

# **Executive Summary**

**Assessment of Investment and Financial Flows to Address  
Climate Change in the Key Sectors Electricity Production,  
Electricity Demand and Water Management**

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# 1. Introduction

The purpose of this study is to assess investment and financial flows in the sectors Electricity production, Electricity demand and Water management in Turkmenistan to ensure that national decision-makers for socio-economic development of the country have reliable information about climate change and its impact on these economic sectors, and on possible adaptation and mitigation measures up to 2030.

The results of the I&FF assessments were calculated terms of investment and financial flows needed for sustainable development in the sectors in relation to climate change. The assessment findings will also improve understanding of economic and political challenges of climate change in the context of Turkmenistan's compliance with the provisions of the UN Framework Convention on Climate Change (UNFCCC) and will therefore help in determining the national position in the UNFCCC negotiations.

Investment Flows include capital costs of new real assets with a lifetime of more than one year, and Financial Flows are ongoing expenditures on programmatic measures, and operating costs associated with program activities, which include costs other than those which relate to the expansion or introduction of new real assets.

An important result of this project is the fact that national experts have acquired skills investment and financial analysis. International experts sent to national experts their experience and knowledge. UNDP has prepared and provided guidance on financial analysis, and also provided substantial assistance to the National Panel on Climate Change reported on issues of global climate change among policy makers, and leaders of ministries and agencies, organized the first inter-ministerial dialogue in Turkmenistan.

## 1.1 Objectives

The main objectives of this work was to identify and describe the various options and actions related to addressing issues arising from climate change in the sectors of electricity production and demand and water management. To do this, it is necessary to prioritize mitigation activities in the sectors electricity production and demand, which will affect a significant reduction in greenhouse gas emissions and adaptation activities in the sector water management, influenced greatly reduce water scarcity in the context climate change. We evaluated the costs of implementing these measures. To achieve this goal in the development of each sectoral assessment addressed the following tasks:

- Delimitation of the sector
- Identification of mitigation / adaptation measures
- Identification of investment and financial flows in the historical period (2000-2008 years)
- Identification of scenarios for the sector - the base scenario and mitigation / adaptation
- Projection of investment and financial flows in the baseline and mitigation / adaptation scenario (2009-2030 years)
- Comparison of the baseline scenario and mitigation scenario / adaptation
- Assess feasibility of policies to mitigate / adapt to climate change in selected sectors.

## 1.2 Reasons for the choice of sectors

### 1.2.1 Electricity production and demand - climate change mitigation

The I&FF assessment for electricity production and demand is based on an analysis of energy efficiency measures both the production and use of electricity.

Power, responsible for electricity production in Turkmenistan, is the basic sector of the economy, the level of development of which depends on the implementation of national plans to accelerate the socio-

economic growth. The development of power system in the years of independence of Turkmenistan to facilitate the goal of promoting energy security.

In recent years the energy sector of Turkmenistan received a powerful impetus in its development, thus fully meeting the growing demand of domestic consumers and to organize the export of energy supplies in neighboring countries.

Power is the largest consumer of fossil fuels and natural gas in industry (80-85%). The share of industry in gross domestic consumption of gas fuel over 20%.

According to an inventory of greenhouse gas (GHG) emissions in 2004 the bulk of GHG emissions in Turkmenistan, comes from energy-related activities (87%), including GHG emissions from fuel combustion and methane from activities related to oil and gas. The structure of these GHG emissions electricity sector belongs to a significant fraction - 15.7% emission.

Taking into account such factors as the close relationship of power and economy, to meet growing domestic demand and exports of electricity, the consumption of large amounts of fossil fuels, significant potential energy savings and natural gas sector, Electricity was chosen for the I&FF assessment due to changes in climate.

Domestic consumption of electricity in the country is 83-85%. The main consumer of electrical energy is the population, which accounts for 29% of all the released energy, of which 14,8% of the population in urban and peri-urban and 14.2% for the rural population.

In the electricity development program of Turkmenistan provides annual increase of power consumption by 3-4%, thus, electricity demand in 2030 increased by 2,1 times compared with the Year 2009. This increase takes into account the increase in electricity consumption of the population in relation to population growth and improving well-being, which will boost the purchasing power of people to buy more of various household appliances.

Increasing volumes of domestic demand of electricity in the future, and with significant savings potential impact on the choice of the sector Energy consumption as a key to limiting greenhouse gas emissions and assessment of investment and financial flows to address climate change.

### *1.2.2 Water management - Adaptation to Climate Change*

Water management is the most important economic sector in Turkmenistan. The Initial National Communication on UN Framework Convention on Climate Change, noted that Turkmenistan is one of those regions that may be most affected by global warming. In the first place it will affect agriculture, which is based entirely on irrigated agriculture.

