Investment and Financial Flows (I&FF) Assessment Report

Assessment of investment and financial flows to address climate change mitigation in the sector Electricity Generation

REPORT
Assessment of investment and financial flows to address climate change mitigation in the sector "Electricity production“

CONTENTS

1. Introduction

The sector Electricity Generation is part of the energy sector of Turkmenistan, which is a complex organization that provides design, construction, installation, pad, repairs and maintenance of power facilities and provides central electricity and heat supply to all consumers in several cities. Options for the development and implementation of state policy of Turkmenistan in the power industry by the Ministry of Energy and Industry.

One of the first electric power facilities of Turkmenistan is the Hindu Kush to the power line voltage of 16.5 kV length of 38,7 km, which were commissioned in 1913. At the power plant there are three turbine generators with a capacity of 400 kW, the total capacity of 1.2 MW, the Austro-Hungarian company "Hans". Despite its considerable age (96 years) power and today continues to produce electrical energy. [9]

Up to 1957 electricity consumers of electric energy Turkmenistan was carried out from small isolated diesel power plants and power stations.

In May 1957, was set up specialized management of the energy economy at the Economic Council of Turkmenistan (now HEC "Turkmenenergo“), which allowed the energy to concentrate power in a single office, and gave a sharp impetus to the development of energy sector of Turkmenistan.

The main stages of the development of Turkmenistan's energy system are:
1913 - Commissioning of the first hydroelectric power station
1957 - Education branch of the national energy management
1966 - Implementation of Phase 1 to connect remote areas of Turkmenistan to the United Energy System of Central Asia
1969 - Start of construction of the Mary thermal power plant
1970 - Association Ashgabat, Mary and Chardzhou power
1979 - Achieving a 100 per cent level of centralization of power in rural areas of Turkmenistan
1980 - Completion of the formation of centralized power in Turkmenistan
1987 - The commissioning of Unit 8 Mary thermal power plant and bringing its total capacity to 1,685 MW
1996 - Completion of high-voltage power lines Sadie-Dashoguz and adherence Dashoguz province to the centralized power system in Turkmenistan
1998 - Commissioning of the first gas turbine unit of the company "General Electric
2001 - Building on its own the first 500 kV Serdar.

Currently, the system of the State Power Corporation "Turkmenenergo“ Ministry of Energy and Industry of Turkmenistan includes: 8 state power, industrial associations and one company of electric networks; management of urban lighting the city of Ashgabat; Specialized Production Association Turkmenenergoabatlayysh, Gosenergonadzor, Enterprise Energoendzham and management of housing and communal services. [9]

The Corporation is an integrated organization that provides operation and maintenance of power plants, provides central electricity consumers of the economy. Because the electric power industry is completely state-owned, the state, through HES "Turkmenenergo“ oversees the entire process of production, transportation and distribution of electricity.

Turkmenistan is the only country in the world, where social welfare by Presidential order of 1993 people provided with free electricity, gas and water, in 2006 the Presidential decree, this social benefit is extended until 2030.

Since independence, the development of the energy industry based on the complete satisfaction of consumers of electricity in Turkmenistan, as well as increase the level of exports to neighboring countries - Tajikistan, Kazakhstan, Afghanistan, Iran and Turkey.

Turkmenistan has commissioned new generating capacity, which increased the installed capacity of power grid and improve the balance of power on the province.

Abadan hydro 2h123 MW, 1998, 2003
Balkanabadskaya hydro 3h42 MW, 2003
Seidi CHP 80 MW, 2004
Ashgabat GES 2h127, 1 MW, 2006
Dashoguz GES 2h127, 1 MW, 2007

Input power generating facilities continues. Has now completed the construction of gas turbine power plant in Akhal province. Is nearing completion and construction of gas turbine power plants in Avaza and Balkanabat. The capacity of all three plants is 254 MW. With the commissioning of these power plants gas turbine power plants will amount to 1,643 MW, which would represent 42% of the total installed capacity of 3,909.2 MW.

Structure installed capacity of power plants groups of equipment for the year 01/01/2008

№	Electric equipment	Power on 01.01.2008 year	
		MW	Share in%
1	The units 210-215	2105	62,99
2	IES 90 atm	100	2,99
3	TPP below 100 ata	255	7,63
4	Gas turbine	880,4	26,35
5	Hydroelectric	1,2	0,04
	Total:	3341,6	100

Since independence, Turkmenistan's power industry built and put into operation a number of power plants to ensure stable operation of power system reliability and quality of power supply to consumers of electricity in Turkmenistan and increasing exports:

- 500 kV „Serdar-Dashoguz“ length 378 km - in 1996, for the security of supply Dashoguz province;
- VL-220 kV "Balkan Gonbad" (Iran) and stretches 248 km - in 1999, to export electricity to Iran and Turkey;
- VL-220 kV "Kerk Sunrise" 40 km from the crossing of the river Amu-Darya - 1998, for transmission of electricity from Turkmenistan's energy consumers the right bank, abandoning the export of electricity from Uzbekistan;
- PS-220 kW "Balkan" - 1999 - for the export of electricity to Iran.

In 2001, commissioned SS 500 "Serdar", calling-out of 500 kV "Mary GRES-Serdar-Karakul" (Uzbekistan) and VL-220 kV "Industrial-Serdar-Dashoguz“. This large energy complex was built by the Turkmen builders in the short term - 6 months, while the object is provided with modern equipment and has a high technical equipment. Putting this important energy facility allowed:

- Ensure the Turkmen electricity transmission grid to domestic consumers from its own sources of energy, ie power system has become economically independent.
- Economically advantageous to distribute the transmission of electrical power for 220-500 kV networks from Mary HPS in Lebap, Dashoguz and for export to the countries of Central Asia.
- Increase the capacity of VL-220 kV ”Serdar-Dashoguz" by reducing the line at 76 km.

In 2004, commissioned VL-220 kV “Shatlyk-Sarakhs-Iran" for the transfer of electricity to Iran.

In 2005, commissioned FS-220 "Baharly" to unload the existing overhead 110 kV in this site and improve the quality of electricity at the consumer.

In 2008, to ensure a reliable supply of large industrial center - Yashyldepinskogo gas refinery commissioned 220 kV "Farap, 110 kV" Yashyldepe and 110 kV line "Farup Samandepe", "Samandepe-Yashyldepe" and "Yashyldepe-Burdalyk".

In accordance with the National Program "Strategy of economic, political and cultural development of Turkmenistan until 2020" will considerably increase electricity production by increasing their own consumption and export. In 2020, it is assumed that electricity production in Turkmenistan will reach 26.38 billion kWh In 2008, the Company produced 14.97 billion kilowatt-hours of electricity, i.e. will increase in 1,8 times. (A-4)

Ministry of Energy and Industry has developed a program of power sector development to 2020 [4], which is currently under negotiation and approval by the Government of Turkmenistan. To increase electricity generation in the program is scheduled capacity growth through the following activities:

1) Modernization of eight units at the Mary and two hydroelectric power plants Turkmenbashi thermal power station.

To date, six hydroelectric power plants at the Mary worked normative life (27 years). Two power units of Mary HES and two units of Turkmenbashi thermal power station were operating time of more than 22 years and are close to working out moto. Upgrading power plants and hydroelectric Mary Turkmenbashi thermal power station will increase the available capacity of the Turkmen energy to 645 MW and reduce specific fuel consumption of generating units, to reduce emissions of harmful substances into the atmosphere, to extend the 20-year lifetime of the reactors, and automate the management unit. The calculations show that the cost of upgrading power plants will pay for Turkmen exports only from the saving of natural gas for 3-5 years.

2) Transfer of gas turbine power plants to combined cycle (co-generation).

The four existing gas turbine power plants and three under construction, which will be commissioned in early 2010, work on a circuit. Electric Power Development Programme 2020 provides all the power transfer to the combined method of electricity generation - simultaneous production of electricity and thermal energy. In Europe, this method is called "co-generation" or steam-gas cycle. The use of co-generation at Abadan gas turbine power plant is not planned yet, because it has great achievements and, according to experts, you must first decide whether to modernize or replace a new power plant. This issue will be addressed after 2030.

3) Construction of new gas turbine power steam-gas cycle.

The program to develop the power until 2020 plans to build new power plants that use technology co-generation.

Despite the fact that the program provides for development of the electricity as the construction of new power plants steam-gas cycle and the transfer of existing power plants on the steam-gas cycle, the analysis of the historical period indicates that the current practice of applying technology gas turbine simple cycle power plants will continue in the next 10 years. This is primarily due to the fact that the unit costs for the construction of a MW steam-gas turbines in 2,5 times higher unit costs for the construction of 1 MW of conventional gas turbine power plants. Therefore, this study provides the baseline scenario for growth of capacity through the construction of gas power in simple cycle, the reconstruction of power and the output of work mentally and physically worn out turbines. The introduction of more advanced and climate-friendly technologies associated with the co-generation, is planned in the scenario of climate change mitigation.

In the power grid construction program envisages the construction of 220 kV ring around Ashgabat, which will greatly improve the reliability of electricity supply in Ashgabat, because achieved mutual redundancy Ashkhabad, Akhal and Abadan power plants.

