransgas" for electric power production: the gas compressor stations - Karakumskaya, Belek.
5. Application of non-fire method of branch cutting-in to gas-main pipelines and pipe-bends of "Turkmengas".
6. Recover of acid gases from torches in Dovletabat oil-gas field.
7. Reduction of GHG emission from gas extraction in Dovletobat oil-gas field.

In the oil industry there is a sufficient potential for utilization and using of petroleum gas which can be used for power engineering and petrochemical purposes.

The innovative-active scenario suggests the following energy saving projects in the oil industry:

1. Application of small-sized units of gas petroleum utilization to extinguish torches in "Gamyshdidjaneft" oil fields.
2. Petroleum gas utilization in "Gumdagneft" oil field.
3. Application of small-size unit for utilization of petroleum gas to extinguish torches in Keymir oil field.

4. Application of small-size unit for utilization of petroleum gas to extinguish torches in Yashildepe oil field.
5. Utilization of petroleum gas from the sea block - 1 (Petronas company).
6. Utilization of petroleum gas from the sea block - 2 (Dragon oil company).
7. Application of unit for utilization of petroleum gas in Cheleken oil field.
8. Petroleum gas utilization in "Khazarneft" oil field.

Realization of the projects will result in reduction of GHG emission in gas branch by 8-10 million $CO_2$ tons per year, in oil branch - by 18-20 million $CO_2$ tons per year.

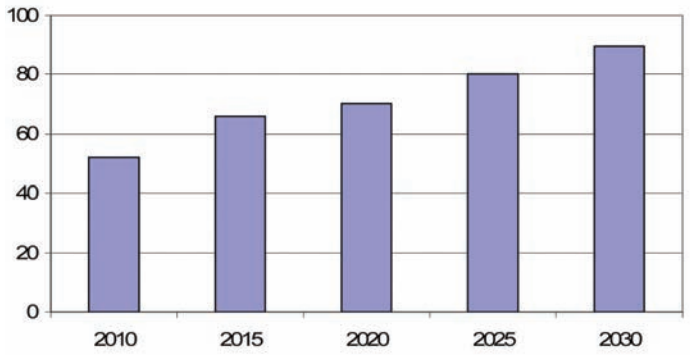


Fig.70. GHG emission from the oil-and-gas complex in 2010-2030 under the innovative-active scenario, Gg $CO_2$

Thus, the oil-and-gas complex has a significant potential to reduce GHG emission into atmosphere. Realization of each project will need significant investments at the phase of preparing and the phase of performance. However, it should be noted that the projects on utilization of methane from gas extraction and transportation, and oil extraction can be realized under Clean Development Mechanism of the Kyoto Protocol, due to easy replication. Moreover, at the existing level of prices at the world market high hydrocarbon incomes of such projects will fully cover investments within 8-10 years.

### 4.3.3. Chemical industry

The chemical industry is one of the perspective and developing branches of the national economy. The State Concern "Turkmenchemistry" manages the chemical industry that includes 10 large-size enterprises.

Industrial enterprises of "Turkmenchemistry" produce important types of chemical production - mineral fertilizers (nitric, phosphate, potash), technical iodine, sulfuric acid, sodium sulfate, technical carbon.

Over last years, the production of nitric fertilizers has significantly increased owing to putting into operation in 2005 of Tejen carbamide plant that uses high advanced technologies (designed capacity - 350 thousand tons per year).

Phosphoric fertilizers were produced at level of 110-250 thousand tons. Over last years the technical iodine production increased and amounted to 460 tons per year against 250 tons per year, due to building of new capacities at Bereket iodine plant. Technical carbon was produced in Khazar chemical plant in amount of 1-2 thousand tons per year.

*Table 9*

**Chemical production by main products**

| Product, thousand ton | Year | | |
|---|---|---|---|
| | 2000 | 2005 | 2007 |
| Mineral fertilizers | 348.0 | 549.1 | 769.6 |
| *including* | | | |
| phosphate | 118.8 | 145.0 | 240.0 |
| technical iodine | 248.7 | 410.2 | 463.6 |
| sulphuris acid | 92.45 | 93.66 | 142.1 |
| sodium sulfate | 19.62 | 17.37 | 15.54 |
| technical carbon | 1.54 | 2.23 | 1.47 |

The majority of the chemical enterprises were constructed 20-30 years ago. Over the years of their operation there were not undertaken any reconstructions at them. Therefore, energy efficiency of the equipment of these enterprises, such as specific electric power and gas consumption per unit of output are by 10-70% higher than of equipment based on new technologies.

Presently, at chemical enterprises of "Turkmenchemistry" the maintenance and repairing of energy units (boilers, furnaces) are performed regularly. The main reason why capital repair work is not implemented in the chemical branch is a shortage of working capital.

Currently, the strategic program of the chemical industry development until 2030 is being elaborated. It will specify actions to be taken to develop the chemical branch of Turkmenistan. According to the program, the production capacities for most important kinds of chemical output will be significantly increased compared to 2000: mineral fertilizers - 20,1 fold, of which nitric – 18.1 fold, phosphate – 3 fold, potash - up to 2.5 million ton per year; the technical iodine production will grow 4.6 fold; sodium sulfate - 20.4 fold.

Due to realization of the measures including the construction of new units, plants based on up-to-date technologies, the advanced energy conservation technologies will be installed at the chemical enterprises. The available plants and units at the enterprises "Maryazot", "Garabogazsulfat" (bischofite production), Turkmenabat chemical plant (phosphoric fertilizers production), Khazar chemical plant (iodine production) will be reconstructed and upgraded.

It is assumed that after putting into operation of new chemical units the obsolete ineffective energy consuming units (iodine, bromide, sodium sulfate, sulfuric acid, calcium and carbamide production) will be removed. Realization of the measures will essentially increase the energy conservation indicator of the chemical enterprises.

In view of the fact that upon modernizing the abovementioned units will operate at full designed capacity, the total natural gas saving should make 350 million $m^3$ per year, and the electric power – 1.0 million kW/h.

The innovative-active scenario suggests for the chemical industry the implementation of projects on effective consumption of natural gas, electric power and heat. Realization of

the following projects will allow reduce GHG emission by 500-600 thousand $CO_2$-eqv ton per year.

1. Designing, mounting, starting-up and adjustment of electric filters to catch technical carbon at Khazar chemical plant
2. Stabilization of drilling water temperatures due to heat-insulating brine pipes at Khazar chemical plant
3. Reduction of heat losses due to improving heat-insulation at "Maryazot" enterprise
4. Reconstruction of boilers at "Maryazot" enterprise
5. Reconstruction of the workshop of non-concentrated nitric acid production at "Maryazot" enterprise
6. Major overhaul of boilers utilizing waste heat at the ammonia synthesis unit at "Maryazot" enterprise.
7. Major overhaul of boiler units and heat-insulated pipelines at "Garabogazsulfat" enterprise
8. Major overhaul of ammoniac cooling systems for producing sodium sulfate at "Garabogazsulfat" enterprise.
9. Heat-insulation of brine pipes and major overhaul of boiler units at Balkanabat iodine enterprise.
10. Major overhaul of boiler units, heat-insulation of pipelines and equipment at Turkmenabat chemical enterprise.

### 4.3.4. Industry of building materials

The Ministry of construction and building materials in Turkmenistan has 8 large industrial associations and enterprises producing around 30 kinds of building materials. The assortment includes 100 varieties of these items: various types of cement, building glass, slate, asbestos-cement and reinforced concrete pipes, ceramic brick, wall-concrete stones, non-metallic materials, reinforced concrete structures, enriched kaolin, facing materials of natural stones, waterproofing materials, ceramic tiles, etc.

Over 2000-2007, the output of this industry had grown significantly (6 fold). In 2007, the growth in cement production accounted for 101.6%; nonmetallic materials -123.2%; reinforced concrete structures -104.9%; wall materials - 101.5%; porous aggregate - 102.5%.

One of the main kinds of all this output is non-metallic materials - mortar sand, crushed stones. Their total production makes 3.5 million $m^3$ per year. To increase the production of nonmetallic materials the development program of the branch stipulates construction of new crashing-sorting lines and modernization of available ones.

To satisfy the needs of the country in building reinforcements, channel bars, angle bars, etc. the metallurgical works with the capacity of 160 thousand tons per year was put into operation in 2008. Iron-and-steel scrap is used as a raw material.

The cement production and the glass production are the main energy intensive enterprises of the industry of building materials in Turkmenistan.

Glass is produced in the Ashgabat glass-works that has already been operating over 50 years and has obsolete equipment of almost 100% depreciation. In 2007, production of glass reduced 2.8 fold compared to 2006. To satisfy the needs of Turkmenistan in high-quality glass there was taken the decision to construct a new glass-works based on float-glass technologies in Ovadandepe settlement. It will be put into operation in 2011. The annual glass output will equal 5.8 million $m^2$ of pane glass. Specific natural gas and electric power consumption per product unit will drop nearly 3 fold. Transparent and rendered glass, glass containers and dual-pane windows are planned to be produced.

Currently, cement is produced by 2 cement works in Kelyata and Bakharly settlements.

The first one uses obsolete technologies of wet-mix process. The other works was constructed and put into operation in 2005, with dry-mix process cement production. Specific natural gas consumption per product unit in Bakharly cement works is twice lower, and specific electric power consumption - by 20% less, than in the Kelyata cement works.

The development program of industry of building materials stipulates removal of the Kelyata cement works and construction in 2011 of the second cement works in Bakharly based on advanced technologies. It will lead also to notable reduction of natural gas and electric power consumption at these enterprises.

### 4.3.5. Housing and municipal services

The sector of municipal services including its regional departments managed by administration authorities (hyakimliks) is responsible for supply of heat and hot water to the households. In large cities the heat is delivered through the central heating systems. In Turkmenistan, each of 12 large cities has enterprises of heat supply managed by hyakimliks (city administration). Currently, about 70-75% of consumers in the cities get the heat from such central systems, and the rest ones get heat from stand alone gas furnaces.

For the central heating systems the heat is generated at thermal power stations (joint production of heat and electricity) and at boiler-houses. All the boiler-houses of large cities are at present time fully reconstructed with replacement of boilers in view of fuel saving and GHG emission reduction.

The city housing sector consists mainly of modern high-rise apartment houses and of apartment houses constructed in 1960-1991.

New houses are constructed with applying of advanced technologies. For instance, the walls are heat-insulated with foil-clad mineral cotton. According to the plans of increase of living area per person and in consideration of the population growth forecast, it is intended to supply heat to the new high-rise apartment houses from stand alone gas-fueled boiler-houses.

Old multi-storey apartment houses were constructed without taking into account the climatic conditions of Turkmenistan, including high solar radiation.

Effectiveness of the central heating system in cities is inadequate because of the following factors:

- the average efficiency of small boilers accounts for 50-60%, and of middle-size boilers - 75-80%;
- the one thirds of the heating network capacity falls to heating of premises;
- the heat losses because of leakage and unauthorized discharge of water are great (approximately 15-20% of total heat supply);
- the losses at main heat supply networks account for 8-15% because of insufficient insulation and leakages;
- the losses from internal heating system of buildings account for 10-20% because of insufficient conditions of the system functioning.