Anticipated increase in air temperature and decrease in annual rainfall as a result of climate change, primarily affect the decrease in water flow and changes in the hydrograph of the rivers, increased evaporation from water surface, which ultimately affect the availability of irrigation water, which is based agriculture country. Preliminary calculation shows that the flow of local rivers will decline by more than 30%. In the water balance of Turkmenistan on the Amu Darya is about 90% of the total. According to specialists of the Republic of Uzbekistan of the Amu Darya runoff may decrease by 10-15%, which significantly affect the total water resources of Turkmenistan.

Implementation of Agrarian Policy in Turkmenistan is largely dependent on the availability of the national economy of water resources needed for irrigated agriculture. Thus, the factors to ensure the sustainability of agriculture and the need to meet the growing needs of the population in food products show relevance consideration of the impact of climate change on water management and determine the sector Water management major sector of the economy to adapt to possible climate change.

All adaptation measures, which are discussed in this paper, are aimed at water conservation in the country in connection with the alleged climate change that will guarantee the sustainable development of water sector and to guarantee the necessary agricultural water resources.

### **1.3 Previous analyses utilized**

In the preparation of the Second National Communication under UN Framework Convention on Climate Change CO<sub>2</sub> emissions by sector Electricity have been identified, and it outlines activities to reduce CO<sub>2</sub> emissions, which are discussed in this paper, as well as a peer evaluation of production and domestic consumption of electricity for the period 2021-2030 years.

In 2007, the President of Turkmenistan was initiated work on the revision of curricula in the oil and gas, elektroenergeticheskoooy and other industries to make them more feasible for implementation. By December 2008 was prepared by the Revised Programme of electricity until 2020, which is used in this assessment.

The problems of GHG emission reductions in electricity consumption is still not studied in detail. In this paper, the first attempt to identify high priority activities to increase technological efficiency in the sector of Electricity in Turkmenistan.

In the course of the assessment for the first time an analysis of major household appliances: light bulbs, air conditioners and electrical appliances for heating. To assess the long-term growth in demand of electricity due to increased sales of electric power development program has been used until 2020, as well as peer review for the period until 2030.

To assess I&FF sector water management in this study used different materials of international environmental conferences, seminars and meetings, as well as results of international and national projects. Key test results for the sector in relation to climate change presented in the Initial National Communication, the Second National Communication to the UNFCCC, National Action Plan for the President of Turkmenistan on the Environment.

### **1.4 Institutional arrangements and collaborations**

The I&FF assessment in the sectors electricity production and demand conducted by the Ministry of Energy and Industry of Turkmenistan and its subdivisions HES Turkmenenergo. The basic structure of expert groups to assess I&FF in each sector represented by officials and experts of the Ministry of Energy and Industry. Experts have been appointed officially by the Ministry in response to a request from the UNDP Resident Representative in Turkmenistan.

At the first stage of development assessment project leaders organized a meeting of experts group with international experts, which the team agreed on procedures to provide data for the assessment and approval of the final sectoral report by the Ministry of Energy and Industry. The experts groups were defined lists of data needed to perform the tasks assessing I&FF and O&M. For the I&FF assessment also a survey of specialists in all power plants and power suppliers was conducted to refine the data of annual reports and gathering additional information, organized visits to selected apartments, houses, industrial buildings in the provinces and Ashgabat to determine the number of used bulbs.

In assessing I&FF for the sector water management was attended by representatives of the Ministry of Water Resources of Turkmenistan, its provincial industrial associations for Water Management and Research and Project Research Institute Turkmensuvlymtaslama. The team of experts to assess I&FF in this sector was formed on the basis of a formal submission to the Ministry of Water Resources in response to a request from the UNDP Resident Representative in Turkmenistan.

Institutional issues and cooperation between various departments were discussed at the beginning of this project, which was organized by the intersectoral meeting with the participation of key government ministries and departments of Turkmenistan, in particular, the Ministry of Water Resources, Ministry of Agriculture, the National Committee for Hydrometeorology at the Cabinet of Ministers of Turkmenistan.

Many of the indicators relating to investment flows, are based on data from the institute Turkmensuvlylymtaslama. To coordinate the implementation of the expert meetings were held every two weeks, starting from September 1, 2009, after gathering all the information as necessary, but not less than once a month.

## **1.5 Basic methodology and key terminology**

Each of the sectoral assessments I&FF performed the following steps, which include the basic 8 steps under the leadership of UNDP:

1. Define key assessment parameters (sector scope, analytical approach, institutional arrangements)
2. Collect relevant (historical, current and projected) information to develop scenarios
3. Determine the baseline scenario
4. Determine mitigation / adaptation
5. Perform an assessment I&FF and O&M for the baseline scenario
6. Perform an assessment I&FF and O&M for the mitigation scenario
7. Calculate the change in IF, FF and O&M expenditures necessary to implement the mitigation or adaptation scenario
8. Evaluate policy implications
9. Prepare a sectoral report
10. Agree and approve the reports to the relevant ministry and partners.