In the future, girdling the Turkmen energy by overhead cables of 500 kV, and by 2020 plans to build a 500 kV high voltage Turkmenbashi-Ashgabat-Balkanabat that will allow for the mutual redundancy of eastern and western parts of the Turkmen energy.

A large amount of construction and reconstruction of electric networks laid in initiated by President Gurbanguly Berdimuhamedov Development Programme, towns and villages in Turkmenistan.

Today in electricity engaged eight stations, seven of which are included in the scope of this work.

Mary GES

At the station, installed eight steam turbine units, manufactured in the factories of the Soviet Union (LMZ, TDF, Elektrotyazhmash). Design capacity of each unit is 210 MW. Six blocks of eight worked normative lifespan, two blocks have the operating time of more than 20 years. As a consequence, due to various defects in power units have capacities from 100 to 170 MW instead of 210 MW project. In order to improve efficiency of the Mary GES planned implementation of the modernization of power plants.

By rough estimate ZAO “Yarovit Energo" reconstruction of a hydroelectric power unit of Mary will cost $ 64 million. These costs will be paid back to Turkmenistan for 3-5 years.

Despite the fact that the deadline for payback at the Turkmenbashi thermal power station is lower than at the Mary HPP, reconstruction should be started at the Mary HPP, because currently in the Balkan province construct two gas power plants with total capacity of 508 MW, which in the next 5 years will cover the increased load on the Balkan province.

Besides saving fuel reconstruction can extend the life of power, to increase their reliability, automate management power units and to increase the available output power of Mary in 470 MW hydroelectric power station.

Abadan GES

The main equipment of Abadan GES consists of two parts:

1) Gas turbine power plant which has two gas turbines, manufactured by Dzhenerel Electric (USA). The capacity of each gas turbine 123 MW. First gas turbine installed and commissioned in 1998, and the second in 2003. The two gas turbines to be translated into a combined or steam-gas cycle, which will save fossil fuels.

2) steam-turbine power plant, which installed steam turbine PT-25-4 (FCZ) station number 5,25 MW. Date of entry into service in March 1962, operating time 47 years 5 months compared to a standard 27 years. The condensing turbine K-50-90-3 (LMZ) station number 6, the power is equal to 50 MW, the date of commissioning in October 1964, operating time 45 years [9].

With a total installed capacity of 75 MW turbines are currently due to poor technical condition capable of carrying capacity in the winter of 25 MW (33,3% of installed capacity), in the summer of 15 MW (20% of installed capacity).

With the commissioning of new gas turbine power Akhal hydroelectric turbines from station number 5 and 6 are to be written off, as physically spent their lifespan, and the further exploitation of which is economically feasible.

Turkmenbashi thermal power station

The main equipment of Turkmenbashi thermal power station consists of two parts

1. HPP's TV part, in which there are two steam-turbine power unit, manufactured in the factories of the former Soviet Union (LMZ, TDF, Elektrotyazhmash).

Mean time Units Turkmenbashi thermal power station is more than 22 years and is close to working out moto. Due to various defects blocks are output from 100 to 120 MW instead of 210 MW project. To improve the energy efficiency of the planned write-off of equipment, as well as the modernization of two units.

By rough estimate of ZAO Yarovit Energo reconstruction of one unit of Turkmenbashi thermal power station will cost 86 million dollars. These costs will be paid back to Turkmenistan for 5 years.

Besides saving fuel reconstruction can extend the life of power, to increase their reliability, automate management power units and to increase the available output power Turkmenbashi thermal power station of 175 MW.

2. CHP's TV part, which are in operation, two steam turbines Fri 60-90/13 (LMZ), station number 1 and 2 with capacity of each turbine is 60 MW. Date of commissioning № 1 - December 1965; № 2 - December 1966. The mean time of 44 and 43, respectively, compared to a standard 27 years.

With a total installed capacity of 120 MW turbines are currently due to poor technical condition, capable of carrying capacity of only 25 MW (20,8% of installed capacity).

With the commissioning of new gas turbine power Avazinskaya hydroelectric turbines № 1 and № 2 be written off, as physically spent their lifespan, and the further exploitation of which is economically feasible.

Ashgabat GES and GES Dashoguz

Ashgabat HPP was commissioned in February 2006, and Dashoguz HPS in December 2007. Installed capacity of each plant is 254.2 MW - two gas turbines of 127.1 MW of firm General Electric (USA). The two gas turbine power plants can be transferred to the steam-gas cycle, which will increase plant efficiency, reduce consumption of natural gas in electricity generation.

Balkanabadskaya GES

The power plant was commissioned in 2004. Installed capacity of power plants of 126 megawatts - three gas turbines of 43 MW of firm General Electric (USA). With the commissioning in 2010, two more gas turbines with a capacity of 127.1 MW (General Electric), the total installed capacity of power plants will amount to 380.2 MW. This power can also be transferred to the steam-gas cycle.

Seidi CHP

At Seidi CHP has two district heating turbine PT-80/100 (LMZ), one in 1992, the second in 2004. Because of the low extraction of steam power consumer in the winter can carry the load 75 MW of installed capacity of 160 MW, ie 46,8% of the nominal power. To improve the efficiency of power plants must increase steam heat consumers.

Gindikushskaya GES

As noted, the Gindikushskoy hydroelectric turbines installed three firms "Hans" (Austro-Hungarian), with a capacity of 400 kW each. Total installed capacity of hydropower is 1,2 MW. The service life of 96 years.

1.0 Evaluation of Energy Efficiency

The main indicators of energy efficiency in the sector of "Electricity production" are the specific consumption of fuel for production of 1 kWh electricity consumption of electricity for its own needs of the total output.

At Mary GES in 2008, the specific consumption of fuel has exceeded the normative value at 120.3 g / kWh and electricity consumption for its own needs is 7,2%. In this work includes activities to modernize the power of this station.

Specific consumption of fuel for hydropower Abadan in 2008 showed a deviation from the standard ratio at 47.35 g / kWh, electricity consumption for own needs amounted to 2,3%. This is due to the fact that the plant has equipment (turbines, boilers) with a lifetime of more than 45 years, which is morally and physically worn out. In this study include activities on decommissioning and the cancellation of this equipment.

Specific consumption of fuel for the Turkmenbashi thermal power station in 2008 exceeded the normative value at 216.7 g / kWh, electricity consumption for own needs amounted to 10.76%. These high values can be explained by the fact that the power plant is operated equipment (turbines, boilers) with a lifetime of more than 45 years, which is morally and physically worn out. In this paper we reviewed the activities of the conclusion of the work and the cancellation of this equipment, as well as the modernization of two units.

Specific consumption of fuel and electricity consumption for its own needs for Ashkhabad GES and GES Dashoguz in 2008 are within the design specifications, as these plants were commissioned in 2006-2007. However, it is possible to improve their performance through the transfer of these gas-turbine power plant steam-gas cycle, as provided in this paper.

Specific consumption of fuel and electricity consumption for its own needs for Balkanabadskoy GES in 2008 corresponds to the design standards as well as a power plant put into operation in 2004. However, with the introduction of new units in 2010, it is possible to improve their performance through the transfer of this gas turbine power station on the steam-gas cycle. Such events discussed in this paper.

Specific consumption of fuel for the Seidi CHP in 2008 showed the excess of its design goal to 117.74 g / kWh, electricity consumption for its own needs amounted to 10,71%. These high values due to the fact that power plants are installed turbines with steam extraction for industrial purposes. Currently, the consumer - Seidi Refinery (SNPZ) does not use steam. In this paper, the issue of improving energy efficiency of the CHP is not considered, since it will be decided in conjunction with the modernization SNPZ.

It can be concluded that the availability and use of obsolete and outdated equipment at power plants cause significant excess of design standards for specific fuel consumption and power consumption for its own needs. In this paper some issues related to improving technological efficiency of production of electricity, which will save significant amounts of fossil fuels (natural gas) and thereby reduce emissions of greenhouse gases in the atmosphere.

1.1 Objectives

Evaluation of investment and financial flows, primarily intended for national officials, policy makers of the country in the future.

The main objective of this work - to identify and describe the options for policies related to addressing climate change in the sector of "Electricity production", in other words, to define priorities for action to mitigate climate change in the sector of "Electricity production", which can be implemented to reduce greenhouse gas emissions. Such events also help to ensure sustainable development of power of Turkmenistan, which is a basic sector for the development of all sectors of the economy. We evaluated the costs of implementing these measures. To achieve this goal in the process of following tasks:

- Delimitation of the sector;
- Identification of measures to reduce GHG emissions in the sector;
- Evaluation of investment and financial flows in the historical period (2000-2008 years);
- Identification of scenarios for the sector - the base scenario and mitigation;
- Evaluation of investment and financial flows in the baseline and mitigation scenario (2009-2030 years);
- Comparison of the baseline scenario and mitigation scenario;
- Assess feasibility of interventions to mitigate climate change in the sector of "Electricity production".

1.2. Justification

1.2.1 The previous tests conducted

In the preparation of the Second National Communication under UN Framework Convention on Climate Change have been identified CO_2 emissions by sector "electricity production", which in 2030 could reach 30 mln.tn with current practice and the planned amount of electricity - 42 billion kWh . These volumes were taken from the Electric Power Development Programme, which operated at that time. In compiling this program before each branch was tasked with the annual increase in gross output by 20%. In 2007, the President of Turkmenistan was initiated work on the revision of curricula in the oil and gas, electricity and other industries to make them more feasible for implementation. By December 2008 was prepared by the Revised Programme of electricity until 2020. According to this document and the expert evaluation on the 2020-2030 years, electricity production in 2030 reached 35.5 billion kwh of volumes, which looks more realistic [9].