Quality of central heating system can be considerably improved by means of co-generation of heat and electric power. The heat is possible to be utilized at power stations, thus saving significant amounts of natural gas used for heat production and consequently reducing the GHG emission.

The "Program of socioeconomic development until 2020" provides priority to development of the socioeconomic sphere, manufacturing industry and oil-and-gas branch. Therefore, construction of residential buildings, boiler-houses, repair of schools, medical facilities and the heat, water and electricity supply enterprises are the priority directions of the strategy.

In 2006, under the UNDP/GEF project "Turkmenistan: improving efficiency of energy use in heat and hot water supply" implemented together with the Government, there was prepared the draft national strategy of centralized heat supply development. Realization of this project by elementary technological improvements would lead to saving of 20-30% of heat. In view of increase of gas export owing to the saved volumes, the return on investments would come within several years. During 15 years the natural gas saving would make over 19 billion thousand $m^3$, GHG emission reduction - 36.6 million tons in $CO_2$ equivalent.

## 4.4. Policy options to mitigate climate change

Growth of energy efficiency in the economy is the determining factor in elaboration of the policy of climate change addressing in Turkmenistan. Energy branches, including the oil-and-gas complex and the power engineering have a considerable potential for energy conservation and can contribute significantly to improvement of the national energy efficiency indicators and reduction of GHG emission in Turkmenistan.

By experts' estimations, in 2010-2030, the potential of energy saving in power engineering only will equal to 35-40 billion $m^3$ of natural gas, total decline in $CO_2$ emissions into atmosphere owing to energy saving will reach 65-75 million tons. In view of gas prices at the foreign market, the investments for most actions on increase of energy saving under the mitigation or innovative-active scenario would be recovered due to export of natural gas saved in the energy industries.

Clean Development Mechanism (CDM) of the Kyoto Protocol also offers certain opportunities to attract additional investments. Within 10 years, carbon profits from applying the steam-gas cycle technologies to a gas-turbine power station will amount to nearly US$ 45-50 million, that recovers 25-30% of the project realization cost.

However, as a rule, the technological development only is insufficient, and the energy conservation policy should be also focused on improvement of energy use norms and standards. For example, it is possible to establish the target norms in power engineering – a certain percentage of efficiency of power units in 2020 and 2030; in the oil branch - annual percentage increase in recycling of petroleum gases, in the gas branch - annual percentage decrease in amounts of gas consumption for own needs.

Presently, the legal framework in sphere of energy efficiency is not duly developed and has no direct influence; therefore either it should be revised or additional bylaws should be developed. It is necessary to develop a national program on energy conservation establishing strategic targets such as annual decrease in GDP energy consumption, achievement of energy efficiency targets in different spheres of the economy.

The legal framework for introduction of efficient energy saving measures should be based on energy conservation law aimed at encouraging the energy savings and creating the policy of state regulation of energy use and developing the RES-based power generation. To encourage using of renewable energy sources (RES) the law may specify tax concessions for investments to creation of RES-based plants and tax exemption to equipment and technologies for these plants. It is advisable to include to the national program on energy efficiency certain key targets for RES, for example, increase of RES share in the energy balance of the country by 1-2% within every five years.

It may be useful to set up a state fund of energy efficiency to invest to the energy efficiency measures. This fund can be financed by revenues from export of the natural gas saved.

Effective institutional mechanisms are the essential condition of implementation of productive measures and strategies in the sphere of energy efficiency. In this respect, it is necessary to establish in Turkmenistan a national authority responsible for pursuance of the state policy in sphere of sustainable energy resources use and energy conservation.

# CHAPTER 5. OTHER INFORMATION RELATED TO THE CONVENTION GOALS

## 5.1. Researches and systematic observations

Studying the issues of climate and its change is highly important for Turkmenistan as the annual average temperature of atmospheric air here is one of the highest in the world. It causes unfavorable conditions for the human organism functioning and for development of many national economy branches. In summer, when the air temperature becomes high, the use of energy resources sharply increases due to necessity of cooling housing and industrial facilities. In this regard, a possible drop in surface waters can accentuate even without that the pressing water consumption situation in the country.

Nonetheless, the research studies on climate change were conducted up to now in a limited scope. Not broad, episodic studies in the climate area (studies of climatic system processes, monitoring and model analysis of climate, vulnerability and adaptation, climate change mitigation) took place at some higher education institutions of the country (Turkmen State University named after Makhtumkuli, Turkmen University of Agriculture, Turkmen Medical Institute, Turkmen Polytechnic Institute) and at branch research institutes (National Institute of Deserts, Flora and Fauna of Ministry of Nature Protection of Turkmenistan, Scientific Research Institute "Suwilimtaslama" of Ministry of Water Management, Institute of Land Management of Ministry of Agriculture and others).

The current program of research and scientific work of the Academy of Science of Turkmenistan specifies the issues of nature protection among the priority ones. The goal of the program is introduction of new technologies, development of geological, solar-geophysical, radiation and other studies, improvement of observations over the state of environment; improvement of informational technologies on gathering, disseminating and managing of observational data, improvement of modeling and projecting methods while studying natural resources under conditions of arid climate; studying of physical processes in the Sun-Earth system, etc.

Turkmenistan takes part in many international projects and programs on climate study of UNEP, WMO, WHO, UNESCO and other organizations including:

- World Climate Program (WCP);
- World Climate Study Program (WCSP);
- Global Climate Observation System (GCOS).

Turkmenistan takes part in the activities undertaken by UNFCCC and IPCC. Ecological studies are conducted also under CA ISDC at the regional level.

International and regional cooperation on fulfillment of systematic climate observations in Turkmenistan is implemented through the World Meteorological Organization within the Interstate Board on Hydrometeorology, with the support of the International Fund for the Aral Sea.

The National Committee on Hydrometeorology under the Cabinet of Ministers of Turkmenistan (Turkmengidromet) is the main organization engaged in systematic observations of climate. According to Law on "Hydro-Meteorological Activity in Turkmenistan", the Cabinet of Ministers of Turkmenistan and the Turkmengidromet administer and regulate this activity. The Cabinet of Ministers defines the national policy in the hydrometeorology sphere, and Turkmengidromet directly implements this policy. In this connection, Turkmengidromet is responsible for organization of monitoring of atmosphere, marine environment, surface waters, agricultural crops and pastures, radiation on the surface of the earth. Turkmengidromet ensures development and functioning of observation network, system

of collecting, storing, processing, analyzing and disseminating of obtained data in order to provide monitoring.

Currently the meteorological observations in Turkmenistan are conducted at 48 points according to the working plan of the second class stations. These are regular 8-timeline observations of wind regime, air temperature and humidity, cloudiness, precipitation, soil temperature, solar radiance visibility and continuation, atmospheric events. The observations are performed at 37 points according to the program of meteorological point, i.e. regular 2-timeline observations of maximum and minimum air temperature, precipitation and atmospheric events. Compared to 1980-1989 period, when the greatest number of meteorological stations and points was available, the number of points reduced by over 30% and the number of stations reduced by 20% to the year 2002.

The agro-meteorological network was organized to cover each etrap (sub-region) of the agricultural zone of Turkmenistan. The biggest number of agro-meteorological observations was conducted in 1980-1989, full observations at 46 stations and reduced observations at 15 stations. At present time, the observations are performed by 3 velayat centers on hydrometeorology, at agro-meteorological station of Yoloten, 24 weather stations and 18 agro-meteorological points.

Currently, aerologic observations are performed only in Turkmenbashi city where they were launched in October, 1957. There, temperature and wind sounding of atmosphere is conducted to determine by altitude such characteristic indicators as wind direction and speed, air temperature and humidity, atmospheric pressure.

Total number of regular observation points checking the atmospheric ozone amount is five in territory of Turkmenistan – Ashgabat, Turkmenbashi, Turkmenabat, Repetek and Murgab. These observations of total ozone content were launched in December, 1961 in Ashgabat.

Currently, Ministry of Nature Protection of Turkmenistan is responsible for controlling the atmosphere pollution. The Research Production Center for Environmental Monitoring (RPCEM) is responsible for conduction of this control. This Center must provide the state administration agencies and economy sectors with information about environment pollution status and extreme situations caused by critical level of pollution.

The monitoring of atmospheric air pollution in Turkmenistan is performed at the stationary points located in Ashgabat, Abadan, Turkmenabat, Mary, Dashoguz, Turkmenbashi and Balkanabat cities. The following ingredients are controlled during the observations: solid substances (dust), carbon oxide, nitrogen dioxide and oxide, sulfur dioxide, formaldehyde, phenol, sulfates, hydrocarbons, hydrogen sulfide, ammonia, chlorine, anhydrous hydrogen fluoride. In the sanitary-hygienic zone of large industrial facilities the under flare observations of major contaminant emissions are periodically conducted. Also, route observation is performed to check concentration in the air of carbon oxide emitted from automobiles.

The hydrological observational points are based on the principle of covering all water units and obtaining the main indicator – annual water flow. Besides, there are the observations of water level and temperature, ice thickness and brash ice in the period of icing, weighted sediment discharge, turbidity and granulometric content of the weighted sediment.

At present, observations are conducted at seven points along the Amudarya River: Keliph, Mukri, Atamurat, Turkmenabat, Eljik, Birat and Lebap, three points of which are used for measuring of water discharge and weighted sediment.

The Garagum River and smaller rivers of Turkmenistan such as Murgab, Etrek, Tejen, Kugitang, Firyuzinka and Sekizyap are also provided with hydrological points in the required quantity.

The observations of the Caspian Sea regime are conducted at six marine stations – Turkmenbashi, Bekdash, Garabogazgol, Guvli-Mayak, Hazar and Ogurdjali (island Ogurchinskiy). Observations are conducted for level, temperature, salinity of water, coastal wind-induced waves as per standard time – 4 times per day. The Garabogazgol station conducts measurements of water discharge in the channel and observations of the Garabogazgol Bay water level and mineralization.

At present time, in Turkmenistan there is no program for conducting observations from the space. However, many organizations within their framework of work jointly with international organizations take part in different projects on satellite surveys of the territory of the country. For instance, the satellite information in photographs is received in "Turkmengidromet" since 1973.

## 5.2. Technologies transfer

The major sources of GHG emission into atmosphere in Turkmenistan are the oil and gas complex, power engineering and transport sector.

The growth dynamics of total GHG emissions in Turkmenistan is tightly connected to exploring, processing and using of fuel, irrational management of fuel and energy resources and using of obsolete technologies in the economy sectors.

Current status and development perspectives of the abovementioned sectors of the national economy suggest the quite necessity to renovate technologically the industrial units with environmentally safe innovations. The huge stocks of natural hydrocarbon resources proved by independent international experts and the considerable volume of produced oil and gas exported to foreign countries provide the possibility for Turkmenistan to follow the innovative way of development in all economy sectors. This is the priority direction of economy development in Turkmenistan. President of Turkmenistan notes that in regulation of investment activity the government will first of all strive to attract capital in a form of innovative technologies in all spheres of the economy. The oil and gas sector remains to be a leader of the economy. However, this sector has also outdated production parameters and some technologies need to be updated.