Investment Flow (IF) - This capital cost includes:

- Construction of new and upgrading existing power plants for the sector Production of electricity
- Acquisition of incandescent lamps, air conditioners, electrical appliances for heating in the baseline scenario and the acquisition of energy-saving lamps, energy-efficient air conditioners, construction of gas-fired boiler for heating instead of using electrical appliances for heating in the mitigation scenario for the sector of Electricity
- New real assets with a lifetime of more than one year, for example, capital expenditure on new agricultural irrigation system, the implementation of the comprehensive reconstruction of irrigated land (Krause), implementation of measures to improve the reclamation of land used (DRF), construction of additional reservoirs, rehabilitation and construction new hydraulic structures and others for the sector Water management.

Financial Flow (FF) - is the current cost of program activities, staff training, the cost of workshops, dissemination of popular literature, the training of new personnel and staff development.

Operation and maintenance costs (O&M) - are operating expenses, which include:

- Raw materials
- Payment for water
- Production services
- Fuel
- Energy
- Fund pay
- Deductions for social insurance
- Payment for environmental
- Other.

## 2 Sectoral assessment summaries

### 2.1 Sector Electricity production

#### 2.1.1 Scope of the sector

To date, sector electricity production includes seven thermal power plants and one hydroelectric power station. In this paper covers the activities of electricity production in all existing thermal power plants and power plants, which will be commissioned in 2030. The scope does not include only Gindikushskaya hydroelectric power, because she works only 2-3 months a year and is the current museum exhibit age is 97 years.

Of the seven, three thermal power plants equipped with steam-turbine plant (HPP Mary, Turkmenbashi thermal power station and Seidi CHP), three - gas turbine (Balkanadsakya HPS, HPS Ashgabat and Dashoguz GES), and a power station - gas turbine and steam turbine (Abadan power plant). All gas turbine power plants operate on a simple cycle.

#### 2.1.2 Base year and assessment period

The assessment period includes the historical period from 2000 to 2008, as well as long-term period from 2009 to 2030, the discount rate adopted at the 10% level.

The base year adopted in 2008, because this year has changed the dollar towards a significant increase compared with the previous period 2000-2007. Thus, in 2008, the cost-oriented, which are calculated in the national AZM significantly reduced when converted into U.S. dollars. Prior to May 1, 2008 the official dollar exchange rate was 5200 manat, and from May 1, 2008 - 14250 manat or 2,85-denominated manat (from January 1, 2009).

#### 2.1.3 Mitigation measures, which are included in the assessment I&FF

For the baseline scenario

- Upgrading of hydro power plants in Mary and Turkmenbashi thermal power station;
- Conclusion of the work and the cancellation of obsolete and worn-out steam turbine at the hydroelectric Abadan and Turkmenbashi thermal power station.
- Mitigation scenario - additional activities to those listed in the baseline scenario
- Translation of existing gas turbines at the steam-gas cycle;
- Construction of new power plants steam-gas cycle for the increasing amount of their own consumption and export of electricity;
- Construction of power plants using renewable energy sources (wind, sun) in communicating with the volume of electricity production from renewable energy sources up to 1% of total production in 2030.

All these measures will save a considerable amount of fuel and natural gas, which eventually lead to a reduction in greenhouse gas emissions.

#### 2.1.4 Summary of I&FF assessment

The total cost for the mitigation scenario (2008-2030 years) is 5451.77 million U.S. dollars, and the baseline scenario 3,434.76 million U.S. dollars. Investment costs are equal to 4089.30 and 2375.20 million U.S. dollars. Execute the mitigation scenario climate change will require a total additional cost - 2,02 billion U.S. dollars, of which investment costs - 1,71 billion U.S. dollars over the base scenario.

In the mitigation scenario will decrease I&FF and O&M for the construction of a simple gas cycle power plants. This is because the projected in the baseline scenario, these activities, namely the construction of additional gas turbine capacity of 127.1 MW at five existing power plants and three gas turbines at each of the four new power plants, the mitigation scenario does not work. Instead, the existing power plants will be converted to combined-cycle, and new power plants will be built around the co-generation.

Transfer to combined-cycle power plants will be implemented from 2011 to 2020, so in these years have seen an increase in costs I&FF on this type of activity. Construction of new power plants that use technology co-generation, to be implemented in 2021-2028, respectively, which also affect the growth I&FF for this activity.

A large amount of IF for the introduction of alternative energy sources to account for the years 2018-2020. During these years, is planned as the construction of wind power and solar thermal power plant of 50 MW.

According to estimates in this assessment, the amount of potential for energy savings for the years 2010-2030 in this sector is - 40,3 billion m<sup>3</sup> of natural gas, the total reduction in CO<sub>2</sub> emissions resulting from energy savings will amount to 75,5 million tons of CO<sub>2</sub> equivalent reduction in emissions of greenhouse gases in 2030 in the mitigation scenario will reach 4.816 million tons of CO<sub>2</sub> equivalent.

### *2.1.5 Investment Organization*

The government of Turkmenistan is a major investment entity to assess I&FF, and internal budgetary source I&FF for the sector Production of electricity. Therefore, the realization of all investments offered in this paper will only be possible with public funds or foreign credits guaranteed by the government.