In the preparation of the Second National Communication under UN Framework Convention on Climate Change were also identified measures to reduce CO_2 emissions, which are discussed in this paper [3].

The decline in electricity generation for the future entailed, and adjusting the volume of construction of power plants. The revised program of power development until 2020 and peer review to 2030 include:

- Annual output growth of 3-5% and bring it in 2020 to 26.38 billion kWh (compared with 2008 growth at 1.8 times) and in 2030 to 35.5 billion kWh. h (compared with 2008 increased by 2,4 times);
- Annual growth in personal consumption by 3-4%;
- Annual growth in electricity exports by 8-10%;

The main activities that reduce CO_2 emissions in the sector of "Electricity production" are:
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, solar) in communicating with the volume of electricity production from renewable energy sources up to 1% of total production, ie up to 355 mln.kvt.ch in 2030.

All these measures will reduce the specific fuel consumption for 1 kWh of electricity and thus save a considerable amount of fuel that will eventually lead to a reduction in CO_2 emissions.

1.2.2 Institutional arrangements and collaboration

Score I&FF sector "Electricity production" conducted with the support of key ministries for this sector - the Ministry of Energy and Industry of Turkmenistan and its subdivisions HES "Turkmenenergo".

The Group of Experts for the sector "Electricity production" has been formulated on the basis of the official presentation of officials and experts of the Ministry of Energy and Industry in response to a request from the UNDP Resident Representative in Turkmenistan to identify experts to perform I&FF.

In the first phase of the project managers of the project was organized by the expert group meeting with international experts, which the team agreed on procedures to provide data for evaluation and approval of final sectoral report by the Ministry of Energy and Industry.

The experts group has been defined the following list of data for tasks assessing I&FF and O&M: the number of generated electricity, the amount of the released energy, the unit cost of fuel to produce 1 kWh of electricity, operating time of power, technical specifications of the main equipment of power plants, electric power costs for their own needs amount of fuel consumed, the cost of I&FF and O&M. All data were collected from annual reports of power and HES "Turkmenenergo" [9].

At each plant specialists shops provide information to the production and technical department (PTI) power. VET compile and transmit a report to the BSE "Turkmenenergo". Production and technical management of the corporation "Turkmenenergo modify, compile and prepare annual reports on the corporation "Turkmenenergo" [9].

From the annual reports for the construction of power plants and annual reports of management of capital construction HES "Turkmenenergo obtained data on new power plants put into operation, as well as the necessary data to determine I&FF and O&M for each facility [9].

In carrying out this study conducted a survey of specialists in all power plants to refine the data of annual reports and collect additional information necessary to assess I&FF.

To coordinate the implementation of the expert meetings were held every two weeks, starting from September 1, 2009, after gathering all the information as needed, but not less than once a month.

1.2.3 The basic methodology and key terms

The method used to assess the reduction of emissions of CO_2 in the atmosphere, based on reducing consumption of fossil fuels (natural gas) for power generation. For each of the proposed measures is determined by fuel savings from the introduction of this event, which is then multiplied by a factor of CO_2 emissions from combustion of the fuel. To estimate emissions of CO_2 emission factors are developed for those fuels that are used for power in Turkmenistan.

Based on the analysis of the "Electric Power Development Programme of Turkmenistan until 2020" [4], the new edition of which was prepared in December 2008, and peer review to 2030 developed two scenarios: a base scenario and the mitigation of climate change for the sector of "Electricity production".

Baseline scenario. This scenario assumes that the growth of capacities needed for electricity production, the planned program for the development of electric power until 2020, and evaluated by experts prior to 2030, will occur at the expense of upgrading power plants and hydroelectric power station on the Mary Turkmenbashi thermal power station, as well as construction of new gas turbine power plants necessary power, which will operate in simple cycle.

In the baseline scenario identified two activities that will reduce emissions of CO_2 in the atmosphere:

- Output from the work of obsolete and worn-out equipment at the Turkmenbashi thermal power station and hydro Abadan and replacing it with new gas turbine. Specific consumption of fuel on the new equipment will be 2-3 times lower.
- Modernization of worn-out equipment at the hydropower stations and Mary Turkmenbashi thermal power station, the implementation of which will increase the available capacity of the Turkmen energy to 645 MW, to reduce the specific consumption of fuel for electricity generation, reduce emissions of CO_2 in the atmosphere and extend a 20-year lifetime of the reactors. The calculations show that the cost of upgrading power plants will pay off 3-5 years only from the export of the saving of gas. Calculation of CO_2 emissions in the baseline scenario is made with the backdrop of increased electricity generation by year and reduce specific fuel consumption for electricity in the implementation of planned activities.

Mitigation scenario. This scenario assumes that the growth of capacities needed for electricity production during 2010-2020 years, will be at the expense of upgrading units at the Turkmenbashi and Mary HPP HPP (645 MW), the transfer of existing and planned for commissioning in 2010, gas turbine power plants on steam -gas cycle (720 MW) and construction of wind and solar power (84 MW). In the years 2021-2030 the growth of electricity generation will be met through construction of steam-gas combined cycle power plant (1496 MW) and construction of power plants using renewable energy (45 MW). Calculations show that the costs of carrying out activities to transfer gas turbine power plants at steam-gas cycle will pay off for 5-6 years only from the export of the saving of fuel (natural gas).

On this basis, we calculated the investment and financial flows to 2030.
To calculate I&FF under both scenarios were used the following documents:

- Second National Communication under UN Framework Convention on Climate Change (Ashgabat, 2009)
- National program "Development of power industry of Turkmenistan until 2020"
- Expert assessment of "Development of Turkmenistan for electricity 2021 - 2030 years"
- Proposals from Yarovitenergo Company Ltd and CARE-Holding to modernize power plants and power plant Mary Turkmenbashi thermal power station
- Proposals from the company Yarovitenergo and Chalyk-Energy to transfer the existing simple cycle power plant to combined cycle
- The project proposal of the company «goetzpartners» to build solar power stations
- Annual reports and Power HBT "Turkmenenergo
- Reference book on the energy third edition, revised and enlarged Moscow, "Energia", 1978
- Handbook on designing power systems Second Edition, revised and enlarged Moscow "Energy", 1977.

"Investment Flow" (IF) - a capital cost of building new and upgrading existing power plants.

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 upgrading of the operating personnel.

"The cost of operation and maintenance" (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. The scope, the input data and scenarios

2.1 Scope of the sector

Sector “electricity production" includes seven thermal power plants and one hydroelectric station. 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.

The equipment power plants with steam turbine, except for steam turbine, includes boilers for the chemical preparation of water, generators, transformers and switchgear. Cooling hydroelectric turbines at the Mary made the waters of the Karakum river at the Turkmenbashi thermal power station with sea water, while the remaining power of the closed-loop (cooling towers).

The equipment power plants with gas turbine, except for gas turbines include generators, transformers and switchgear.

In this study covered all seven thermal power plants. The scope does not include only Gindikushskaya hydroelectric power, because she works only 2-3 months a year and is the current museum exhibit, her age is 97 years.

Sector Electricity Generation is a major consumer of fuel (natural gas, fuel oil, diesel fuel) in the industry. It accounts for 87% of industrial consumption of gas in Turkmenistan. According to the inventory for the period 2000-2004, emissions of CO_2 in this sector of the country ranks third, after the oil and gas sector of the population and constitute 16% of the total emissions [3].

Clearly, for increasing energy efficiency should be a number of measures on rational use of electricity in the power industry, such as alignment chart loads, reducing power consumption for its transformation and transportation and others. However, these measures do not give a significant reduction in CO_2 emissions, and therefore in this study were not considered, and mitigation of climate change by reducing CO_2 emissions from performing activities in the sector, "Energy consumption" addressed in a separate sector report.

With regard to investment organizations, it should be noted that all expenditures undertaken in the sector of "Electricity production" is the public funds allocated to the Ministry of Energy and Industry of Turkmenistan in accordance with the Presidential order. Thus, the government of Turkmenistan is a major investment entity to assess I&FF, and internal budgetary source I&FF for the sector "Electricity production“.

2.2 Input data and scenarios

2.2.1 The evaluation period and the parameters of cost accounting

The evaluation period includes the historical period from 2000 to 2008, as well as long-term period from 2009 to 2030.

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 is traditionally calculated in national AZM significantly reduced when converted into U.S. dollars. On the basis of cost-oriented in 2008 were estimated expenditure for 2009-2030 O&M years, and then translated into U.S. dollars. According to expert opinion in 2008 as the base reflects the actual costs of O&M in U.S. dollars in subsequent years until 2030. IF and FF were calculated directly in U.S. dollars, so the choice of these indicators did not affect the base year.

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 1 January 2009) [12].

In accordance with the existing practice of designing and in consultation with international experts for this work, the discount rate adopted at the 10% level.

2.2.2 Method of analysis

To assess I&FF developed two scenarios for developments in the sector "Electricity production", which are based on the" Program of development of power industry until 2020 "[4], and expert assessment of power development until 2030.