Development program of the oil and gas industry of Turkmenistan until 2030 ratified by Resolution of Halk Maslakhaty (People's Council) of Turkmenistan on October 25, 2006 envisages gas production increase to 250 billion of cubic meters and oil – to 100 million tons a year based on attraction of investments and advanced technologies.

The foreign investments and advanced technologies to the oil and gas complex are in the first place required for:

- development and technological enhancement of infrastructure, services;
- development of oil and gas refining;
- conduction of prospecting seismology, exploration work, well-drilling and full re pair of wells;
- intensification of oil and gas production;
- development of hydrocarbon resources of Turkmen sector of the Caspian Sea;
- construction of larger gas pipelines.

The present environmental state of the economy sectors of Turkmenistan by GHG emission level is not assessable quantitatively as in recent years no required targeted and scaled surveys have been conducted.

However, deep changes in the economy of the country over the independence years have allowed providing the main industrial sectors with advanced environmentally safe

technologies. The achievements of last years in this regard include the complete reconstruction of the Turkmenbashi Refinery and enterprises of leading economy sectors, the construction of new factories supplied with enhanced environmentally safe technologies. The construction of new and reconstruction of existing facilities have been implemented by foreign companies based on ecologically safe technologies. The characteristic feature of the developing economy of present Turkmenistan is the introduction and application of famous advanced technologies and techniques. The investments provided annually for this purpose amount to hundreds of millions of USD.

This aim is achieved in two directions of the innovative policy: using of the national scientific, intellectual potential to develop original local technologies and purchasing of foreign technologies adapted to local conditions.

The worldwide companies of Europe, the USA, Japan, Korea, Turkey and China conduct their activity today in Turkmenistan. The patent department of Ministry of Economy and Development of Turkmenistan has totally registered about 1 000 inventions and innovative technologies; over 41% out of them relate to technologies of the developed countries that have significantly influenced the modern development of the economy of the country. These worldwide companies include Siemens, General Electric, Dragon Oil, Schneider-Elektric, Enex,¬ Bouygues, Hyundai, Boeing, Komatsu and others that actively participate in realization of large-scale projects including the projects on development and modernization of key sectors of the national economy – oil and gas sector and power engineering, with supply of equipment for wind and solar power stations, communication facilities, agriculture and water management facilities, transport infrastructure, etc.

Inventions and innovative technologies registered in Turkmenistan cover such economy sectors as the oil and gas and chemical industries, power engineering, construction and mining, textile, agriculture, etc.

The growth of important segments of the innovation sector is rather notable, such as development and manufacturing of technical means for using of alternative energy sources. The actual problems are also elaborations related to reserved energy storage as well as crystal silicon processing technology for production of solar panels and other innovations.

Technologies transfer and their purchase on contractual basis are one of the ways of achievement of the economic development through advanced technological innovations. As of beginning of 2009, Turkmenistan has registered 27 license agreements and 17 agreements on cession of right for invention and technologies using.

The present system of industrial property protection in Turkmenistan ensures a proper legal protection of facilities of industrial property including inventions, technologies, know-how, useful models, industrial designs and trade marks, and guarantees security of advanced technologies import to the country.

The national protection system of industrial property includes the relevant legal base, the patent department with functions of accepting applications, performing examination, registration and publication of inventions, institute of patent attorney, appeal commission, patent -informational fund, judicial protection and community of inventors.

Participation of Turkmenistan in the Paris Convention on industrial property protection, in Treaty on patent cooperation, membership in the World Organization of Intellectual Property and the Eurasian Patent Organization provide to the owners of inventions and technologies the legal protection of industrial property at the world and regional level. Over 300 patents issued on the basis of Treaty on patent cooperation (WAPC) are effective today on the territory of Turkmenistan. The laws of Turkmenistan "On Inventions and Industrial

Designs" and "On Trade Marks, Service Marks and Names of Place of Commodity Origin" issued in November, 2008 have passed through international expertise in the World Organization of Intellectual Property and enhanced the guarantee of protection of inventions and technologies, proper protection of industrial property owner's rights at the national.

In addition to attracting foreign technologies, Turkmenistan has a certain own scientific-engineering potential of development and introduction of new technologies. The evidence to it is a big number of patents issued to local inventors. By the beginning of 2009, about 600 inventions of local inventors have been recorded in the state registrar of Turkmenistan.

As for total amount of patents issued to local inventors, 40% are referred to the oil and gas sector, 31% - to power engineering and chemical sectors, 16% - agriculture, 13% - to other sectors of the industry.

The present research, engineering, intellectual potential involving SRI, RPO, design departments and 300 inventors allows Turkmenistan to developing own elaborations of innovative technologies and technical solutions.

Development of innovative, ecologically safe technologies aimed at using the alternative renewable energy sources is one of priority trends of science in Turkmenistan. The Institute "Gyun" of Academy of Science of Turkmenistan is one of few institutions of the CIS countries that perform studies in the area of renewable energy sources. Agreement signed in 2009 between Government of Turkmenistan and Islamic Development Bank for provision of grant to finance research work on alternative energy sources allowed to expand this research.

In future, it is envisaged to design a conception of development alternative power engineering industry in Turkmenistan with suggestion of such directions as:

- purchasing of foreign units generating electric and heat energy while using alternative energy sources;
- manufacturing in Turkmenistan of technical means for the alternative energy sector;
- expanding of national scientific prospecting activity producing new technologies in the area of alternative power industry.

The issues of environmental security, GHG emission reduction, environment protection are reflected in the long-, medium- and short-term programs of socioeconomic development of Turkmenistan and also in the target programs of separate economic branches. Among the activities aimed at ensuring the environmental security there should be emphasized the introduction of energy-saving technologies. The modern easy-to-operate gas turbine units comply with the highest standards of labor and environment protection. In future, all these units will be switched to the combined operating cycle allowing usage of thermal energy of emissions that will also provide the efficiency increase.

The European Belgian Company "Enex" and the German Company "Schneider Elektric" will implement modernization of the power supply system of the country and deliver the advanced, environmentally safe technologies to the country.

The long-term development programs anticipate expanding of technological cooperation of Turkmenistan. In 2009, Turkmenistan and EU signed the memorandum on cooperation in the sphere of energy. The memorandum on long-term cooperation with one of the largest European energy companies "RWEAG" envisages its participation both in the projects on development of oil and gas fields of the Caspian Sea shelf, and in the projects of new energy technologies transfer. Signed and adopted by the European Parliament on April 22, 2009 a new trade-economic agreement between EU and Turkmenistan will become in future a foundation for considerable qualitative changes. This document provides great

opportunities for European companies that tend to supply their modern technologies and designs to the perspective Turkmen market. Within the framework of this agreement the Memorandum of Understanding and Cooperation in the energy sphere was signed.

According to Decree of President of Turkmenistan, on May 14, 2009 a corresponding inter-branch Commission was established in Turkmenistan to actively attract advanced technologies and foreign investments to the national economy through realization of ecologically safe and energy-saving technologies under Clean Development Mechanism of the Kyoto Protocol of UN Framework Convention on Climate Change.

## 5.3 Education, training and public awareness

"Education, training and public awareness on climate change issues and its impact" (Article 6, UNFCCC) hold an important place among activities envisaged by UNFCCC and are aimed to involve various groups of the society into activities related to climatic problems. In order to provide assistance for realization of all the elements of Article 6 of the Convention and public involvement into decision making and implementing process on UNFCCC goals achievement, the Delhi Working Program as per Article 6 of the Convention for the next 5 years was adopted at 8th Conference of Parties of UNFCCC in 2002, Delhi.

Turkmenistan as a participant of UNFCCC actively implements the Delhi WP as per Article 6 of UNFCCC providing the activities on education, trainings and public awareness on climate change issues and its impacts. This work is conducted at the national, regional and sub-regional levels within the country. Simultaneously, the discussions about the global climate change have identified a need of increasing public awareness in various population groups, lack of highly qualified personnel and educational materials on climate problems.

The State Commission on ensuring implementation compliance with Turkmenistan's obligations indicated in UN environmental conventions and programs was created to implement global conventions in Turkmenistan, including UNFCCC. Activities on public awareness and education on climate change issues in Turkmenistan are coordinated by Ministry of Nature Protection which is a responsible body for UNFCCC realization in Turkmenistan.

Public awareness and education on climate change cover different (target) population groups: scientists, teachers, school children, students, managers and specialists of ministries and departments of key economy sectors, industrial enterprises, business and private entrepreneurs, mass media representatives, active members of NGOs and public communities.

The main activities are focused on:

- conduction of trainings for different population groups;
- conduction of national workshops with participation of representatives of the min istries and departments, social workers, policy makers and specialists working on development of plans and strategies of individual economy sectors which influence the climate or to a large degree depend on climatic changes;
- participation at regional and international meetings on climate change and the Kyoto Protocol issues;
- development of methodological guidebooks and training materials for school children, students and teachers;
- release of popular science films and video;
- publication of informational booklets and calendars;
- conduction of ecological campaigns and ecology days dedicated to the World Environment Day and other important ecology events;
- presentations on TV channels and radio, preparation of articles and publications on climate change and its adverse impact in scientific magazines and newspapers.

Over last years, the public awareness in Turkmenistan has allowed to considerably increase interest and activities of people at all levels, yet a lot of job is to done further to fully cover the public.

In 1999, "National Program on Education and Upbringing of Pre-school Children in Turkmenistan" was adopted in accordance with International Declaration on Children's Rights, the Constitution of Turkmenistan and Law "On Education". For promotion of knowledge traditional extracurricular activities are widely applied such as the day of knowledge on ecology, thematic events, competitions, contests for drawings, lectures on nature protection which are organized by specialists of local agencies on nature protection, representatives of public organizations. In the recent years, after the adoption of Law "On Public Associations" (2003), their activities intensified.

According to Decree of President of Turkmenistan "On Education System Advancement in Turkmenistan", great attention is paid to compulsory environmental education in secondary schools and institutions of higher education of Turkmenistan. Teaching programs on the subjects "Natural Science" and "Ecology Basics" have been revised. The students study ecology basics, general provisions of nature protection and environmental legislation of Turkmenistan, as well as international environmental conventions. Furthermore, extra optional activities and thematic events are conducted as well as environmental clubs function.

Professional knowledge on science basics of climate change is possible to gain in two institutions of higher education of Turkmenistan. A study course "Meteorology and Climatology Basics" including climate change issues is taught at the meteorology department of the geography faculty of the Turkmen State Pedagogic Institute named after S.Seydi and at the ecology and hydrometeorology department of the natural geography faculty of the Turkmen State University named after Makhtumkuli. The program of this course was updated while preparing the National Communication of Turkmenistan on climate change.

The problem of human-induced climate change, except for scientific aspects of changes in climatic system, includes a number of economic, technical, technological and socio-political problems requiring the soonest response and solution.

The Turkmen Polytechnic Institute has been training engineers and technical ecologists specializing at "Environment Protection and Rational Management of Natural Resources" for production and technological, project constructor and research work in the sphere of technologies of waste treatment and utilization of industrial facilities, development of ecologically safe and energy-saving technologies. Major special disciplines are lectured such as "Applied Industrial Ecology", "Theoretical Basics of Environment Protection", "Chemistry of Environment", "Atmospheric Air Protection from Pollutants", "Waste-free Manufacturing and Secondary Resources", "Ecological Monitoring", "Projecting Basics and Ecological Expertise", "Human Ecology".