### *2.1.6 Recommendations for policy makers*

Given that the savings gas can be realized in the foreign market at a price of \$ 200 per 1 m<sup>3</sup>, the country's budget will go further sum of about \$ 8 billion for the years 2010-2030, which fully covers the additional costs (2,02 billion U.S. dollars) for the implementation of the mitigation scenario.

A number of measures to save energy, provided in the mitigation scenario can be implemented Clean Development Mechanism, which will attract additional investment flows.

Policies in energy conservation should focus on improving the norms and standards in the field of energy, such as target setting standards for the efficiency of power plants and fuel rate for electricity. Develop a national program for energy conservation, which will establish the main strategic tasks, such as the annual reduction in energy intensity of GDP, the achievement of targets for energy efficiency in various sectors of the economy.

The legal basis for implementing energy efficiency measures for energy conservation should be a law on energy conservation, aimed at promoting energy conservation, creating the foundation for state regulation in the field of energy use and development of renewable energy (RE). To stimulate the introduction of RES in the energy balance of the country, the law may provide tax incentives for investment in renewable energy and exemption from import duties on equipment for renewable energy.

For the investment of energy efficiency measures and the development of renewable energy sources can serve as a state fund energy efficiency, financed by revenues from the export of gas due to the saving of energy efficiency measures. In order to implement productive activities and strategies for energy efficiency should be established in Turkmenistan, a national body who will be responsible for carrying out state policy on efficient use of energy resources and energy conservation.



### *2.1.7 Key uncertainties and methodological limitations*

At the time of development assessment I&FF development program for electricity until 2020 and until 2030 was not approved by the Government. Available in electricity legislation on energy conservation have been developed over 20 years ago. They are outdated and inconsistent with the realities of present time.

As the uncertainty it may be noted a significant increase in the dollar against the national currency in 2008, which impacted on the fact that the assessment costs for the period 2009-2030 O&M years based on data from 2008.

## **2.2 Sector Electricity demand**

### *2.2.1 Scope of the sector*

The share of major household appliances: electric light bulbs, air conditioners and electrical devices account for more than a quarter of total domestic energy consumption in Turkmenistan (expert analysis on the basis of preparatory studies). Both the consumer - residential and departmental sectors make heavy use of electricity for lighting, air conditioning and heating. Therefore, the scope of the assessment I&FF and O&M include these activities, and paid special attention to the definition of measures aimed at reducing energy consumption in the use of these appliances.

### *2.2.2 Base year assessment period*

The assessment period includes the historical period from 2000 to 2008, as well as long-term period from 2009 to 2030, the discount rate adopted at the 10% level.

The base year adopted in 2008, because this year has changed the dollar towards a significant increase compared with the previous period 2000-2007. Thus, in 2008, the cost-oriented, which are calculated in the national AZM significantly reduced when converted into U.S. dollars. Prior to May 1, 2008 the official dollar exchange rate was 5200 manat, and from May 1, 2008 - 14250 manat or 2,85-denominated manat (from January 1, 2009).

### *2.2.3 Mitigation measures, which are included in the assessment I&FF*

#### Baseline scenario

The reduction in specific energy consumption occurs as a result of forced replacement of incandescent light bulbs with energy efficient lamps. While this change is not more intense, as planned in the mitigation scenario, however, will take place in any case, but later and for a longer period, resulting in the cessation of production of filament lamp manufacturers and re-profiling the production of energy-saving lamps.

Reduction of specific energy consumption for activities associated with air conditioning and heating, will not happen.

#### Mitigation Scenario

Reduction of specific energy consumption will occur as a result of three events:

- Replace incandescent light bulbs with energy saving;
- Replacement of existing air conditioners for energy efficiency;
- Replacement of electric heating with gas boiler.

#### *2.2.4 Summary of I&FF assessment*

The total cost of the mitigation scenario is 521.013 million U.S. dollars in the base scenario 475.643 million U.S. dollars. It would take the total additional cost for all types of investments of \$ 45.37 million for the period 2010-2013. Investment costs amount, respectively, 402.213 and 209.305 million U.S. dollars. Mitigation scenario would require almost 2 times more investment than the baseline scenario. The volume of emission reductions over the period 2010-2030 will amount to 20.89 million tonnes of CO<sub>2</sub> equivalent.

Significant increase in IF in the years 2011-2020 due to the fact that in the period 2011-2015 years is planned for the complete replacement of incandescent lamps, as well as plans to abandon the use of electrical appliances for heating and to improve the heating of gas-fired boiler in the years 2011-2020. Between the years 2011-2030 will be a planned replacement of air-conditioners air conditioners with high performance efficiency. In the period 2021-2030 years replacement exhaust his term of incandescent lamps and the construction of gas-fired boiler for newly constructed homes and buildings departmental sector will be in much smaller amounts than in the years 2011-2020.

A similar trend is observed for the FF in the years 2011-2020, the additional annual FF for this period amount to 0.03 million U.S. dollars, and in 2011-2030 years, 0,005 million U.S. dollars.