The main stages of development scenarios:

1) The analysis of the equipment of existing power plants, the timing of their operation and technical parameters of their work. Determined the maximum power that can carry the equipment, annual power output and specific fuel consumption for production of 1 kWh [9]
2) The causes of low efficiency of power plants and planned activities to increase their energy efficiency.
3) On the basis of global experience in power plants have been identified at the transfer of gas-turbine power plants in the steam-gas cycle, as well as construction of new power plants using co-generate.
4) The analysis of opportunities for the introduction of renewable energy sources have been identified at the construction of power plants using solar and wind energy [8].

Data for the PT and PA expenditures presented in the sectoral reporting manat, so they are translated into dollars at the existing rate.

IF and FF for the years 2010-2030 are based on the volume of construction and modernization of power plants planned in the Programme of Electric Power Development of Turkmenistan until 2020 and some experts estimate up to 2030. Value (currency) are taken from the existing proposals for the construction and modernization of thermal and solar power. The construction cost of wind power are based on the proposals of the leading companies, published on the Internet [8].

O&M for the years 2010-2030 were determined by linear trends based on data for 2008 with an annual increase in fuel costs, as well as the increasing cost of repairs and maintenance of the newly introduced equipment.

2.2.3 Historical I&FF and O&M data, as well as subsidies

The historical period before the figures for 2000-2008 year. Data on fuel consumption for this period are from the annual reports of power calculation determined by CO_2 emissions from the combustion of each type of fuel (natural gas, fuel oil, diesel fuel). Cost IF and FF for the construction of new gas turbine power plants in this period are from contracts (currency) for the construction of these plants. Operating costs (O&M) for raw materials, fuel, labor and other costs are taken from annual reports of power in manat. In the tables these costs are translated into U.S. dollars at the official rate of $ 1 = 5200 manat to April 2007 and 1dollar = 14250 manat from May 2007 to 2008.

For 9-months 2009 IF and FF are from the quarterly reports on capital construction and for the IV quarter added to the expected cost of IF and FF (in currency). Similarly, we define the cost-oriented in manat with their translation into U.S. dollars at official exchange rate of 2.85 manat per 1 U.S. dollar.

Based on the annual cost of fuel (gas, fuel oil, diesel fuel) from the annual reports for the 2000-2008 year, and the coefficients of CO_2 emissions by burning natural gas, fuel oil and diesel fuel were found emissions of CO_2 from the burning of each fuel type, as well as the total volume of CO_2 emissions from combustion of all fuels (see Annex).

Entrepreneurs in the sector of "Electricity production" are based on actual costs for the construction of gas turbine stations. FF evaluated based on actual costs of training for the

operation of gas turbine power plants and the reconstructed unit № 2 at Mary GES, as well as costs for staff development of power plants, held annually in the training center HES "Turkmenenergo“ [9].

Data for the determination of PA expenditures derived from annual reports of power plants and include the cost of repairs and maintenance of power plants, fuel costs and staff salaries.

The cost of electricity production by type of investment (million USD)
Category Investment Organization - Government; Channel I&FF funds - Internal budgetary funds

Type of investment	**Construction of new power plants**			**Operation of power plants built before 2000**		
Year	**IF**	**FF**	**O&M**	**IF**	**FF**	**O&M**
2000	8,00	0	1,11	0	0,18	13,71
2001	11,90	0	1,08	0	0,21	24,52
2002	29,60	0	1,13	0	0,15	29,55
2003	48,00	0,05	1,24	0	0,14	39,0
2004	4,20	0,08	2,21	0	0,12	40,37
2005	45,90	0,16	2,27	0	0,15	48,02
2006	114,15	0,22	3,64	0	0,14	49,81
2007	65,00	0,18	1,79	0	0,15	24,6
2008	170,00	0,28	2,6	0	0,14	19,49
Total	**496,75**	**0,97**	**17,07**	**0,00**	**1,38**	**295,07**

The total cost of electricity production (historical period) (million USD)

	IF	**FF**	**O&M**
2000	8,00	0,18	20,82
2001	11,90	0,21	25,60
2002	29,60	0,15	30,68
2003	48,00	0,19	40,24
2004	4,20	0,20	42,58
2005	45,90	0,31	50,29
2006	114,15	0,36	53,45
2007	65,00	0,33	26,39
2008	170,00	0,42	22,09
Total	**496,75**	**2,35**	**312,14**

As the table shows a significant increase in IF account in 2006 and especially 2008. This is due to the fact that in 2005-2006, built Ashgabat gas turbine power station in 2006-2007 Dashoguz turbine power plant, and in 2008 started the construction of three gas turbine power (all power plant of 254 MW simple cycle).

In accordance with the norms of depreciation for the full recovery of fixed assets, approved by Decree of the President of Turkmenistan, the service life of gas turbine power plants is 16.4 years.

Growth-oriented in 2005-2006 associated with the implementation of the reconstruction of the turbine unit № 2 Mary GES funded NGOs. Reduction of O&M in 2007-2008 reflects a change in the dollar to the national currency in May 2007.

2.2.4 Base scenario

The base scenario assumes that the entire increase in capacity required to increase electricity generation by 2030, implemented by the construction of gas turbine power plants.

There are two areas that could reduce fuel consumption for electricity generation. First - this is the conclusion of the work morally and physically worn-out equipment, fuel consumption for which two to three times the average specific fuel consumption of BSE "Turkmenenergo. Second - it is modernization of hydroelectric power of Mary and Turkmenbashi thermal power station, which will reduce the specific fuel consumption for these power units and, consequently, reduce gas consumption for electricity.

Emissions of CO_2 for the period 2009-2030 years are based on the estimated amount of fuel needed to produce the planned amount of electricity in those years, taking into account measures to modernize power plants and the withdrawal of worn-out steam turbine power plants and construction of new gas turbine power stations (see Appendix).

Total IF in the baseline scenario is made up of entrepreneurs to modernize existing power plants; IF to decommission obsolete and worn-out steam turbine and IF for the construction of new gas turbine power plants.

Total FF and O&M of this scenario consist of FF and O&M for the modernization of existing power plants, construction of new gas turbine power plants, and operating power plants built before 2009.

When performing calculations I&FF and O&M, the following assumptions:
1. Input capacity needed to ensure the volume of electricity generation until 2030, carried out by the construction of gas turbine power plants. The cost of one power plant approved $ 120 million (cost Dasoguz power plant, commissioned in December 2007) [9].
2. I&FF and O&M to modernize power plants and the withdrawal of worn-out steam turbine are defined in the relevant sections.

Total I&FF and O&M with the increasing costs O&M at the annual growth in fuel consumption and higher wages for the base scenario presented in the end of the section.

A) Upgrading of existing power plants

Calculation I&FF and O&M carried out on the basis of the draft plan for the modernization to upgrade power plants and hydroelectric Mary Turkmenbashi thermal power station until 2030.

Plan for modernization of power plants by 2020

Year	2009	2010	2011	2012	2013	2014	2015
Mary GES			Energy block № 5	Energy block № 3	Energy block № 1	Energy block № 4	Energy block № 6

Turkmenbashi thermal power station							

Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021-2030**
Mary GES	Energy block № 7	Energy block № 8	Energy block № 2			—
Turkmenbashi thermal power station				Energy block № 11	Energy block № 12	—

The cost of upgrading is taken from the proposal ZAO Yarovitenergo "[6]. Cost of upgrading a unit of the Mary HPS is 64 million. The cost of upgrading a unit of Turkmenbashi thermal power station is 86 million dollars. When performing calculations for Mary GES, the following distribution of funds:

- Modernization of one unit runs for two years;
- In the first year of preparatory work carried out at a cost of $ 20 million;
- In the second year running all the major work on the modernization, which cost $ 44 million.

When you upgrade a power Turkmenbashi thermal power station adopted the following schedule of distribution of funds:

- Modernization of one unit runs for two years;
- In the first year of preparatory work carried out and production equipment, the cost of these works is 20 million;
- In the second year running all the major works on modernization, which cost is 66 million.
- Calculation of the PT is made taking into account the necessary training for the operation of power after the upgrade.

The calculation of O&M necessary to maintain power in the normal state, defined as follows: After upgrading the unit every five years you need to repair at a cost of 4,2 million U.S. dollars, ie, annually 0.84 million U.S. dollars. Thus, the additional working capital costs for a single unit after the upgrade are 0,84 million U.S. dollars each year.

Costs O&M on fuel, salaries and other costs identified for the operation of power plants built before 2009 and are described below.

B) The decommissioning of obsolete and worn-out steam turbine with the substitution of electricity generated by new modern power

In 2010, after commissioning Akhal turbine power station is planned decommissioning of the old steam turbines Abadan HPP exhaust its lifespan: the steam turbine-type PT-25-90 with a steam production and installed capacity of 25 MW and lasting 48 years, steam turbine-type K-50-90 50 MW installed capacity and service life for 45 years. Thus, the planned total capacity for the decommissioning of 75 MW.

Electricity generation capacity will be decommissioned in place to produce hydroelectric Akhal expected specific fuel utilization is 382 g / kWh. (By analogy with Ashgabad GES), which is much lower than the values of this indicator in the old part of Abadan HPS [9].