"Economy of Nature Management", "Environment Protection", "Ecology and Rational Management of Natural Resources" are lectured in different institutions of higher education.

Since 1997, 35 projects have been implemented and are currently implemented with support of "Tempus" at total cost of 8.5 million euro. Currently, 12 projects continue to be realized with financial support of 3 million euro. As it is known, one of the key trends of the educational reform in Turkmenistan is the broad international cooperation. In this large-scale process a priority is given to studying of the advanced world experience, inviting of teachers from leading high educational schools to work in our country, developing of study tours for students, establishing of close inter-institution and scientific contacts, introducing

of innovation teaching technologies including multimedia and informational technologies. There have been established the contacts between institutions of higher education of Turkmenistan and European countries under the EU program "Tempus".

While studying, the students of ecology specialties come to practical work at the subdivisions of Ministry of Nature Protection of Turkmenistan – at National Institute of Deserts, Flora and Fauna, at nature reserves and regional administrations of nature protection. Students of meteorology specialty work some time at the subdivisions of National Committee on Hydrometeorology. Under institutional measures on ecology education actively realized within the framework of NEAP, mass media is highly attracted to conduct public awareness campaigns.

A study work has been conducted in Turkmenistan on preparation and publication of new up-to-date educational and methodological materials including various respective issues of ecology and climate change problems.

Methodological textbooks "Ecology" have been published for teachers of secondary schools of Turkmenistan and also booklets "Climate Change and Sustainable Development" in Russian and English.

## 5.4. Constraints, gaps and capacity needs

The preparation of the Second National Communication of Turkmenistan on Climate Change showed that the level of understanding of climate change problems by the society has increased compared to the preparation period of the Initial National Communication. However, the urgency of climate change problem constantly growing within the latest decades and the present examples of its adverse impact on different aspects of the community sustainable development require strengthening of measures to mitigate climate change.

In 1991, after gaining the state independence, Turkmenistan chose a path of gradual transition to the market economy. The state regulation remained a foundation for economic relations in the transition period.

Particular attention by the government is given to the issues of using of natural resources and the nature protection. It is necessary in this work to engage all the opportunities and mechanisms for successful achievement of solutions and removal of gaps. In particular, it is important to perfect the legislative and institutional bases in order to enhance activities of the state as well as citizens in solving the climate change issues in Turkmenistan. The work in this area is mainly conducted within the framework of international projects on implementation of the obligations of Turkmenistan arising from the international environmental Conventions.

To achieve success corresponding to the urgency of the problem, it is necessary to further improve the legal regulatory base and create a government institutional structure based on proper financial support.

Existing constraints cause some gaps in implementing activity on the climate change problem. The main directions in streamlining of this activity include:

1. Development of the national strategy on climate change problem;
2. Further work on bringing of legislation of Turkmenistan referred to climate change problem into compliance with the international requirements;
3. Establishment of permanently functioning national institutional structure to deal with the issues of climate change;
4. Providing of trainings for personnel and organizing permanently functioning ex pertise work on preparation of national communications;
5. Complete reflection of climate change issues in the strategic programs of economic development of the country;

6. Full coverage of this problem by mass media;
7. Including of materials related to climate change problems into the educational plans and programs of higher educational institutions of Turkmenistan;
8. Translation into the state language of international documents on climate change;
9. Enhancement of coordination of activities of the ministries, departments and economic agents of Turkmenistan on cooperation in decision making related to climate change;
10. Expanding of international contacts of Turkmen specialists;
11. Publishing of educational, popular scientific and informational materials, meth odologies on climate change issues in the state language;
12. Development of the energy balance sheet of the country;
13. Wider distribution and highlighting of the government programs on branches development until 2030.

Existing constraints and gaps in the work on achieving the goals of UNFCCC in Turkmenistan confirm the importance of capacity building in this area. This issue was earlier raised also in such projects as INC/FNC/TNA, Regional project on inventory, Project on self-assessment of the national capacity, etc. The SNC preparation has demonstrated that many capacity needs identified in those documents still remain to be actual problem today. Present legislative, technical, institutional, methodological, financial and scientific-educational capacity building needs in respect of climate change can slow down the pace of development in the area of using of up-to-date, environmentally safe, energy-efficient and energy-saving technologies.

It is important to develop a national strategy on climate change to successfully perform the goals and tasks identified in UNFCCC. Under this document it is necessary to set a task of improving a system of assessment of GHG emissions and sinks through establishment of a national system on GHG inventory that will allow define in dynamics the "contribution" of Turkmenistan to the global warming. There is a need to improve statistical system of reporting by inclusion into it of data required to conduct GHG inventory. Furthermore, it is necessary to expand research work on climate change issues, for instance, on identifying of national coefficients of GHG emissions from different sources, on climate change impact on human health and on development of different economy sectors of Turkmenistan.

Due to difficulty to obtain some macroeconomic data while preparing SNC, the baseline scenario and mitigation scenario have been constructed mainly based on assumptions and expert estimations. For the same reasons it was not possible to use LEEP, MARCAL software, etc. which are assigned for computer modeling of GHG emissions in compliance with certain economic development of the country and separate branches of the economy. As this software requires a wide set of macroeconomic data as input data for models, construction of scenarios with using of software tools was not possible.

The current legal base referred to energy conservation is not fully developed and does not have a direct effect; therefore, it requires either reviewing or developing of additional by-law acts. To promote energy efficiency of production it is necessary to develop and pass a law on energy efficiency which shall contain a system of incentives.

The existing legal acts referred to energy conservation in such sectors as oil and gas complex and power engineering were developed over 20 years ago. They have become outdated and do not comply with the present standards. Therefore, it is necessary to improve norms and standards in the area of energy production and use.

It is highly important to restore preparation of the energy balance sheet on the regular basis and develop a strategy on radical energy saving for the nearest 20 years. Moreover,

it is necessary to continue assessment of vulnerability of different sectors to climate change. Development of adaptation strategy especially for vulnerable sectors is a priority task. Identifying priority areas of adaptation and development for them of adaptation measures are of high importance. On all priority sectors it is necessary with attraction of international institutes and experts to conduct analysis of costs and benefits of proposed adaptation measures for different scenarios of the economy development, population growth and climate change using software tools of modeling and submit the results to Government of Turkmenistan for consideration.

To strengthen international cooperation on climate change there is a need to attract leading experts of different ministries and departments to solve climate change issues, participate in the international discussions, conferences, seminars and meetings including conference of parties and sessions of UNFCCC. It is essential to take active part in the international network activities on climate change, especially in the Asian-Pacific network on climate change.

To fundamentally improve activities on climate change in Turkmenistan it is necessary to strengthen the material and technical basis of hydrometeorology service, expand the observational network and types of observation. Furthermore, it is highly important to widely cover climate change issues by mass media and advocate measures to mitigate climate change and adaptation to climate change among different groups of population. Results of work conducted under the SNC preparation have induced taking into account the clime change issues when preparing the long-term programs of branch development in certain economy branches, for instance in the Water Management. It is necessary to consider climate change issues when preparing medium-term and long-term development plans in all socially vulnerable sectors of the economy.

# Acronyms and abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| WB | World Bank |
| GDP | Gross domestic product |
| RES | Renewable energy sources |
| WMO | World Meteorological Organization |
| WHO | World Health Organization |
| IHE | Institution of higher education |
| SRPS | State regional power station |
| GCOS | Global Climate Observing System |
| GTU | Gas turbine unit |
| GTPS | Gas turbine power station |
| HFCs | Hydrofluorocarbons |
| | |
| GEF | Global Environment Facility |
| IWM | Integrated Water Management |
| CE | Coefficient of efficiency |
| CCD | Convention to Combat Desertification |
| CBD | Convention on Biodiversity |
| FF | Forests remaining forests |
| LF | Lands converted to forest lands |
| IPCC | Intergovernmental Panel on Climate Change |
| | |
| IFAS | International Fund for the Aral Sea |
| CDM | Clean Development Mechanism |
| NMCs | Non-methane carbons |
| NEAP | National Environmental Action Plan |
| | |
| | |
| OSCE | Organization for Security and Cooperation in Europe |
| GHG | Greenhouse gases |
| PPP | purchasing-power parity |
| UNDP | United Nations Development Program |
| UNFCC | United Nations Framework Convention on Climate Change |
| EU-Tacis | European Union's Technical Assistance to the Commonwealth of Independent States and Mongolia |
| SDW | Solid domestic wastes |
| FER | Fuel & energy resources |
| | |
| | |
| | |
| UNEP | United Nations Environment Program |
| UNESCO | UN Educational, Scientific and Cultural Organization |
| CROPWAT | Irrigation Model |
| FAO | Food and Agricultural Organization |
| LEAP | Long-range Alternatives Planning System |
| LULUCF | Land Use and Land Use Change in Forestry |
| MAGICC/SCENGEN | Model for GHG impact assessment on climate change and database for scenario construction |
| NCSP | National Communication Support Program |
| PRECIS | Regional model "Providing Regional Climates for Impacts Studies" |
| STAIR | Services, Transport, Agricultural, Industry and Residential energy model |
| WEAP | Water Evaluating and Planning System |
| WWF | World Wildlife Fund |

| Units of Measurement | |
|---|---|
| °C | Celsius degree |
| tcf | Tons of conventional fuel |
| ha | Hectare |
| km | Kilometer |
| $km^2$ | Square kilometer |
| $km^3$ | Cubic kilometer |
| $m^3$ | Cubic meter |
| mm | Millimeter |
| t | Ton |
| toe | Ton in oil equivalent |
| Gg $CO_2$-eqv. | Gigagram in $CO_2$-equivalent |
| Gcal. | Gigacalorie |
| kWh | Kilowatt-hour |
| MW | Megawatt |
| kg/ha | Kilogram per hectare |
| mg/L | Milligram per liter |

| Chemical symbols | |
|---|---|
| $H_2O$ | Water |
| CO | Carbon oxide |
| $CO_2$ | Carbon dioxide (carbonic gas) |
| HFCs | Hydrofluorocarbons |
| $N_2O$ | nitrous oxide |
| NOx | Nitrogen oxide |
| $CH_4$ | Methane |
| $SO_2$ | Sulfurous anhydride |