The main reason for reducing the additional costs for O&M is to save electricity. Despite relatively low tariffs for electricity to let go of local consumers, a significant decrease in O&M in the mitigation scenario, which covers IF in the 148.2 million U.S. dollars. Therefore, the additional investment costs for implementation of planned measures to reduce energy consumption will require a little more than \$ 45 million.

There is a very significant potential for saving electricity only for lighting, air conditioning and heating in the amount of 13,8-14% of the total electricity demand, leading to a total saving of natural gas - 11,2 billion m<sup>3</sup> and the reduction of CO<sub>2</sub> emissions - almost 21 million tons by 2030.

#### *2.2.5 Investment Organization*

Costs incurred by the sector Energy demand includes both public and private funds needed to purchase incandescent air conditioners, electrical appliances for heating, and only public funds for the construction of gas-fired boiler and heating mains.

#### *2.2.6 Recommendations for policy makers*

Energy saving in lighting, air conditioning and heating can bring additional revenue to the state budget on the export of the saving of gas is 2.24 billion dollars at a price of \$ 200 per 1 m<sup>3</sup>. These calculations show a significant net economic benefits of nearly 2.2 billion U.S. dollars from the investment of additional resources of 45.37 million U.S. dollars in the mitigation scenario. Reducing demand for electricity in 2030 in the mitigation scenario impact on the refining industry with plans to introduce new generating capacity in the power - no need to build two gas turbine power stations planned total cost of 240 million U.S. dollars, which can also be attributed to the direct benefits of energy conservation.

Major household appliances, including appliances, studied in this paper is imported into Turkmenistan. Therefore, to achieve significant benefits in terms of reducing energy consumption and related greenhouse gas emissions need to improve trade policy in the country that it was aimed at the entry of goods with higher energy efficiency requirements in the consumer market. This could be used the whole range of measures: from information and advisory services to financial instruments and mandatory control measures.

Mandatory measures include the introduction of energy efficiency standards to outdated and inefficient technology is no longer dominated the consumer market. Financial incentives can be represented by such

measures as reducing import tariffs for energy-efficient technologies, reduction of VAT for energy-efficient products, etc. Also, in order to attract high-efficiency products in the consumer market, are important outreach activities such as training, information campaigns, etc.

To fulfill the above measures necessary to establish a leading state agency, which will have the capacity and authority to execute, monitor and control, especially the mandatory measures.

In order to improve the heating, in addition to these measures must be approved by the state strategy to improve the supply of heating buildings in cities and towns.

In order to finance measures to promote the efficient use of electricity, can serve as a state fund for energy efficiency, replenished with funds from the export of natural gas, savings on energy conservation.

### *2.2.7 Key uncertainties and methodological limitations*

The lack of statistics on the number of prodaannyh conditioners, electrical appliances for heating and incandescent lamps in the historical period. To assess the historical data for the implementation of air conditioners and electrical appliances for heating experts group collected data on their implementation in 2009 for the city of Ashgabat and interpolate these data to other provinces (regions) of Turkmenistan.

As the uncertainty it may be noted a significant increase in the dollar against the national currency in 2008, which impacted on the fact that the assessment costs for the period 2009-2030 O&M years based on data from 2008.

## **2.3 Sector Water management**

Turkmenistan, differing vast desert territory, and hot and dry climate has its own sources of surface water in very small quantities. The main sources of surface waters are transboundary.

Under development in national and international centers of regional climate change scenarios show increases in the future, the average temperature and decrease in flow of transboundary rivers. This can seriously affect the development of agriculture of Turkmenistan and the country's food security. Thus the state of the sector Water management significantly depends sustainable development of the country.

### *2.3.1 Scope of the sector*

Due to the fact that in Turkmenistan for more than 90% of the total water used in irrigated agriculture, for nastoyascheey assess the scope of the sector including water used for irrigation.

Irrigated agriculture - is irrigated agriculture, which includes the construction and operation of irrigation and drainage networks, waterworks, reservoirs, water distribution sites, land reclamation.

The urgency of the consideration of water supply of irrigated agriculture is also due to the following factors:

- Adaptation activities developed in this sector will actually save a substantial amount of water and provide guaranteed provision of economic sectors of water resources and, therefore, to ensure sustainable development of water sector and the economy as a whole;
- The share of agriculture in the national gross domestic product reaches about 20% and ensuring food security of the country, and therefore the importance of this sector is beyond doubt.

### *2.3.2 Base year assessment period*

In the period from 2000 to 2005 the official exchange rate of national currency against the U.S. \$ 1 \$ 1 = 5200 manat. Historical financial data in national currency (2000-2008 years) in the organization of water

complex were identified for this course. In this connection, in this paper as the base year adopted in 2005 under UNDP management.

The assessment period is until 2030. The historical period before the figures for 2000-2008. Data provided by the Ministry of Water Resources of Turkmenistan and the Research and design institute Turkmensuvlymtaslama.

In accordance with the existing practice of designing the discount rate adopted at the 10% level.