Also in 2010 the withdrawal of the old part of the Turkmenbashi thermal power station after commissioning Avazinskoy gas turbine power plants. Will be decommissioned steam turbine-type PT-60-90-16 with an installed capacity of 60 MW in the amount of 2 pcs. and service life 43-44 years. The total capacity of the decommissioned steam turbines of 120 MW.

Under the terms of the saving evaluated submission of fuel, reducing CO_2 emissions as a result of the withdrawal of the old steam turbines and hydroelectric Abadan Turkmenbashi thermal power station will reach 232,092 tons / year.

The output of old power plants, exhaust its lifespan, with the substitution of their energy is the new modern power plants before 2030 will be implemented as follows:

- After commissioning Avazinskoy gas turbine power plant of 254 MW is planned withdrawal of the old steam turbine type PT-60/90-16 in quantity 2 pcs. Which are operated at this time at the Turkmenbashi thermal power station. The capacity of each turbine of 60 MW / hour.
- Commissioning Avazinskoy gas turbine power station is scheduled for May 2010, therefore, the withdrawal of the old turbines Turkmenbashi thermal power station will be completed in 2010.
- After commissioning of Akhal gas turbine power plant with a capacity of 254 MW is planned withdrawal of the old steam turbine-type K-50 and type PT-25/90-16 exploited at this time in

Abadan HPS. Turbine-type K-50 50 MW / hour, and the turbine type PT-25/90-16 25 MW / hour.

- Commissioning of Akhal gas turbine power station is scheduled for February 2010, hence the withdrawal of old hydroelectric turbines Abadan will be implemented in 2010.

When performing calculations IF adopted as the basis for the cost of dismantling the old equipment and improvement of the liberated territory. According to the Estimates and Financial proposals contractors above expenses are as follows:

- The cancellation of the old steam turbines Abadan GES - 480 thousand U.S. dollars.
- The cancellation of the old steam turbines Turkmenbashi thermal power station - 720 thousand U.S. dollars.

Since these costs are one-off nature, they belong to the IF in 2010, as the conclusion of the old steam turbines Abadan DES and Turkmenbashi thermal power station in 2010. The cost of the PC and PA in this case absent.

B) Construction of new gas turbine power

The following table shows the project implementation plan new facilities needed to provide specified amounts of electricity by 2020 [9] and the estimated volume of electricity until 2030.

To calculate the IF and FF data construction used in the construction of power plants Dasoguz for 2030, which added the necessary repair costs in accordance with the requirements of the equipment manufacturer.

Draft plan for the construction of gas turbine power plants until 2020

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Akhal ES		STU -254		STU -127								
Ashgabat GES						STU -127						
Dashoguz GES								STU -127				
Balkanabadskaya GES		STU -254								STU -127		
Avazinskaya GES		STU -254										STU -127

Draft plan for the construction of gas turbine power plants by 2030

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
HPP in Akhal province		STU -381				STU -381				
HPS in Lebap				STU -127						
HPP in Mary province								STU -381		

D) Operation of power plants built before 2009

Until 2009 commissioned power plants in the following plants:

1) Abadan state power (from 1962 to 2003)
2) Turkmenbashi teloelektrotsentral (from 1965 to 1986)
3) Mary Public Power Plant (from 1973 to 1987)
4) Seidi teloelektrotsentral (from 1992 to 2004)

5) Balkanabadskaya Public Power Plant (from 2003 to 2004)
6) Ashhabadsakya state power (from 2005 to 2006)
7) Dashoguzsakya state power (from 2006 to 2007)

FF for the operation of power plants built before 2009, identified from the analysis of the FF for the 2000-2009 year, which basically consider training in the training center "Turkmenenergo“.

Calculation O&M conducted on the basis of evidence O&M in 2008 with the addition of the cost of increased gas consumption in connection with the increase in electricity generation and anticipated increases in wages.

The cost of electricity production by type of investment. Baseline scenario (million USD)
Category Investment Organization - Government; Channel I&FF funds - Internal budgetary funds

Types of investments	Modernization of existing power plants			Conclusion worn steam turbines			Construction of gas turbine power plants			Operation of power plants built before 2009		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2008	0	0	0	0	0	0	170,00	0,28	2,6	0	0,14	19,49
2009	0	0	0	0	0	0	360,00	0,37	0	0	0,11	22,09
2010	20,00	0,12	0	1,20	0	0	140,00	0,09	4,74	0	0,11	22,09
2011	64,00	0,22	0	0	0	0	0	0,09	6,05	0	0,11	22,09
2012	64,00	0,31	0,84	0	0	0	60,00	0,27	8,99	0	0,11	22,09
2013	64,00	0,12	1,68	0	0	0	0	0,09	8,99	0	0,11	22,09
2014	64,00	0,25	2,52	0	0	0	60,00	0,27	12,07	0	0,11	22,09
2015	64,00	0,51	3,36	0	0	0	0	0,09	12,07	0	0,11	22,09
2016	64,00	0,21	4,20	0	0	0	60,00	0,27	15,15	0	0,11	22,09
2017	64,00	0,12	5,04	0	0	0	0	0,09	15,15	0	0,11	22,09
2018	64,00	0,36	5,88	0	0	0	60,00	0,27	18,23	0	0,11	22,09
2019	86,00	0,24	6,72	0	0	0	0	0,09	18,23	0	0,11	22,09
2020	66,00	0,18	7,56	0	0	0	60,00	0,27	19,91	0	0,11	22,09
2021	0	0,15	8,40	0	0	0	80,00	0,09	19,91	0	0,11	22,09
2022	0	0,13	8,40	0	0	0	100,00	0,45	22,19	0	0,11	22,09
2023	0	0,22	8,40	0	0	0	80,00	0,09	22,99	0	0,11	22,09
2024	0	0,28	8,40	0	0	0	100,00	0,45	26,07	0	0,11	22,09
2025	0	0,23	8,40	0	0	0	80,00	0,09	26,67	0	0,11	22,09
2026	0	0,34	8,40	0	0	0	100,00	0,45	29,15	0	0,11	22,09
2027	0	0,56	8,40	0	0	0	80,00	0,09	29,99	0	0,11	22,09
2028	0	0,19	8,40	0	0	0	100,00	0,45	32,23	0	0,11	22,09
2029	0	0,11	8,40	0	0	0	0	0,09	33,37	0	0,11	22,09
2030	0	0,40	8,40	0	0	0	0	0,09	34,85	0	0,11	22,09
Total	**684,00**	**5,25**	**121,80**	**1,20**	**0,00**	**0,00**	**1690,00**	**4,88**	**419,60**	**0,00**	**2,56**	**505,47**

The total cost of electricity production in the Baseline scenario (million USD)
Category Investment Organization - Government; Channel I&FF funds - Internal budgetary funds

Year	Costs without discounting			Discounted costs		
	IF	FF	O&M	IF	FF	O&M
2008	170,00	0,42	22,09	170,00	0,42	22,09
2009	360,00	0,48	22,09	327,27	0,44	20,08
2010	161,20	0,32	26,83	133,22	0,26	22,17
2011	64,00	0,42	28,14	48,08	0,32	21,14
2012	124,00	0,69	31,92	84,69	0,47	21,80
2013	64,00	0,32	32,76	39,74	0,20	20,34
2014	124,00	0,63	36,68	69,99	0,36	20,70
2015	64,00	0,71	37,52	32,84	0,36	19,25
2016	124,00	0,59	41,44	57,85	0,28	19,33
2017	64,00	0,32	42,28	27,14	0,14	17,93
2018	124,00	0,74	46,20	47,81	0,29	17,81
2019	86,00	0,44	47,04	30,14	0,15	16,49
2020	126,00	0,56	49,56	40,15	0,18	15,79
2021	80,00	0,35	50,40	23,17	0,10	14,60
2022	100,00	0,69	52,68	26,33	0,18	13,87
2023	80,00	0,42	53,48	19,15	0,10	12,80
2024	100,00	0,84	56,56	21,76	0,18	12,31
2025	80,00	0,43	57,16	15,83	0,09	11,31
2026	100,00	0,90	59,64	17,99	0,16	10,73
2027	80,00	0,76	60,48	13,08	0,12	9,89
2028	100,00	0,75	62,72	14,86	0,11	9,32
2029	0,00	0,31	63,86	0,00	0,04	8,63
2030	0,00	0,60	65,34	0,00	0,07	8,03
Total	**2375,20**	**12,69**	**1046,87**	**1261,12**	**5,02**	**366,43**

2.1.1 Mitigation Scenario

In the mitigation scenario assumes that the 2020 increase in capacity required to increase electricity generation is accomplished through the transfer of gas-turbine power plants on the steam-gas cycle and in the years 2020-2030 due to construction of power plants steam-gas cycle. Provision two directions, which can reduce fuel consumption for electricity generation:

1) Transfer of gas turbine power plants on the steam-gas cycle and further construction of power plants only steam-gas cycle.
2) The construction of power plants using renewable energy sources (wind and solar power).

Eliminating the emissions from the baseline emissions reductions calculated in these two areas, received the amount of CO_2 emissions for the mitigation scenario.