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# ANNEX

**Table 1**

## National inventory of anthropogenic emissions and sinks of GHG not controlled by Montreal Protocol, 1994, Gg

| Categories of GHG sources and sinks | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOCs | $SO_2$ |
|---|---|---|---|---|---|---|---|
| **Energy** | **14701.7250** | **768.5793** | **0.0657** | **46.8296** | **109.5943** | **12.9915** | |
| **A. Fuel combustion (by sectors)** | **14701.7250** | **0.5003** | **0.0657** | **46.8296** | **109.5943** | **12.9915** | |
| **1 Power engineering** | **6784.5810** | **0.1220** | **0.0120** | **18.2300** | **2.4270** | **0.6060** | |
| a Production of electric and heat power | 6784.5810 | 0.1220 | 0.0120 | 18.2300 | 2.4270 | 0.6060 | |
| **2 Processing industry** | **508.3850** | **0.0090** | **0.0009** | **1.3660** | **0.1820** | **0.0460** | |
| a) Chemical industry | 296.5540 | 0.0050 | 0.0005 | 0.7970 | 0.1060 | 0.0270 | |
| b) Production of construction materials | 211.8310 | 0.0040 | 0.0004 | 0.5690 | 0.0760 | 0.0190 | |
| c) Textile industry | - | - | - | - | - | - | |
| d) Other* | | | | | | | |
| **3 Transport** | **860.7300** | **0.2520** | **0.0410** | **9.6370** | **104.6390** | **11.7530** | |
| a) Civil aviation | - | - | - | - | - | - | |
| b) Automobile transport | 860.7300 | 0.2520 | 0.0410 | 9.6370 | 104.6390 | 11.7530 | |
| c) Railway transport | - | - | - | - | - | - | |
| d) Water transport | - | - | - | - | - | - | |
| **4 Other sectors** | **5146.5300** | **0.0922** | **0.0093** | **13.8304** | **1.8441** | **0.4610** | |
| **a) Municipal sector** | 1853.3300 | 0.0332 | 0.0033 | 4.9804 | 0.6641 | 0.1660 | |
| **b) Households** | 3293.2040 | 0.0590 | 0.0060 | 8.8500 | 1.1800 | 0.2950 | |
| **c) Other *** | 1401.4990 | 0.0251 | 0.0025 | 3.7662 | 0.5022 | 0.1255 | |
| **B Methane emissions from oil and gas operation** | | **768.0790** | | | | | |
| **1 Oil and natural gas** | | 768.0790 | | | | | |
| a) Oil | | 0.6070 | | | | | |
| b) Natural gas | | 745.3640 | | | | | |
| c) Ventilation and combustion in flares while producing oil and gas | | 22.1080 | | | | | |
| **Memo items** | | | | | | | |
| International bunker | | | | | | | |
| Aviation | | | | | | | |
| Marine | | | | | | | |
| **$CO_2$ emissions from biomass** | | | | | | | |
| **Industrial processes** | **495.9503** | **0.0693** | **1.1266** | **2.0053** | **0.8649** | **5.7193** | **1.4458** |
| **A Production of minerals** | **343.7003** | | | | | **0.0721** | **0.207** |
| **1 Production of cement** | **340.9417** | | | | | | **0.207** |
| **2 Production of lime** | - | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 Production of glass | 2.7586 | | | | | 0.0721 | |
| B Chemical production | 152.25 | 0.0693 | 1.1266 | 2.0053 | 0.8649 | 0.7291 | 1.2388 |
| 1 Production of ammonia | 152.25 | | | | 0.8019 | 0.4771 | 0.003 |
| 2 Production of nitric acid | | | 1.1266 | 2.0028 | | | |
| 3 Production of sulfuric acid | | | | | | | 1.2163 |
| 4 Production of technical carbon | | 0.0693 | | 0.0025 | 0.063 | 0.252 | 0.0195 |
| C Other production | | | | | | 4.9181 | |
| 1 Production of foodstuffs and drinks | | | | | | 4.9181 | |
| D Using fluorocarbons and sulfur hexafluoride | | | | | | | |
| 1 Refrigerators and air-conditioners | | | | | | | |
| 2 foam fire extinguishers | | | | | | | |
| 3 Other extinguishers | | | | | | | |
| 4 Aerosols | | | | | | | |
| 5 Dissolvent | | | | | | | |
| E Other | | | | | | | |
| Agriculture | | 111.03 | 1.74 | | | | |
| A Enteric fermentation | | 108.15 | | | | | |
| B Growing rice | | 2.88 | | | | | |
| C Agricultural soils | | | 1.74 | | | | |
| "Land use, lands use change and forestry" | | | | | | | |
| A Forestry | | | | | | | |
| 1 Forests remaining forests | | | | | | | |
| 2 Lands converted to forest lands | | | | | | | |
| 3 Fires (Burnt biomass) | | | | | | | |
| B Land use. Land use change | | | | | | | |
| 1 Land use change | | | | | | | |
| 2 Perennial plantings | | | | | | | |
| 3 Human settlements | | | | | | | |
| Total waste | | 15.3 | | | | | |
| A Solid wastes | | 15.3 | | | | | |
| 1 Controlled wastes | | | | | | | |
| 2 Non-controlled wastes | | 15.3 | | | | | |
| 3 Other | | | | | | | |
| B Waste water | | | | | | | |
| 1 Industrial waste water | | | | | | | |
| 2 Domestic and commercial waste water | | | | | | | |
| 3 Other | | | | | | | |
| C Burnt wastes | | | | | | | |
| D Other | | | | | | | |

**Table 2**

## National inventory of anthropogenic emissions and sinks of GHG not controlled by Montreal Protocol, 2000, Gg

| Categories of GHG sources and sinks | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOCs | $SO_2$ |
|---|---|---|---|---|---|---|---|
| **Energy** | **23425.6730** | **1042.2102** | **0.1710** | **79.3897** | **177.4839** | **21.6676** | |
| **A Fuel combustion (by sectors)** | **23425.6730** | **0.7239** | **0.1710** | **79.3897** | **177.4839** | **21.6676** | |
| **1 Power engineering** | **6910.9620** | **0.1247** | **0.0126** | **18.5685** | **2.4690** | **0.6180** | |
| a Production of electric and heat power | 6910.9620 | 0.1247 | 0.0126 | 18.5685 | 2.4690 | 0.6180 | |
| **2 Processing industry** | **1495.8080** | **0.0272** | **0.0028** | **4.0183** | **0.5331** | **0.1336** | |
| a Chemical industry | 289.8410 | 0.0052 | 0.0005 | 0.7789 | 0.1039 | 0.0260 | |
| b Production of construction materials | 215.6830 | 0.0039 | 0.0004 | 0.5796 | 0.0773 | 0.0193 | |
| c Textile industry | 101.0050 | 0.0022 | 0.0003 | 0.2701 | 0.0333 | 0.0086 | |
| d Other* | 889.2790 | 0.0159 | 0.0016 | 2.3897 | 0.3186 | 0.0797 | |
| **3 Transport** | **1846.1130** | **0.3360** | **0.1320** | **21.4040** | **169.7620** | **19.7360** | |
| a Civil aviation | 257.2580 | 0.0070 | 0.0000 | 1.0210 | 0.4250 | 0.0640 | |
| b Automobile transport | 1377.9220 | 0.3120 | 0.1270 | 15.4660 | 167.6100 | 19.3080 | |
| c Railway transport | 210.9340 | 0.0170 | 0.0050 | 4.9160 | 1.7270 | 0.3640 | |
| d Water transport | Н.д. | Н.д. | Н.д. | Н.д. | Н.д. | Н.д. | |
| **4 Other sectors** | **12283.5110** | **0.2201** | **0.022** | **33.0092** | **4.4012** | **1.1003** | |
| a Municipal sector | 2231.9300 | 0.0400 | 0.0040 | 5.9978 | 0.7997 | 0.1999 | |
| b Households | 10051.5810 | 0.1801 | 0.0180 | 27.0114 | 3.6015 | 0.9004 | |
| c Other * | 889.2790 | 0.0159 | 0.0016 | 2.3897 | 0.3186 | 0.0797 | |
| **B Methane emissions from oil and gas operations** | | **1041.4863** | | | | | |
| **1 Oil and natural gas** | | **1041.4863** | | | | | |
| a Oil | | 1.1181 | | | | | |
| b Natural gas | | 1011.057 | | | | | |
| c Ventilation and combustion in flares while producing oil and gas | | 29.3112 | | | | | |
| **Memo items** | | | | | | | |
| International bunker | 80.882 | 0.002 | 0.000 | 0.321 | 0.134 | 0.020 | |
| Aviation | 80.882 | 0.002 | 0.000 | 0.321 | 0.134 | 0.020 | |
| Marine | | | | | | | |
| **$CO_2$ emissions from biomass** | | | | | | | |
| **Industrial processes** | **397.2146** | **0.0165** | **1.2947** | **2.3022** | **0.9409** | **8.1482** | **0.7729** |
| **A Production of minerals** | **221.4062** | | | | | **0.162** | **0.1259** |
| **1 Production of cement** | **207.4115** | | | | | | **0.1259** |
| **2 Production of lime** | **7.7955** | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **3 Production of glass** | **6.1992** | | | | | **0.162** | |
| **B Chemical production** | **175.8084** | **0.0165** | **1.2947** | **2.3022** | **0.9409** | **0.6109** | **1.6269** |
| **1 Production of ammonia** | **175.8084** | | | | **0.9259** | **0.5509** | **0.0035** |
| **2 Production of nitric acid** | | | **1.2947** | **2.3016** | | | |
| **3 Production of sulfuric acid** | | | | | | | **1.6188** |
| **4 Production of technical carbon** | | **0.0165** | | **0.0006** | **0.015** | **0.06** | **0.047** |
| **C Other production** | | | | | | **7.3753** | |
| **1 Production of foodstuffs and drinks** | | | | | | **7.3753** | |
| **D Using fluorocarbons and sulfur hexafluoride** | | | | | | | |
| **1 Refrigerators and air-conditioners** | | | | | | | |
| **2 foam fire extinguishers** | | | | | | | |
| **3 Other extinguishers** | | | | | | | |
| **4 Aerosols** | | | | | | | |
| **5 Dissolvent** | | | | | | | |
| **E Other** | | | | | | | |
| **Agriculture** | | **107.71** | **1.99** | | | | |
| **A Enteric fermentation** | | 106.99 | | | | | |
| **B Growing rice** | | 0.72 | | | | | |
| **C Agricultural soils** | | | 1.99 | | | | |
| **"Land use, lands use change and forestry"** | **-714.265** | - | - | - | - | - | - |
| **A Forestry** | | - | - | - | - | - | - |
| **1 Forests remaining forests** | 52.611 | - | - | - | - | - | - |
| **2 Lands converted to forest lands** | -782.291 | - | - | - | - | - | - |
| **3 Fires (Burnt biomass)** | | - | - | - | - | - | - |
| **B Land use. Land use change** | | - | - | - | - | - | - |
| **1 Land use change** | 0.032 | | | | | | |
| **2 Perennial plantings** | 57.576 | - | - | - | - | - | - |
| **3 Human settlements** | -42.193 | - | - | - | - | - | - |
| **Total waste** | | **18.25** | | | | | |
| **A Solid wastes** | | ***18.25*** | | | | | |
| **1 Controlled wastes** | | | | | | | |
| **2 Non-controlled wastes** | | 18.25 | | | | | |
| **3 Other** | | | | | | | |
| **B Waste water** | | | | | | | |
| **1 Industrial waste water** | | | | | | | |
| **2 Domestic and commercial waste water** | | | | | | | |
| **3 Other** | | | | | | | |
| **C Burnt wastes** | | | | | | | |
| **D Other** | | | | | | | |