### *2.3.3 Adaptation activities, which are included in the I&FF assessment*

Adaptation scenario assumes implementation of the necessary adaptation measures for climate change conditions for the sustainable provision of agricultural needs for water for irrigation. As mentioned above, water scarcity can be about 5.5 km<sup>3</sup> without the expansion of irrigated area. Specific indicators for the calculation of investment in specific activities, such as IAPSO, Crozet, introduction of advanced irrigation methods are the same as the baseline. Due to the fact that the implementation of these activities in the adaptation scenario assumes a substantially larger area, their total value has grown. The list of key adaptation measures as defined by experts, includes:

- Improving water resources management (transition to integrated water resources management - IWRM).
- Optimization of the distribution of agricultural production with due regard for the needs of the country in need of agricultural production and minimize the use of water resources (here the need to consider the development of economic and mathematical models of optimization of distribution of agricultural production).
- Implementation of measures that increase efficiency of irrigation systems - reconstruction of canals and hydraulic structures, the implementation of anti activities, etc.
- The introduction of advanced irrigation methods (drip, sprinkler irrigation) and the improvement of existing (traditional), namely, the use of siphons, tubes.
- Implementation of a comprehensive reconstruction of irrigated land (Krause). Complex reconstruction includes the following activities:
  - Per capita intake
  - Main canal and distribution network
  - Sprinklers and spillway, the waste network
  - Drainage network
  - A capital planning
  - Pumping stations (if available)
  - Maintenance of the road.
- Implementation of measures to improve the reclamation of land used (DRF) - performed on lands that do not require complete reconstruction. In general, this work is the reconstruction and, if necessary, additional construction of collector-drainage network.
- Construction of additional reservoirs and increasing capacity of existing ones. The latter include such reservoirs as Hauzhanskoe and Saryyazynskoe.
- Reconstruction of existing and construction of new hydraulic structures that reduce waste and water management, etc.
- Implementation of breeding work on the cultivation of drought resistant crops.
- The possibility of the involvement of additional water (slightly saline drainage water, underground water and sewage) and their quantitative capabilities.

These activities were designed I&FF and O&M 2030. The calculation showed that the implementation of planned activities on adaptation scenario would eliminate the deficit of water resources by 2030, with a total value of expenditure for the period 2009-2030 years will be about 16.1 billion U.S. dollars.

### *2.3.4 Summary I&FF assessment*

It should be noted that Turkmenistan was the first time an analysis of investment and financial flows in the sector Water management in relation to climate change and adaptation measures have been developed to facilitate removal of water scarcity.

The main result of this work are calculated amount of additional investitsiionnyh and financial revenues, which represent the difference in all types of investments in adaptation and baseline scenario. In the calculations made the condition that the size of investment for items such as improving water resource management, optimization of the distribution of agricultural production, the implementation of breeding work on the cultivation of drought-tolerant crops - the same in both scenarios. In other activities, investments made in the adaptation scenario, significantly higher than in the base. The total amount of costs in the baseline scenario for the period of 2009-2030 years is 10482 million U.S. dollars, and on adaptation scenario - 16,098 million U.S. dollars, i.e. additional quantity of investment is 5616 million dollars.

The I&FF assessment also showed the economic benefits of holding adaptation activities. Given an annual average income obtained in Turkmenistan on 1 hectare of irrigated land, equal to U.S. \$ 350, it can be concluded that the elimination of the deficit of water in 5 km<sup>3</sup>, irrigated area increased by 500 thousand hectares, and the benefits of an adaptation activities in the order of 175 million U.S. dollars.

### *2.3.5 Investment Organization*

The only source of investment for the sector Water Management in Turkmenistan ist he government. For the development of water infrastructure are allocated large amounts of capital investments: own funds of the Ministry of Water Resources of Turkmenistan, the state budget, State Monetary Fund, the State Fund for the oil and gas industry and mineral resources and other public structures.

Hence, the implementation of adaptation measures proposed in this paper will only be possible with public funds or foreign loans under government guarantee.

### *2.3.6 Recommendations for policy makers*

For the sustainable development of the sector Water Management in Turkmenistan is necessary to improve the system of national and regional water relations. Including:

- Transition from administrative district of the principle of water management to the management of irrigation systems - Integrated Water Resources Management (IWRM)
- Study and implementation of Turkmenistan's experience of water user associations and farmers associations
- Gradual introduction of paid water use
- Encouraging the introduction of new technologies that economize irrigation water
- Increased breeding work on the cultivation of drought-and salt-tolerant crops
- Improving regional water policy and strengthening the legislative framework for the effective management of transboundary water resources
- Better promote the initiative of President of Turkmenistan expressed in April 2009, a summit of leaders of the organizers of the Fund for the Aral Sea in Kazakhstan, the joint solution of acute energy problems in Central Asian countries and issues of transboundary water resources, climate initiative on adaptation and mitigation of climate change.

### *2.3.7 Key uncertainties and methodological limitations*

1. As the main uncertainty is necessary to note the absence of formally approved program of industry development for the period up to 2030, which served as the basis for determining the baseline scenario for the prevailing rate of development of the industry in the historical period (2000-2008).