I&FF and O&M in the mitigation scenario derived from I&FF and O&M for the modernization of existing power plants, decommissioning of obsolete and worn-out steam turbine, gas turbine power plants, the transfer of gas turbine power plants built before 2010, on the steam-gas cycle, the construction of new power plants steam -gas cycle and the construction of wind and solar power.

I&FF and O&M for the transfer of gas-turbine power plants on the steam-gas cycle power plant construction on the steam-gas cycle and the use of renewable energy sources are defined in the relevant sections.

Total I&FF and O&M with the increasing costs O&M at the annual growth in fuel consumption and higher wages for the mitigation scenario presented at the end of the section.

A) The construction of simple cycle gas turbine power

As in the baseline scenario, the mitigation scenario included the construction of the following gas turbine power stations, which will be introduced in 2010: Avazinskaya HPS, HPS and Akhal Balkanabadskaya HPS.

I&FF and O&M for these gas-turbine power plants are calculated the same way as in the baseline.

B) Relocation of existing gas turbine power plants on the steam-gas cycle power plants and construction of steam-gas cycle

In recent years Turkmenistan's gas turbine power plants are built. At these plants the exhaust gases, temperatures above 500oS released into the atmosphere, resulting in reduced plant efficiency, increase the unit cost of fuel. If the gas turbine power transfer to steam-gas cycle, without burning fuel can produce additional quantities of electricity.

Having considered the proposals of the companies "Chalyk Energy", "Guarantees goat", "Cotham Eneterpreyz" Translation of the gas turbine power plants on the steam-gas cycle and explore the world experience of using modern gas-turbine power plants using co-generation, experts of the Ministry of Energy and Industry concluded that there is a real technical possibility of transfer of gas turbine power plants on steam-gas cycle.

The table below lists the power and plan to put their work on the steam-gas cycle.

Proposals for the transfer of gas turbine power plants on steam-gas cycle to 2020

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Akhal GES				STS -120								
Ashgabat GES						STS -120						
Dashoguz GES								STS				

								-120				
Balkanabadskaya GES										STS -120		
Avazinskaya GES												STS -120

Thus, by 2020 all gas turbine power stations built from 2005 to 2010 will be transferred to the steam-gas cycle. This will be built HRSG operating on flue gases of gas turbine power plants, as well as steam turbines of 120 MW. These facilities are consistent with the capacity (127 MW) gas turbine units to be built in the base scenario. In other words, for each of these power plants instead of the planned installation of a third gas turbine plant with capacity 127 MW in the base scenario, the mitigation scenario provides installation of steam turbine capacity of 120 MW and the transfer of power to the steam-gas cycle. As noted above, such a transfer is not subject to Abadan HPS.

Proposals for the construction of gas turbine power plant steam-gas cycle to 2030

Year	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
HPP in Akhal province		STU - 254, STS -120				STU - 254, STS -120				
HPS in Lebap				STU - 254, STS -120						
HPP in Mary province								STU - 254, STS -120		

During the period of 2020-2030 years in the mitigation scenario will be constructed combined-cycle power plant instead of the conventional gas turbine power plants as provided for in the base scenario. Power plants for both scenarios are similar.

Based on the estimated amount of the saving of fuel through the transfer of gas-turbine power plants on the steam-gas cycle, defined annual reduction in CO_2 emissions - 515,243.3 tons per year.

Calculation I&FF and O&M translation of existing power plants on the steam-gas cycle is made on the basis of existing business offers "Chalyk Energy“. The costs of translation will be 162 million U.S. dollars. [7]

In the calculations, the basis is assumed that the translation work on the steam-gas cycle is performed for 2 years. In the first year will be carried out preparatory work, as well as manufacturing equipment. The cost of the first year will amount to 50 million. In the second year of planned major works, the cost of their execution would amount to 112 million U.S. dollars.

According to the business proposals of foreign companies working capital costs for steam turbines are $ 3 for every 1 MWh of energy produced. Thus, the O&M costs is as follows: O&M = ΣЭ x 3 $

Where ΣЭ - total electricity generated by steam turbines, steam-gas cycle.

FF for gas turbine power plants steam-gas cycle, determined based on the training needs of staff operating the new equipment, similar to the training of personnel for the operation of gas turbine power plants in the baseline. The cost of such training has been taken from existing contracts.

B) Construction of wind and solar power

The geographical location of Turkmenistan is such that 80% of its territory, the number of sunny days is over 2500 hours / year, while direct solar radiation is kVt.ch/m^2 1800-1860. Experts Ministrestva Energy and Industry jointly with the consulting company «goetzpartners» (Germany) and the company «Concentrix colar» (Germany) discussed the possibility and expediency of construction of photovoltaic solar power plants, as well as a pilot project of building a power plant on the outskirts of the capital of Turkmenistan - Ashgabat. [8]

Currently, the Ministry of Energy and Industry jointly with the company «goetz-partners» (Germany) is studying the possibility of wind power in Turkmenistan. [8]

Analysis of wind speed and energy efficiency, jointly held with experts Windtest on the basis of three weather stations (Cooley Lighthouse, Turkmenbashi and Balkanabat) showed that the average wind speed in the vicinity of the meteorological stations at altitudes of 50 and 80 meters respectively, are:

Cooley Lighthouse - 4,6 m / s 4,9 m / sec.
Turkmenbashi - 5,0 m / s 5,4 m / sec.
Balkanabad - 6,8 m / s 7,3 m / sec.

The minimum speed is suitable for the use of wind generators have, respectively, 5,0 m / s 6,0 m / sec. Thus, in the area Balkanabad economically feasible to install wind generators. Are being explored the most efficient wind generators, and work is underway on preparation of a pilot project.

Given that at the time of carrying out this work in Turkmenistan, there is no program for the development of renewable energy sources, suggested that the first phase (2020) begin with the introduction of windmills, as the technical and economic efficiency of their use is higher than that from solar power, and after 2020 to increase the use of solar power.

The generated renewable electricity by 2030 will be brought to the level of 1% of the total power produced in Turkmenistan. According to expert assessment, the total electricity output in 2030 will amount to 35.5 billion kWh Thus, by 2030 electricity generation from renewable energy sources will amount to 355 mln.kVt.ch. Based on the company «goetzpartnezs», the average energy output per year from wind plants with a capacity of 1 MW will be 3,5 mln.kVt.ch, and a solar plant with a capacity of 1 MW - 1,85 mln.kVt.ch. These indicators allowed to determine the power of wind and solar installations needed for the development of 355 mln.kVt.ch year.

Power of solar power:

- 10 MW of photovoltaic (there is a pilot project to 2MW)
- 50 MW solar thermal

As stated above, in 2030 electricity generation from renewable sources will be in the amount of 355 mln.kVt.ch. Power of solar power plants planned 60 MW. Electricity generation by these power plants will 60h1, 85 = 111 mln.kVt.ch. Therefore wind turbines must develop 355-111 = 244mln.kVt.ch and their capacity to be equal to 244 / 3,5 = 69,7 MW or 46 windmills with a unit capacity of 1,5 MW.

In 2010, the need to explore and identify areas where the average annual wind speed is optimal for the installation of wind facilities. Therefore, the year construction of the first windmill adopted in 2011.

Proposals for the construction and commissioning - Renewable Energy

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wind		3	3	3	3	3	3	3	3	3	3
Solar			2				2				50

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Wind	3	3	3	3	3	3	3	6	6	6
Solar				2			2			2

In accordance with these data in the years 2011-2020 will be introduced each year wind plant with a capacity of 3 MW. Consequently, the annual output from wind farms will be: 3 x 3,5 = 10,5 million kWh.

Annual savings of natural gas and reduce emissions of CO_2 from the introduction of windmills will be 3.85 million m^3 and 7.21 tons respectively.

Given that the average energy output per year from the 1 MW solar power plant is 1.85 million killowatts hours, calculated the annual cost of natural gas and reducing CO_2 emissions by introducing solar power plants, which were as follows: 1.36 million m^3 and 2 , 55 tons, respectively.

As developed in 2008 for Turkmenistan pilot project construction cost of photovoltaic solar power plant of 10 MW of 79.1 million euros or 118.0 million U.S. dollars and annual operating costs of photovoltaic solar power station - 0,08 million U.S. dollars 1 MW.

Projects for geothermal and wind power in Turkmenistan is not developed, so for the calculations used data provided by «goetzpartnezs»: [8]

Solar thermal solar power 50 mW:

- Investment costs of 497 million U.S. dollars
- Operating costs of 6.35 million U.S. dollars
- Annual electricity mln.kvt.ch 165

Wind power capacity of 1,5 MW:

- Investment costs of 1.9 million USD
- Operating costs 0,04 million U.S. dollars

The most effective conditions of Turkmenistan defined wind-generator unit capacity of 1.5 MW. Given the fact that in areas with sufficient wind load for efficient operation of wind generators, which is scheduled to install, there is excess capacity, is invited annually to enter on two wind-machine. The cost of a wind machine is estimated taking into account their delivery to Turkmenistan in accordance with the business proposal to the company «Vestas». [8]

Based on the above data, calculations made I&FF and O&M to the construction and operation of power plants using renewable energy sources.