**Table 3**

## National inventory of anthropogenic emissions and sinks of GHG not controlled by Montreal Protocol, 2004, Gg

| Categories of GHG sources and sinks | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOCs | $SO_2$ |
|---|---|---|---|---|---|---|---|
| **Energy** | **25181.1730** | **1296.9469** | **0.2916** | **87.9390** | **237.1814** | **27.6556** | |
| **A Fuel combustion (by sectors)** | **25181.1730** | **0.8492** | **0.2916** | **87.9390** | **237.1814** | **27.6556** | |
| **1 Power engineering** | **8248.0670** | **0.1496** | **0.0153** | **22.1583** | **2.9412** | **0.6791** | |
| a Production of electric and heat power | 8248.0670 | 0.1496 | 0.0153 | 22.1583 | 2.9412 | 0.7311 | |
| **2 Processing industry** | **802.7200** | **0.0145** | **0.0015** | **2.1564** | **0.2861** | **0.0710** | |
| a Chemical industry | 382.3210 | 0.0068 | 0.0007 | 1.0274 | 0.1370 | 0.0342 | |
| b Production of construction materials | 242.6430 | 0.0043 | 0.0004 | 0.652 | 0.0869 | 0.0217 | |
| c Textile industry | 177.7560 | 0.0034 | 0.0004 | 0.477 | 0.0622 | 0.0151 | |
| d Other* | | | | | | | |
| **3 Transport** | **2284.4570** | **0.4370** | **0.2500** | **26.4160** | **228.9930** | **25.6590** | |
| a Civil aviation | 234.7260 | 0.0060 | 0.0000 | 0.9320 | 1.0000 | 0.0580 | |
| b Automobile transport | 1817.1530 | 0.4100 | 0.2440 | 20.3020 | 226.7850 | 25.2180 | |
| c Railway transport | 222.3470 | 0.0170 | 0.0060 | 5.1820 | 1.8200 | 0.3840 | |
| d Water transport | 10.2300 | 0.0020 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| **4 Other sectors** | **12977.3540** | **0.2325** | **0.0232** | **34.8742** | **4.6499** | **1.1624** | |
| a Municipal sector | 2802.5260 | 0.0502 | 0.005 | 7.5312 | 1.0042 | 0.2510 | |
| b Households | 10174.8280 | 0.1823 | 0.0182 | 27.3430 | 3.6457 | 0.9114 | |
| c Other * | 868.5750 | 0.0156 | 0.0016 | 2.3341 | 0.3112 | 0.0841 | |
| **B Methane emissions from oil and gas activities** | | **1296.0977** | | | | | |
| **1 Oil and natural gas** | | **1296.0977** | | | | | |
| a Oil | | 1.5007 | | | | | |
| b Natural gas | | 1258.2064 | | | | | |
| c Ventilation and combustion in flares while producing oil and gas | | 36.3906 | | | | | |
| **Memo items** | | | | | | | |
| International bunker | 90.600 | 0.003 | 0.000 | 0.360 | 0.150 | 0.022 | |
| Aviation | 90.600 | 0.003 | 0.000 | 0.360 | 0.150 | 0.022 | |
| Marine | | | | | | | |
| **$CO_2$ emissions from biomass** | | | | | | | |
| **Industrial processes** | **344.8836** | **0.0231** | **1.2933** | **2.3** | **1.115** | **10.8046** | **2.426** |
| **A Production of minerals** | **137.1576** | | | | | **0.1242** | **0.0756** |
| **1 Production of cement** | **124.5359** | | | | | | **0.0756** |
| **2 Production of lime** | **7.8693** | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **3 Production of glass** | **4.7527** | | | | | **0.1242** | |
| **B Chemical production** | **207.726** | **0.0231** | **1.2933** | **2.3** | **1.115** | **0.7349** | **2.3504** |
| **1 Production of ammonia** | **207.726** | | | | **1.094** | **0.6509** | **0.0042** |
| **2 Production of nitric acid** | | | **1.2933** | **2.2992** | | | |
| **3 Production of sulfuric acid** | | | | | | | **2.3398** |
| **4 Production of technical carbon** | | **0.0231** | | **0.0008** | **0.021** | **0.084** | **0.0065** |
| **C Other production** | | | | | | **9.9455** | |
| **1 Production of foodstuffs and drinks** | | | | | | **9.9455** | |
| **D Using fluorocarbons and sulfur hexafluoride** | | | | | | | |
| **1 Refrigerators and air-conditioners** | | | | | | | |
| **2 foam fire extinguishers** | | | | | | | |
| **3 Other extinguishers** | | | | | | | |
| **4 Aerosols** | | | | | | | |
| **5 Dissolvent** | | | | | | | |
| **E Other** | | | | | | | |
| **Agriculture** | | **262.66** | **4.16** | | | | |
| **A Enteric fermentation** | | 260.68 | | | | | |
| **B Growing rice** | | 1.98 | | | | | |
| **C Agricultural soils** | | | 4.16 | | | | |
| **"Land use, lands use change and forestry"** | **-829.996** | | | | | | |
| **A Forestry** | | | | | | | |
| **1 Forests remaining forests** | 72.653 | | | | | | |
| **2 Lands converted to forest lands** | -919.127 | | | | | | |
| **3 Fires (Burnt biomass)** | 0.818 | | | | | | |
| **B Land use. Land use change** | | | | | | | |
| **1 Land use change** | 0.032 | | | | | | |
| **2 Perennial plantings** | 57.576 | | | | | | |
| **3 Human settlements** | -41.948 | | | | | | |
| **Total waste** | | **24.32** | | | | | |
| **A Solid wastes** | | ***24.32*** | | | | | |
| **1 Controlled wastes** | | | | | | | |
| **2 Non-controlled wastes** | | 24.32 | | | | | |
| **3 Other** | | | | | | | |
| **B Waste water** | | | | | | | |
| **1 Industrial waste water** | | | | | | | |
| **2 Domestic and commercial waste water** | | | | | | | |
| **3 Other** | | | | | | | |
| **C Burnt wastes** | | | | | | | |
| **D Other** | | | | | | | |

**Table 4**

## GHG emissions and sinks in Gg of $CO_2$-eqvivalent in 1994

| Categories of GHG sources and sinks | $CO_2$ | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Total |
|---|---|---|---|---|---|---|---|
| **Sum of national emissions and sinks** | **15197.675** | **18794.551** | **909.013** | | | | **34901.239** |
| **Energy** | 14701.7250 | 16140.1653 | 20.3670 | | | | 30862.2573 |
| **A Fuel combustion (by sectors)** | 14701.7250 | 10.5063 | 20.3670 | | | | 14732.5983 |
| **1 Power engineering** | 6784.5810 | 2.5620 | 3.7200 | | | | 6790.8630 |
| a Production of electric and heat power | 6784.5810 | 2.5620 | 3.7200 | | | | 6790.8630 |
| **2 Processing industry** | 508.3850 | 0.1890 | 0.2790 | | | | 508.8530 |
| a Chemical industry | 296.5540 | 0.1050 | 0.1550 | | | | 296.8140 |
| b Production of construction materials | 211.8310 | 0.0840 | 0.1240 | | | | 212.0390 |
| c Textile industry | | | | | | | |
| d Other* | | | | | | | |
| **3 Transport** | 860.7300 | 5.2920 | 12.7100 | | | | 878.7320 |
| a Civil aviation | | | | | | | |
| b Automobile transport | 860.7300 | 5.2920 | 12.7100 | | | | 878.7320 |
| c Railway transport | | | | | | | |
| d Water transport | | | | | | | |
| **4 Other sectors** | 5146.5300 | 1.9362 | 2.8830 | | | | 5151.3492 |
| a Municipal sector | 1853.3300 | 0.6972 | 1.0230 | | | | 1855.0502 |
| b Households | 3293.2040 | 1.2390 | 1.8600 | | | | 3296.3030 |
| c Other * | 1401.4990 | 0.5271 | 0.7750 | | | | 1402.8011 |
| **B Methane emissions from oil and gas operations** | | 16129.6590 | | | | | 16129.6590 |
| **1 Oil and natural gas** | | 16129.6590 | | | | | 16129.6590 |
| a Oil | | 12.7470 | | | | | 12.7470 |
| b Natural gas | | 15652.6440 | | | | | 15652.6440 |
| c Ventilation and combustion in flares while producing oil and gas | | 464.2680 | | | | | 464.2680 |
| **Memo items** | | | | | | | |
| International bunker | | | | | | | |
| Aviation | | | | | | | |
| Marine | | | | | | | |
| **$CO_2$ emissions from biomass** | | | | | | | |
| **Industrial processes** | 495.9503 | 1.4553 | 349.2460 | | | | 846.6516 |
| **A Production of minerals** | 343.7003 | | | | | | 343.7003 |
| **1 Production of cement** | 340.9417 | | | | | | 340.9417 |
| **2 Production of lime** | | | | | | | |
| **3 Production of glass** | 2.7586 | | | | | | 2.7586 |
| **B Chemical production** | 152.2500 | 1.4553 | 349.2460 | | | | 502.9513 |
| **1 Production of ammonia** | 152.2500 | | | | | | 152.2500 |
| **2 Production of nitric acid** | | | 349.2460 | | | | 349.2460 |
| **3 Production of sulfuric acid** | | | | | | | |
| **4 Production of technical carbon** | | 1.4553 | | | | | 1.4553 |
| **C Other production** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 Production of foodstuffs and drinks | | | | | | | |
| D Using fluorocarbons and sulfur hexafluoride | | | | | | | |
| 1 Refrigerators and air-conditioners | | | | | | | |
| 2 foam fire extinguishers | | | | | | | |
| 3 Other extinguishers | | | | | | | |
| 4 Aerosols | | | | | | | |
| 5 Dissolvent | | | | | | | |
| E Other | | | | | | | |
| Agriculture | | 2331.6300 | 539.4000 | | | | 2871.0300 |
| A Enteric fermentation | | 2271.1500 | | | | | 2271.1500 |
| B Growing rice | | 60.4800 | | | | | 60.4800 |
| C Agricultural soils | | | 539.4000 | | | | 539.4000 |
| "Land use, lands use change and forestry" | | | | | | | |
| A Forestry | | | | | | | |
| 1 Forests remaining forests | | | | | | | |
| 2 Lands converted to forest lands | | | | | | | |
| 3 Fires (Burnt biomass) | | | | | | | |
| B Land use. Land use change | | | | | | | |
| 1 Land use change | | | | | | | |
| 2 Perennial plantings | | | | | | | |
| 3 Human settlements | | | | | | | |
| Total waste | | 321.3000 | | | | | 321.3000 |
| A Solid wastes | | 321.3000 | | | | | 321.3000 |
| 1 Controlled wastes | | | | | | | |
| 2 Non-controlled wastes | | | | | | | |
| 3 Other | | | | | | | |
| B Waste water | | | | | | | |
| 1 Industrial waste water | | | | | | | |
| 2 Domestic and commercial waste water | | | | | | | |
| 3 Other | | | | | | | |
| C Burnt wastes | | | | | | | |
| D Other | | | | | | | |