2. Some of the uncertainties can be included and some of the specific indicators that were used in the calculations. In the long term to 2030, some of them may change - new models of agriculture and land reclamation techniques will affect the change in operating expenses.
3. Lack of correct performance of financial flows necessitated their definition of peer review. In reality, this figure could change as the upward and downward.
4. Calculations of adaptation activities carried out around without developing a specific project for the implementation of each of these activities.
5. Significant uncertainties in climate change scenarios.
6. The persistence of water issues at the State level in Central Asia.

### 3. Summary tables of incremental investment costs

Additional annual FE, FP and O&M implementation scenarios for mitigation and adaptation sector (million)

Sector	Electricity production						Electricity demand						Water management					
	Additional expenses			Discounted incremental costs			Additional expenses			Discounted incremental costs			Additional expenses			Discounted incremental costs		
Year	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0,79	0	0	0,72	0	0	0	0	0	0	64,4	0,4	3,7	64,4	0,4	3,7
2010	0	0,12	0	0	0,10	0	1,424	0	0,004	1,176	0,000	0,003	82,9	0,5	4,7	75,4	0,5	4,2
2011	55,70	0,24	0,08	41,85	0,18	0,06	17,416	0,221	-1,250	13,085	0,166	-0,939	95,8	0,6	5,4	79,2	0,5	4,4
2012	81,30	0,30	2,52	55,53	0,20	1,72	16,428	0,131	-2,529	11,220	0,089	-1,728	103,0	0,7	5,8	77,4	0,5	4,4
2013	55,70	0,22	2,60	34,59	0,14	1,61	16,131	0,131	-3,788	10,016	0,081	-2,352	111,2	0,7	6,3	75,9	0,5	4,3
2014	57,70	0,26	4,88	32,57	0,15	2,75	15,513	0,031	-5,089	8,756	0,017	-2,872	120,2	0,7	6,8	74,7	0,5	4,2
2015	55,70	0,32	4,96	28,58	0,16	2,55	15,071	0,031	-6,369	7,734	0,016	-3,268	130,4	0,8	7,5	73,6	0,4	4,2
2016	81,30	0,40	7,40	37,93	0,19	3,45	11,023	0,031	-7,303	5,142	0,014	-3,407	141,8	0,9	8,1	72,8	0,4	4,2
2017	55,70	0,37	7,48	23,62	0,16	3,17	11,019	0,031	-7,669	4,673	0,013	-3,252	154,5	0,9	8,9	72,1	0,4	4,2
2018	207,70	0,37	9,77	80,08	0,14	3,77	11,014	0,031	-7,835	4,246	0,012	-3,021	168,7	1,0	9,8	71,6	0,4	4,1
2019	205,70	0,38	9,85	72,10	0,13	3,45	11,009	0,031	-8,006	3,859	0,011	-2,806	184,6	1,1	10,7	71,2	0,4	4,1
2020	254,70	0,56	11,12	81,16	0,18	3,54	11,004	0,031	-8,180	3,506	0,010	-2,606	202,4	1,2	11,8	70,9	0,4	4,1
2021	15,70	0,45	17,55	4,55	0,13	5,08	5,191	0,005	-8,327	1,504	0,001	-2,412	247,8	1,5	14,3	79,0	0,5	4,6
2022	97,70	0,39	19,91	25,73	0,10	5,24	5,417	0,005	-8,476	1,426	0,001	-2,232	270,0	1,6	15,6	78,2	0,5	4,5
2023	15,70	0,41	19,91	3,76	0,10	4,77	5,642	0,005	-8,627	1,351	0,001	-2,065	294,8	1,8	17,1	77,6	0,5	4,5
2024	121,30	0,53	22,35	26,40	0,12	4,86	5,868	0,005	-8,781	1,277	0,001	-1,911	318,8	1,9	18,5	76,3	0,4	4,4
2025	15,70	0,48	22,43	3,11	0,09	4,44	6,094	0,005	-8,938	1,206	0,001	-1,768	345,5	2,0	20,1	75,2	0,4	4,4
2026	97,70	0,06	24,71	17,57	0,01	4,44	5,088	0,005	-9,098	0,915	0,001	-1,636	368,9	2,0	21,5	73	0,4	4,3
2027	39,30	0,55	24,95	6,43	0,09	4,08	5,309	0,005	-9,258	0,868	0,001	-1,514	408,5	2,2	23,8	73,5	0,4	4,3
2028	103,40	0,43	27,33	15,37	0,06	4,06	5,529	0,005	-9,422	0,822	0,001	-1,401	439,1	2,3	25,6	71,8	0,4	4,2
2029	11,40	0,06	27,49	1,54	0,01	3,71	5,750	0,005	-9,589	0,777	0,001	-1,296	480,5	2,5	28,1	71,4	0,4	4,2
2030	85,00	0,12	27,81	10,44	0,01	3,42	5,970	0,005	-3,837	0,733	0,001	-1,199	545,9	2,9	31,7	73,8	0,4	4,3
Total	1714,1	7,02	295,89	602,88	2,46	70,91	192,90	0,750	-142,3	84,293	0,440	-43,68	5279,8	30,1	305,9	1628,9	9,6	93,8