The cost of construction of power plants using renewable energy (million USD)
Category Investment Organization - Government; Channel I&FF funds - Internal budgetary funds

Year	Photoelectric			Geothermal			Wind			Total		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2008												
2009												
2010												
2011							5,7	0,06	0,08	5,7	0,06	0,08
2012	23,6	0,12	0,16				5,7		0,16	29,3	0,12	0,32
2013			0,16				5,7		0,24	5,7		0,4
2014			0,16				5,7		0,32	5,7		0,48
2015			0,16				5,7		0,4	5,7		0,56
2016	23,6	0,12	0,32				5,7	0,06	0,48	29,3	0,18	0,8
2017			0,32				5,7		0,56	5,7		0,88
2018			0,32	150			5,7		0,64	155,7		0,96
2019			0,32	150			5,7		0,72	155,7		1,04
2020			0,32	197	0,18		5,7		0,8	202,7	0,18	1,12
2021			0,32			6,35	5,7	0,06	0,88	5,7	0,06	7,55
2022			0,32			6,35	5,7		0,96	5,7		7,63
2023			0,32			6,35	5,7		1,04	5,7		7,71
2024	23,6	0,12	0,48			6,35	5,7		1,12	29,3	0,12	7,95
2025			0,48			6,35	5,7	0,06	1,2	5,7	0,06	8,03
2026			0,48			6,35	5,7		1,28	5,7		8,11
2027	23,6	0,12	0,64			6,35	5,7		1,36	29,3	0,12	8,35
2028			0,64			6,35	11,4		1,54	11,4		8,53
2029			0,64			6,35	11,4	0,06	1,7	11,4	0,06	8,69
2030	23,6	0,12	0,8			6,35	11,4		1,86	35	0,12	9,01
Total	**118**	**0,6**	**7,36**	**497**	**0,18**	**63,5**	**131,1**	**0,3**	**17,34**	**746,1**	**1,08**	**88,2**

Given the high cost of alternative sources of energy (1 MW solar power plant is 15 times greater than 1 MW of conventional gas turbine power plants) and the fact that by 2030 electricity will release the public for free, and tariffs for industrial consumers remain relatively cheap, in the scenario envisaged to mitigate production electricity from renewable sources in a minimal amount - 1% of the total energy produced.

It should be borne in mind that Turkmenistan has huge reserves of natural gas, which cost for domestic industrial users is 1.26 U.S. dollars per 1000м3, the cost of electricity - about 0.5 cents per 1 kWh While the cost of solar power is 16 cents, that is 32 times more expensive.

Therefore, until 2030 is planned to implement a pilot project for solar power, as well as the elaboration of the existing wind power plants.

The cost of electricity production by type of investment. Mitigation Scenario (million USD)
Category Investment Organization - Government; Channel I&FF funds - Internal budgetary funds

Types of investm ents	Modernization of existing power plants			Conclusion worn steam turbines			Building a simple cycle power plants			Transfer of power on the combined cycle			Construction of combined cycle power plant			Construction of solar and wind power			Operation of power plants built before 2009			Other costs
Year	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O%M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	O&M
2008	0	0	0	0	0	0	170	0,28	2,6	0	0	0	0	0	0	0	0	0	0	0,14	19,49	0
2009	0	0	0	0	0	0	360	0,37	0,00	0	0	0	0	0	0	0	0	0	0	0,11	22,09	0,79
2010	20	0,12	0	1,20	0	0	140	0,09	4,74	0	0,12	0	0	0	0	0	0	0	0	0,11	22,09	0
2011	64	0,22	0	0	0	0	0	0,09	6,05	50	0,18	0	0	0	0	5,70	0,06	0,08	0	0,11	22,09	0
2012	64	0,31	0,84	0	0	0	0	0,27	8,99	112	0,18	2,2	0	0	0	29,30	0,12	0,32	0	0,11	22,09	0
2013	64	0,12	1,68	0	0	0	0	0,09	8,99	50	0,22	2,2	0	0	0	5,70	0	0,40	0	0,11	22,09	0
2014	64	0,25	2,52	0	0	0	0	0,27	8,99	112	0,26	4,4	0	0	0	5,70	0	0,48	0	0,11	22,09	3,08
2015	64	0,51	3,36	0	0	0	0	0,09	8,99	50	0,32	4,4	0	0	0	5,70	0	0,56	0	0,11	22,09	3,08
2016	64	0,21	4,20	0	0	0	0	0,17	8,99	112	0,32	6,6	0	0	0	29,30	0,18	0,80	0	0,11	22,09	6,16
2017	64	0,12	5,04	0	0	0	0	0,09	8,99	50	0,37	6,6	0	0	0	5,70	0	0,88	0	0,11	22,09	6,16
2018	64	0,36	5,88	0	0	0	0	0,27	8,99	112	0,37	8,8	0	0	0	155,70	0	0,96	0	0,11	22,09	9,25
2019	86	0,24	6,72	0	0	0	0	0,09	8,99	50	0,38	8,8	0	0	0	155,70	0	1,04	0	0,11	22,09	9,25
2020	66	0,18	7,56	0	0	0	0	0,27	8,99	112	0,32	10	0	0,06	0	202,70	0,18	1,12	0	0,11	22,09	10,92
2021	0	0,15	8,40	0	0	0	0	0,00	8,99	0	0,33	10	90	0,15	0	5,70	0,06	7,55	0	0,11	22,09	10,92
2022	0	0,13	8,40	0	0	0	0	0,00	9,07	0	0,33	10	192	0,51	4,48	5,70	0	7,63	0	0,11	22,09	10,92
2023	0	0,22	8,40	0	0	0	0	0,00	8,99	0	0,17	10	90	0,33	5,28	5,70	0	7,71	0	0,11	22,09	10,92
2024	0	0,28	8,40	0	0	0	0	0,00	8,99	0	0,17	10	192	0,69	10,56	29,30	0,12	7,95	0	0,11	22,09	10,92
2025	0	0,23	8,40	0	0	0	0	0,00	8,99	0	0,18	10	90	0,33	11,16	5,70	0,06	8,03	0	0,11	22,09	10,92
2026	0	0,34	8,40	0	0	0	0	0,00	8,99	0	0,18	10	192	0,33	15,84	5,70	0	8,11	0	0,11	22,09	10,92
2027	0	0,56	8,40	0	0	0	0	0,00	9,83	0	0,19	10	90	0,33	15,84	29,30	0,12	8,35	0	0,11	22,09	10,92
2028	0	0,19	8,40	0	0	0	0	0,00	9,83	0	0,19	10	192	0,69	20,28	11,40	0	8,53	0	0,11	22,09	10,92
2029	0	0,11	8,40	0	0	0	0	0,00	9,83	0	0	10	0	0,09	21,42	11,40	0,06	8,69	0	0,11	22,09	10,92
2030	0	0,40	8,40	0	0	0	0	0,00	11,31	0	0	10	50	0,09	21,42	35,00	0,12	9,01	0	0,11	22,09	10,92
Total	**684,**	**5,25**	**121,80**	**1,20**	**0**	**0**	**670**	**2,44**	**189,12**	**810**	**4,78**	**154**	**1178**	**3,6**	**126,28**	**746,10**	**1,08**	**88,20**	**0**	**2,56**	**505,47**	**157,89**

The total cost I&FF and O&M on the production of electricity in the mitigation scenarios are defined as the sum of the costs and O&M I&FF cost of upgrading existing power plants, the withdrawal of worn-out steam turbines, the construction of simple cycle power plants, transfer stations to combined cycle power plant combined cycle, the construction of solar and wind power plants, as well as power plants built before 2009.

The total cost of electricity production - Mitigation Scenario (million USD)
Category Investment Organization - Government; Channel I&FF funds - Internal budgetary funds

Year	Costs without discounting			Discounted costs		
	IF	FF	O&M	IF	FF	O&M
2008	170,00	0,42	22,09	170,00	0,42	22,09
2009	360,00	0,48	22,88	327,27	0,44	20,80
2010	161,20	0,44	26,83	133,22	0,36	22,17
2011	119,70	0,66	28,22	89,93	0,50	21,20
2012	205,30	0,99	34,44	140,22	0,68	23,52
2013	119,70	0,54	35,36	74,32	0,34	21,96
2014	181,70	0,89	41,56	102,56	0,50	23,46
2015	119,70	1,03	42,48	61,43	0,53	21,80
2016	205,30	0,99	48,84	95,77	0,46	22,78
2017	119,70	0,69	49,76	50,76	0,29	21,10
2018	331,70	1,11	55,97	127,88	0,43	21,58
2019	291,70	0,82	56,89	102,24	0,29	19,94
2020	380,70	1,12	60,68	121,30	0,36	19,33
2021	95,70	0,80	67,95	27,72	0,23	19,68
2022	197,70	1,08	72,59	52,06	0,28	19,12
2023	95,70	0,83	73,39	22,91	0,20	17,57
2024	221,30	1,37	78,91	48,16	0,30	17,17
2025	95,70	0,91	79,59	18,93	0,18	15,75
2026	197,70	0,96	84,35	35,56	0,17	15,17
2027	119,30	1,31	85,43	19,51	0,21	13,97
2028	203,40	1,18	90,05	30,23	0,18	13,39
2029	11,40	0,37	91,35	1,54	0,05	12,34
2030	85,00	0,72	93,15	10,44	0,09	11,44
Total	**4089,30**	**19,71**	**1342,76**	**1864,00**	**7,48**	**437,34**

3. Results

3.1 Additional changes to I&FF and O&M expenditures

Additional changes represent the difference in I&FF, PA in the mitigation scenario compared to the baseline scenario.