**Table 5**

## GHG emissions and sinks in Gg of $CO_2$-eqvivalent, in 2000

| Categories of GHG sources and sinks | $CO_2$ | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Total |
|---|---|---|---|---|---|---|---|
| **Sum of national emissions and sinks** | **23822.888** | **24531.921** | **1071.267** | ***1,07*** | | | **49426.075** |
| **Energy** | 23425.6730 | 21886.4142 | 53.0100 | | | | 45365.0972 |
| **A Fuel combustion (by sectors)** | 23425.6730 | 15.2019 | 53.0100 | | | | 23493.8849 |
| **1 Power engineering** | 6910.9620 | 2.6187 | 3.9060 | | | | 6917.4867 |
| a Production of electric and heat power | 6910.9620 | 2.6187 | 3.9060 | | | | 6917.4867 |
| **2 Refining industry** | 1495.8080 | 0.5712 | 0.8680 | | | | 1497.2472 |
| a Chemical industry | 289.8410 | 0.1092 | 0.1550 | | | | 290.1052 |
| b Production of construction materials | 215.6830 | 0.0819 | 0.1240 | | | | 215.8889 |
| c Textile industry | 101.0050 | 0.0462 | 0.0930 | | | | 101.1442 |
| d Other* | 889.2790 | 0.3339 | 0.4960 | | | | 890.1089 |
| **3 Transport** | 1846.1130 | 7.0560 | 40.9200 | | | | 1894.0890 |
| a Civil aviation | 257.2580 | 0.1470 | | | | | 257.4050 |
| b Automobile transport | 1377.9220 | 6.5520 | 39.3700 | | | | 1423.8440 |
| c Railway transport | 210.9340 | 0.3570 | 1.5500 | | | | 212.8410 |
| d Water transport | | | | | | | |
| **4 Other sectors** | 12283.5110 | 4.6221 | 6.8200 | | | | 12294.9531 |
| a Municipal sector | 2231.9300 | 0.8400 | 1.2400 | | | | 2234.0100 |
| b Households | 10051.5810 | 3.7821 | 5.5800 | | | | 10060.9431 |
| c Other * | 889.2790 | 0.3339 | 0.4960 | | | | 890.1089 |
| **B Methane emissions from oil and gas activities** | | 21871.2123 | | | | | 21871.2123 |
| **1 Oil and natural gas** | | 21871.2123 | | | | | 21871.2123 |
| a Oil | | 23.4801 | | | | | 23.4801 |
| b Natural gas | | 21232.1970 | | | | | 21232.1970 |
| c Ventilation and combustion in flares while producing oil and gas | | 615.5352 | | | | | 615.5352 |
| **Memo items** | | | | | | | |
| International bunker | 80.8820 | 0.0420 | | | | | 80.9240 |
| Aviation | 80.8820 | 0.0420 | | | | | 80.9240 |
| Marine | | | | | | | |
| **$CO_2$ emissions from biomass** | | | | | | | |
| **Industrial processes** | 397.2146 | 0.3465 | 401.3570 | 1,07 | | | 798.9181 |
| **A Production of minerals** | 221.4062 | | | | | | 221.4062 |
| **1 Production of cement** | 207.4115 | | | | | | 207.4115 |
| **2 Production of lime** | 7.7955 | | | | | | 7.7955 |
| **3 Production of glass** | 6.1992 | | | | | | 6.1992 |
| **B Chemical production** | 175.8084 | 0.3465 | 401.3570 | | | | 577.5119 |
| **1 Production of ammonia** | 175.8084 | | | | | | 175.8084 |
| **2 Production of nitric acid** | | | 401.3570 | | | | 401.3570 |
| **3 Production of sulfuric acid** | | | | | | | |
| **4 Production of technical carbon** | | 0.3465 | | | | | 0.3465 |
| **C Other production** | | | | | | | |
| **1 Production of foodstuffs and drinks** | | | | | | | |
| **D Using fluorocarbons and sulfur hexafluoride** | | | | 1,07 | | | |
| **1 Refrigerators and air-conditioners** | | | | | | | |
| **2 foam fire extinguishers** | | | | | | | |
| **3 Other extinguishers** | | | | | | | |
| **4 Aerosols** | | | | | | | |
| **5 Dissolvent** | | | | | | | |
| **E Other** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Agriculture** | | 2261.9100 | 616.9000 | | | | 2878.8100 |
| **A Enteric fermentation** | | 2246.7900 | | | | | 2246.7900 |
| **B Growing rice** | | 15.1200 | | | | | 15.1200 |
| **C Agricultural soils** | | | 616.9000 | | | | 616.9000 |
| **"Land use, lands use change and forestry"** | -714.2650 | | | | | | -714.2650 |
| **A Forestry** | | | | | | | |
| **1 Forests remaining forests** | 52.6110 | | | | | | 52.6110 |
| **2 Lands converted to forests lands** | -782.2910 | | | | | | -782.2910 |
| **3 Fires (Burned biomass)** | | | | | | | |
| **B Land use. Land use change** | | | | | | | |
| **1 Land use change** | 0.0320 | | | | | | 0.0320 |
| **2 Perennial plantings** | 57.5760 | | | | | | 57.5760 |
| **3 Human settlements** | -42.1930 | | | | | | -42.1930 |
| **Total waste** | | 383.2500 | | | | | 383.2500 |
| **A Hard wastes** | | 383.2500 | | | | | 383.2500 |
| **1 Controlled wastes** | | | | | | | |
| **2 Non-controlled wastes** | | 383.2500 | | | | | 383.2500 |
| **3 Other** | | | | | | | |
| **B Waste water** | | | | | | | |
| **1 Industrial waste water** | | | | | | | |
| **2 Domestic and commercial waste water** | | | | | | | |
| **3 Other** | | | | | | | |
| **C Burned wastes** | | | | | | | |
| **D Other** | | | | | | | |

**Table 6**

## GHG emissions and sinks in Gg $CO_2$-eqv. in 2004

| Categories of GHG sources and sinks | $CO_2$ | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Total |
|---|---|---|---|---|---|---|---|
| **Sum of national emissions and sinks** | **25526.057** | **33262.95** | **1780.919** | **11.43** | | | **60569.926** |
| **Energy** | 25181.1730 | 27235.8849 | 90.3960 | | | | 52507.4539 |
| **A Fuel combustion (by sectors)** | 25181.1730 | 17.8332 | 90.3960 | | | | 25289.4022 |
| **1 Power engineering** | 8248.0670 | 3.1416 | 4.7430 | | | | 8255.9516 |
| a Production of electric and heat power | 8248.0670 | 3.1416 | 4.7430 | | | | 8255.9516 |
| **2 Refining industry** | 802.7200 | 0.3045 | 0.4650 | | | | 803.4895 |
| a Chemical industry | 382.3210 | 0.1428 | 0.2170 | | | | 382.6808 |
| b Production of construction materials | 242.6430 | 0.0903 | 0.1240 | | | | 242.8573 |
| c Textile industry | 177.7560 | 0.0714 | 0.1240 | | | | 177.9514 |
| d Other* | | | | | | | |
| **3 Transport** | 2284.4570 | 9.1770 | 77.5000 | | | | 2371.1340 |
| a Civil aviation | 234.7260 | 0.1260 | | | | | 234.8520 |
| b Automobile transport | 1817.1530 | 8.6100 | 75.6400 | | | | 1901.4030 |
| c Railway transport | 222.3470 | 0.3570 | 1.8600 | | | | 224.5640 |
| d Water transport | 10.2300 | 0.0420 | | | | | 10.2720 |
| **4 Other sectors** | 12977.3540 | 4.8825 | 7.1920 | | | | 12989.4285 |
| a Municipal sector | 2802.5260 | 1.0542 | 1.5500 | | | | 2805.1302 |
| b Population | 10174.8280 | 3.8283 | 5.6420 | | | | 10184.2983 |
| c Other * | 868.5750 | 0.3276 | 0.4960 | | | | 869.3986 |
| **B Methane emissions from oil and gas activities** | | 27218.0517 | | | | | 27218.0517 |
| **1 Oil and natural gas** | | 27218.0517 | | | | | 27218.0517 |
| a Oil | | 31.5147 | | | | | 31.5147 |
| b Natural gas | | 26422.3344 | | | | | 26422.3344 |
| c Ventilation and combustion in flares while producing oil and gas | | 764.2026 | | | | | 764.2026 |
| **Memo items** | | | | | | | |
| International bunker | 90.6000 | 0.0630 | | | | | 90.6630 |
| Aviation | 90.6000 | 0.0630 | | | | | 90.6630 |
| Marine | | | | | | | |
| **$CO_2$ emissions from biomass** | | | | | | | |
| **Industrial processes** | 344.8836 | 0.4851 | 400.9230 | **11.43** | | | 746.2917 |
| **A Production of minerals** | 137.1576 | | | | | | 137.1576 |
| **1 Production of cement** | 124.5359 | | | | | | 124.5359 |
| **2 Production of lime** | 7.8693 | | | | | | 7.8693 |
| **3 Production of glass** | 4.7527 | | | | | | 4.7527 |
| **B Chemical production** | 207.7260 | 0.4851 | 400.9230 | | | | 609.1341 |
| **1 Production of ammonia** | 207.7260 | | | | | | 207.7260 |
| **2 Production of nitric acid** | | | 400.9230 | | | | 400.9230 |
| **3 Production of sulfuric acid** | | | | | | | |
| **4 Production of technical carbon** | | 0.4851 | | | | | 0.4851 |
| **C Other production** | | | | | | | |
| **1 Production of foodstuffs and drinks** | | | | | | | |
| **D Using fluorocarbons and sulfur hexafluoride** | | | | **11.43** | | | |
| **1 Refrigerators and air-conditioners** | | | | | | | |
| **2 foam fire extinguishers** | | | | | | | |
| **3 Other extinguishers** | | | | | | | |
| **4 Aerosols** | | | | | | | |
| **5 Dissolvent** | | | | | | | |
| **E Other** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Agriculture** | | 5515.8600 | 1289.6000 | | | | 6805.4600 |
| **A Enteric fermentation** | | 5474.2800 | | | | | 5474.2800 |
| **B Growing rice** | | 41.5800 | | | | | 41.5800 |
| **C Agricultural soils** | | | 1289.6000 | | | | 1289.6000 |
| **"Land use, lands use change and forestry"** | -829.9960 | | | | | | -829.9960 |
| **A Forestry** | | | | | | | |
| **1 Forests remaining forests** | 72.6530 | | | | | | 72.6530 |
| **2 Lands converted to forests lands** | -919.1270 | | | | | | -919.1270 |
| **3 Fires (Burned biomass)** | 0.8180 | | | | | | 0.8180 |
| **B Land use. Land use change** | | | | | | | |
| **1 Land use change** | 0.0320 | | | | | | 0.0320 |
| **2 Perennial plantings** | 57.5760 | | | | | | 57.5760 |
| **3 Human settlements** | -41.9480 | | | | | | -41.9480 |
| **Total waste** | | 510.7200 | | | | | 510.7200 |
| **A Hard wastes** | | 510.7200 | | | | | 510.7200 |
| **1 Controlled wastes** | | | | | | | |
| **2 Non-controlled wastes** | | 510.7200 | | | | | 510.7200 |
| **3 Other** | | | | | | | |
| **B Waste water** | | | | | | | |
| **1 Industrial waste water** | | | | | | | |
| **2 Domestic and commercial waste water** | | | | | | | |
| **3 Other** | | | | | | | |
| **C Burned wastes** | | | | | | | |
| **D Other** | | | | | | | |