Additional annual FE, FP and O&M implementation scenarios for mitigation and adaptation sector and investment entities (million)

Sector	Electricity production						Electricity demand						Water management					
	Government			Private owners			Government			Private owners			Government			Private owners		
Year	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0,79	0	0	0	0	0	0	0	0	0	64,4	0,4	3,7	0	0	0
2010	0	0,12	0	0	0	0	0,329	0	0,003	1,095	0	0,002	82,9	0,5	4,7	0	0	0
2011	55,70	0,24	0,08	0	0	0	11,267	0,221	-0,633	6,149	0	-0,617	95,8	0,6	5,4	0	0	0
2012	81,30	0,30	2,52	0	0	0	10,946	0,131	-1,273	5,482	0	-1,256	103,0	0,7	5,8	0	0	0
2013	55,70	0,22	2,60	0	0	0	10,856	0,131	-1,892	5,275	0	-1,896	111,2	0,7	6,3	0	0	0
2014	57,70	0,26	4,88	0	0	0	10,676	0,031	-2,553	4,837	0	-2,536	120,2	0,7	6,8	0	0	0
2015	55,70	0,32	4,96	0	0	0	10,540	0,031	-3,193	4,531	0	-3,176	130,4	0,8	7,5	0	0	0
2016	81,30	0,40	7,40	0	0	0	9,474	0,031	-3,471	1,549	0	-3,832	141,8	0,9	8,1	0	0	0
2017	55,70	0,37	7,48	0	0	0	9,468	0,031	-3,579	1,551	0	-4,090	154,5	0,9	8,9	0	0	0
2018	207,70	0,37	9,77	0	0	0	9,461	0,031	-3,626	1,553	0	-4,209	168,7	1,0	9,8	0	0	0
2019	205,70	0,38	9,85	0	0	0	9,454	0,031	-3,674	1,555	0	-4,331	184,6	1,1	10,7	0	0	0
2020	254,70	0,56	11,12	0	0	0	9,447	0,031	-3,724	1,557	0	-4,456	202,4	1,2	11,8	0	0	0
2021	15,70	0,45	17,55	0	0	0	5,426	0,005	-3,765	-0,235	0	-4,563	247,8	1,5	14,3	0	0	0
2022	97,70	0,39	19,91	0	0	0	5,485	0,005	-3,807	-0,068	0	-4,669	270,0	1,6	15,6	0	0	0
2023	15,70	0,41	19,91	0	0	0	5,544	0,005	-3,849	0,099	0	-4,778	294,8	1,8	17,1	0	0	0
2024	121,30	0,53	22,35	0	0	0	5,602	0,005	-3,893	0,266	0	-4,888	318,8	1,9	18,5	0	0	0
2025	15,70	0,48	22,43	0	0	0	5,661	0,005	-3,937	0,433	0	-5,001	345,5	2,0	20,1	0	0	0
2026	97,70	0,06	24,71	0	0	0	4,599	0,005	-3,982	0,489	0	-5,116	368,9	2,0	21,5	0	0	0
2027	39,30	0,55	24,95	0	0	0	4,657	0,005	-4,028	0,651	0	-5,231	408,5	2,2	23,8	0	0	0
2028	103,40	0,43	27,33	0	0	0	4,716	0,005	-4,074	0,814	0	-5,348	439,1	2,3	25,6	0	0	0
2029	11,40	0,06	27,49	0	0	0	4,774	0,005	-4,122	0,976	0	-5,467	480,5	2,5	28,1	0	0	0
2030	85,00	0,12	27,81	0	0	0	4,832	0,005	1,750	1,138	0	-5,588	545,9	2,9	31,7	0	0	0
Total	1714,1	7,02	295,89	0	0	0	153,21	0,750	-61,32	39,696	0	-81,04	5279,8	30,1	305,9	0	0	0



## 4. Acronyms

IF	Investment Flows
FP	Financial flows
O&M	Operation and maintenance costs
I&FF	Investment and Financial Flows
GDP	Gross Domestic Product
USA	United States of America
UNDP	United Nations Development Programme United Nations
UN	United Nations
PPC	Public Power Corporation
GES	State Power
TPP	Thermal power central
GHG	Greenhouse gases
CO <sub>2</sub>	Carbon dioxide (greenhouse gas)
RES	Renewable Energy
IWRM	Integrated Water Resources Management
Krause	Complete reconstruction of irrigated land
MUZ	Reclamation land improvementStan Collection of technical and economic standards
Efficiency	Efficiency
thousand	thousand
million	Million
billion	billion
tn.	Ton
m <sup>3</sup>	cubic meter
km <sup>3</sup>	Cubic Kilometers
MW	A measure of electrical power (megawatt-hour of 1 MW = 1000 kWh)
AZN	The national currency of Turkmenistan
%	Percent sign