Table 7

## Categories of GHG sources in Turkmenistan

| No | Source | GHG | Emission in 2004, Gg $CO_2$-eqv. | Level estimation % | Accumulated contribution % |
|---|---|---|---|---|---|
| **No** | **Total** | | **60569.8667** | | |
| **1** | **Gas transportation and distribution** | **$CH_4$** | **13969.664** | **23.064** | **23.064** |
| **2** | **Fuel combustion, households** | **$CO_2$** | **10174.828** | **16.798** | **39.862** |
| **3** | **Gas production** | **$CH_4$** | **9637.444** | **15.911** | **55.774** |
| **4** | **Fuel combustion, power engineering** | **$CO_2$** | **8248.067** | **13.617** | **69.391** |
| **5** | **Agriculture, livestock, enteric fermentation** | **$CH_4$** | **5474.28** | **9.038** | **78.429** |
| **6** | **Gas leakage under domestic gas consumption** | **$CH_4$** | **2815.226** | **4.648** | **83.077** |
| **7** | **Fuel combustion, municipal sector** | **$CO_2$** | **2802.526** | **4.627** | **87.704** |
| **8** | **Fuel combustion, transport** | **$CO_2$** | **2284.457** | **3.772** | **91.475** |
| **9** | **Agriculture, agricultural soils** | **$N_2O$** | **1289.6** | **2.129** | **93.604** |
| **10** | **Fuel combustion, other** | **$CO_2$** | **868.575** | **1.434** | **95.038** |
| **11** | Ventilation and flare combustion under oil and gas production | $CH_4$ | 764.203 | 1.262 | 96.300 |
| **12** | Wastes, methane emissions from hard wastes disposal | $CH_4$ | 510.72 | 0.843 | 97.143 |
| **13** | Industrial processes, chemical industry, production of nitric acid | $N_2O$ | 400.923 | 0.662 | 97.805 |
| **14** | Fuel combustion, chemical industry | $CO_2$ | 382.321 | 0.631 | 98.436 |
| **15** | Fuel combustion, building industry | $CO_2$ | 242.643 | 0.401 | 98.837 |
| **16** | Industrial processes, chemical industry, production of ammonia | $CO_2$ | 207.726 | 0.343 | 99.180 |
| **17** | Fuel combustion, textile industry | $CO_2$ | 177.756 | 0.293 | 99.473 |
| **18** | Industrial processes, production of minerals, production of cement | $CO_2$ | 124.5359 | 0.206 | 99.679 |
| **19** | Fuel combustion, transport | **$N_2O$** | 77.445 | 0.128 | 99.807 |
| **20** | Agriculture, growing rice | $CH_4$ | 41.58 | 0.069 | 99.876 |
| **21** | Oil production | $CH_4$ | 23.778 | 0.039 | 99.915 |
| **22** | Fuel combustion, transport | $CH_4$ | 9.172 | 0.015 | 99.930 |
| **23** | Industrial processes, production of minerals, production of lime | $CO_2$ | 7.869 | 0.013 | 99.943 |
| **24** | Oil refining | $CH_4$ | 5.805 | 0.010 | 99.953 |
| **25** | Fuel combustion, households | **$N_2O$** | 5.651 | 0.009 | 99.962 |
| **26** | Industrial processes, production of minerals, production of glass | $CO_2$ | 4.7527 | 0.008 | 99.970 |
| **27** | Fuel combustion, power industry | **$N_2O$** | 4.743 | 0.008 | 99.978 |
| **28** | Fuel combustion, households | $CH_4$ | 3.828 | 0.006 | 99.984 |
| **29** | Fuel combustion , power engineering | $CH_4$ | 3.142 | 0.022 | 100.006 |
| **30** | Fuel combustion , municipal sector | **$N_2O$** | 1.556 | 0.011 | 100.018 |
| **31** | Fuel combustion , municipal sector | $CH_4$ | 1.054 | 0.002 | 100.019 |
| **32** | Oil storage | $CH_4$ | 1.052 | 0.002 | 100.021 |
| **33** | Oil transportation | $CH_4$ | 0.88 | 0.001 | 100.022 |
| **34** | Industrial processes, chemical industry, production of technical carbon | $CH_4$ | 0.4851 | 0.001 | 100.023 |

| | | | | | |
|---|---|---|---|---|---|
| **35** | Fuel combustion, other | **$N_2O$** | 0.483 | 0.001 | 100.024 |
| **36** | Fuel combustion, other | $CH_4$ | 0.327 | 0.001 | 100.025 |
| **37** | Fuel combustion, chemical industry | **$N_2O$** | 0.212 | 0.000 | 100.025 |
| **38** | Fuel combustion, chemical industry | $CH_4$ | 0.144 | 0.000 | 100.025 |
| **39** | Fuel combustion, building industry | **$N_2O$** | 0.135 | 0.000 | 100.025 |
| **40** | Fuel combustion, textile industry | **$N_2O$** | 0.116 | 0.000 | 100.026 |
| **41** | Fuel combustion, building industry | $CH_4$ | 0.091 | 0.000 | 100.026 |
| **42** | Fuel combustion, textile industry | $CH_4$ | 0.071 | 0.000 | 100.026 |

**Table 8**

## Estimation by trend

| IPCC category sources | GHG | GHG emission, Gg $CO_2$-eqv. | | Trend estimation | Trend contribution | Accumulated contribution |
|---|---|---|---|---|---|---|
| | | Baseline year (1994) | Current year (2004) | | | |
| **Total** | | **34901.342** | **60569.867** | **0.4616** | | |
| **Fuel combustion, households** | $CO_2$ | **3293.204** | **10174.828** | **0.1278** | **0.277** | **0.277** |
| **Fuel combustion, power engineering** | $CO_2$ | **6784.581** | **8248.067** | **0.1010** | **0.219** | **0.496** |
| **Fuel combustion, other** | $CO_2$ | **1401.499** | **868.575** | **0.0448** | **0.097** | **0.593** |
| **Agriculture, livestock, intestinal fermentation** | $CH_4$ | **2271.15** | **5474.28** | **0.0439** | **0.095** | **0.688** |
| **Gas leakage under domestic gas consumption** | $CH_4$ | **2132.747** | **2815.226** | **0.0254** | **0.055** | **0.743** |
| **Fuel combustion, transport** | $CO_2$ | **860.73** | **2284.457** | **0.0227** | **0.049** | **0.792** |
| **Gas transportation and distribution** | $CH_4$ | **7665.065** | **13969.664** | **0.0191** | **0.041** | **0.833** |
| **Gas production** | $CH_4$ | **5854.829** | **9637.444** | **0.0150** | **0.032** | **0.866** |
| **Industrial processes, production of minerals, production of cement** | $CO_2$ | **340.942** | **124.536** | **0.0134** | **0.029** | **0.895** |
| **Fuel combustion, municipal sector** | $CO_2$ | **1853.33** | **2802.526** | **0.0119** | **0.026** | **0.920** |
| **Agriculture, agricultural soils** | **$N_2O$** | **539.4** | **1289.6** | **0.0101** | **0.022** | **0.942** |
| **Industrial processes, chemical industry, production of nitric acid** | **$N_2O$** | **349.238** | **400.923** | **0.0059** | **0.013** | **0.955** |

**Table 9**

## GDP forecasting until 2030

| | Retrorspective | | Scenarios | Prospective period | | | | |
|---|---|---|---|---|---|---|---|---|
| | Years | | | Years | | | | |
| | **2000** | **2005** | | **2010** | **2015** | **2020** | **2025** | **2030** |
| **GDP growth rate by PPP, %** against previous period (by 5 years) | - | 190 | I | 154 | 137 | 125 | 128 | 131 |
| | | | II | 154 | 137 | 128 | 134 | 140 |
| **Average annual GDP increase rate by PPP, %** | - | 13.7 | I | 9.0 | 6.5 | 4.5 | 5.0 | 5.5 |
| | | | II | 9.0 | 6.5 | 5.0 | 6.0 | 7.0 |
| **GDP per capita by PPP,** USD | 4971 | 7500 | I | 12255 | 16182 | 18638 | 23088 | 30060 |
| | | | II | 12255 | 16182 | 19085 | 24750 | 34438 |

**I – moderate option**
**II – innovative active option**

**Table 10**

## Forecast of GDP by branch distribution in Turkmenistan until 2030

| | **Retrospective** | | Scenarios | **Prospective period** | | | | |
|---|---|---|---|---|---|---|---|---|
| | Years | | | years | | | | |
| | **2000** | **2005** | | **2010** | **2015** | **2020** | **2025** | **2030** |
| **GDP structure** Including: | 100 | 100 | | 100 | 100 | 100 | 100 | 100 |
| **Industry** | 34.4 | 33.9 | I | 46 | 43 | 40 | 38 | 34 |
| | | | II | 46 | 43 | 38.5 | 34 | 29 |
| **Agriculture** | 22.5 | 18.3 | I | 11.7 | 12.3 | 11.5 | 10 | 9.4 |
| | | | II | 11.7 | 12.3 | 10.8 | 8 | 7.5 |
| **Construction** | 6.6 | 5.5 | I | 6.3 | 7.4 | 7.5 | 7 | 6.6 |
| | | | II | 6.3 | 7.4 | 7.7 | 6 | 5.5 |
| **Services** | 36.5 | 42.3 | I | 36 | 37.3 | 41 | 45 | 50 |
| | | | II | 36 | 37.3 | 43 | 52 | 58 |
| Out of them **transport** | 5.2 | 5.1 | I | 3.7 | 3.8 | 3.6 | 4.2 | 4.6 |
| | | | II | 3.7 | 3.8 | 3.7 | 4.3 | 4.8 |

**I – moderate option**
**II – innovative active option**

**Table 11**

## Forecast of energy consumption and energy intensity of the economy of Turkmenistan until 2030

| | Retrospective | | Scenarios | Prospective period | | | | |
|---|---|---|---|---|---|---|---|---|
| | Years **2000** | **2005** | | Years **2010** | **2015** | **2020** | **2025** | **2030** |
| **Consumption of all types of energy,** thousands of toe | 19831.9 | 25200.5 | I | 36834 | 47468 | 56415 | 67604 | 85514 |
| | | | II | 36834 | 47468 | 53920 | 65016 | 80896 |
| **Energy consumption growth rate of all types of energy**, % against the previous period ( by 5 years) | | 127.1 | I | 146 | 129 | 118.8 | 120 | 126.5 |
| | | | II | 146 | 129 | 113.6 | 121 | 124.4 |
| **Average annual increase rate of energy consumption**, % | | 4.9 | I | 7.9 | 5.2 | 3.5 | 3.7 | 4.8 |
| | | | II | 7.9 | 5.2 | 2.7 | 3.9 | 4.4 |
| **Elasticity of energy consumption by GDP,** energy consumption growth per 1% of GDP | | 0.4 | I | 0.88 | 0.80 | 0.78 | 0.74 | 0.87 |
| | | | II | 0.88 | 0.80 | 0.54 | 0.65 | 0.63 |
| **Energy intensity,** toe/ USD by PPP | 0.75 | 0.51 | I | 0.48 | 0.45 | 0.43 | 0.40 | 0.39 |
| | | | II | 0.48 | 0.45 | 0.40 | 0.36 | 0.32 |

**I – moderate option**
**II – innovative active option**

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