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. That is a scenario would require mitigation in 1,72 times more investment than the baseline scenario. Reducing emissions of CO_2 in the atmosphere in 2030 in the mitigation scenario would be 4.816 million tons.

Negative values or reduction of IF, FF and O&M for the construction of a simple gas cycle power plants due to the fact that the proposed baseline scenario in this type of activity: construction of additional gas turbine capacity of 127.1 MW at Balkanabadskoy, Ashgabad, Dashoguz, Akhal and Avazinskoy HPS, as well as three gas turbines for new power plants in the mitigation scenario will not start. Instead, these plants will be installed boiler steam turbine capacity of 120 MW, ie These power plants will be transferred to combined-cycle, while new power stations 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 and O&M for this activity.

Construction of new power plants that use technology co-generation, provided to implement in 2021-2028, respectively, that affect the growth I&FF and O&M for this activity.

The cost of upgrading existing power plants, the output of worn-out steam turbines and power plants built before 2009 in the mitigation scenario are the same as in the baseline scenario, so extra costs I&FF and O&M are equal to 0.

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.

Additional annual IF, FF and O&M on the production of electricity by type of investment (million USD)
Category Investment Organization - Government; Channel I&FF funds - Internal budgetary funds

Types of investm.	Modernization of existing power plants			Conclusion worn steam turbines			Building a simple cycle power plants			Transfer of power on the combined cycle			Construction of combined cycle power plant			Construction of solar and wind power			Operation of power plants built before 2009			Other costs
Year	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	O&M
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,79
2010	0	0	0	0	0	0	0	0	0	0	0,12	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	50	0,18	0	0	0	0	5,70	0,06	0,08	0	0	0	0
2012	0	0	0	0	0	0	-60	0	0	112	0,18	2,2	0	0	0	29,30	0,12	0,32	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	50	0,22	2,2	0	0	0	5,70	0	0,40	0	0	0	0
2014	0	0	0	0	0	0	-60	0	-3,08	112	0,26	4,4	0	0	0	5,70	0	0,48	0	0	0	3,08
2015	0	0	0	0	0	0	0	0	-3,08	50	0,32	4,4	0	0	0	5,70	0	0,56	0	0	0	3,08
2016	0	0	0	0	0	0	-60	-0,10	-6,16	112	0,32	6,6	0	0	0	29,30	0,18	0,80	0	0	0	6,16
2017	0	0	0	0	0	0	0	0	-6,16	50	0,37	6,6	0	0	0	5,70	0	0,88	0	0	0	6,16
2018	0	0	0	0	0	0	-60	0	-9,24	112	0,37	8,8	0	0	0	155,70	0	0,96	0	0	0	9,25
2019	0	0	0	0	0	0	0	0	-9,24	50	0,38	8,8	0	0	0	155,70	0	1,04	0	0	0	9,25
2020	0	0	0	0	0	0	-60	0	-10,92	112	0,32	10	0	0,06	0	202,70	0,18	1,12	0	0	0	10,92
2021	0	0	0	0	0	0	-80	-0,09	-10,92	0	0,33	10	90	0,15	0	5,70	0,06	7,55	0	0	0	10,92
2022	0	0	0	0	0	0	-100	-0,45	-	0	0,3	10	192	0,5	4,48	5,70	0	7,63	0	0	0	10,9

								13,12		3			1							2
2023	0	0	0	0	0	0	-80	-0,09	-14,00	0	0,17	10	90	0,33	5,28	5,70	0	7,71	0	0	0	10,92
2024	0	0	0	0	0	0	-100	-0,45	-17,08	0	0,17	10	192	0,69	10,56	29,30	0,12	7,95	0	0	0	10,92
2025	0	0	0	0	0	0	-80	-0,09	-17,68	0	0,18	10	90	0,33	11,16	5,70	0,06	8,03	0	0	0	10,92
2026	0	0	0	0	0	0	-100	-0,45	-20,16	0	0,18	10	192	0,33	15,84	5,70	0	8,11	0	0	0	10,92
2027	0	0	0	0	0	0	-80,0	-0,09	-20,16	0	0,19	10	90	0,33	15,84	29,30	0,12	8,35	0	0	0	10,92
2028	0	0	0	0	0	0	-100	-0,45	-22,40	0	0,19	10	192	0,69	20,28	11,40	0	8,53	0	0	0	10,92
2029	0	0	0	0	0	0	0	-0,09	-23,54	0	0	10	0	0,09	21,42	11,40	0,06	8,69	0	0	0	10,92
2030	0	0	0	0	0	0	0	-0,09	-23,54	0	0	10	50	0,09	21,42	35,00	0,12	9,01	0	0	0	10,92
Total	**0**	**0**	**0**	**0**	**0**	**0**	**-1020**	**-2,44**	**-230,48**	**810**	**4,78**	**154**	**1178**	**3,6**	**126,28**	**746,10**	**1,08**	**88,20**	**0**	**0**	**0**	**157,89**

Additional annual IF, FF and O&M on the production of electricity (million USD)
Category Investment Organization - Government; Channel I&FF funds - Internal budgetary funds

Year	Additional costs without discounting			Discounted incremental costs		
	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M
2008	0	0	0	0	0	0
2009	0	0	0,79	0	0	0,72
2010	0	0,12	0	0	0,10	0
2011	55,70	0,24	0,08	41,85	0,18	0,06
2012	81,30	0,30	2,52	55,53	0,20	1,72
2013	55,70	0,22	2,60	34,59	0,14	1,61
2014	57,70	0,26	4,88	32,57	0,15	2,75
2015	55,70	0,32	4,96	28,58	0,16	2,55
2016	81,30	0,40	7,40	37,93	0,19	3,45
2017	55,70	0,37	7,48	23,62	0,16	3,17
2018	207,70	0,37	9,77	80,08	0,14	3,77
2019	205,70	0,38	9,85	72,10	0,13	3,45
2020	254,70	0,56	11,12	81,16	0,18	3,54
2021	15,70	0,45	17,55	4,55	0,13	5,08
2022	97,70	0,39	19,91	25,73	0,10	5,24
2023	15,70	0,41	19,91	3,76	0,10	4,77
2024	121,30	0,53	22,35	26,40	0,12	4,86
2025	15,70	0,48	22,43	3,11	0,09	4,44
2026	97,70	0,06	24,71	17,57	0,01	4,44
2027	39,30	0,55	24,95	6,43	0,09	4,08
2028	103,40	0,43	27,33	15,37	0,06	4,06
2029	11,40	0,06	27,49	1,54	0,01	3,71
2030	85,00	0,12	27,81	10,44	0,01	3,42
Total	**1714,10**	**7,02**	**295,89**	**602,88**	**2,46**	**70,91**

3.2 Policy implications

Electricity industry is completely state-owned and governed by administrative means. The government through the Ministry of Energy and Industry and the BSE "Turkmenenergo“ controls the entire process of production, transportation and distribution of electricity. The Government has the right to regulate prices for electricity, its production and distribution, electrical controls, and retains responsibility for investments, repairs and modernization. Therefore, the realization of all investments offered in this paper will only be possible with public funds or foreign credits guaranteed by the government.

The determining factor for the development of Turkmenistan's policy in relation to climate change is to increase the energy efficiency of the economy, which should serve as a basis for a national strategy for reducing GHG emissions. The sector „Electricity production“ is one of the major sectors of the economy of Turkmenistan, which has the potential energy savings and can provide a significant contribution to improving national energy efficiency and reduce GHG emissions.

According to estimates in this study, the amount of potential for energy savings for the years 2010-2030 in this sector is - 40,3 billion m^3 of natural gas, the total reduction in CO_2 emissions resulting from energy savings will amount to 75,5 mln.tn. Thus, the scenarios of climate change mitigation, in other words, the scenario of accelerated development of technologies to improve energy efficiency in power generation will reduce the energy consumption in 2020 to 22,5% in 2030 to

25,5% compared with the baseline scenario. The share of energy efficiency of traditional power generation using fossil fuels - natural gas accounts for about 96% of energy saving and GHG emission reductions from the level of the baseline scenario. Other options involve the use of renewable energy sources (RES).

Given that the savings gas can be realized in the foreign market at a price of $ 200 per 1 m^3, the country's budget will go further sum of about $ 8 billion for the years 2010-2030. According to calculations I&FF and O&M, the script was to mitigate climate change will require a total additional cost - 2,02 billion dollars., Including investment costs - 1,71 billion dollars. beyond the baseline scenario. Thus, we can conclude that the planned measures to improve energy efficiency in the mitigation scenario is fully compensated only through the saving of gas exports.

Clean Development Mechanism (CDM) of the Kyoto Protocol, developed within the context of climate change, also provides some opportunities for attracting additional investment. A number of measures to save energy, referred to in the mitigation scenario can be implemented CDM projects. Thus, the translation of one power plant of 254 MW combined-cycle will reduce annual CO_2 emissions by 4,5 mln.tn. Carbon revenues for the 10-year period is estimated at around 45 million dollars at a price of $ 10 per ton of CO_2, which pays for the project by 26-28%. Given the 10-year cycle of carbon credits, 6-7 similar CDM projects can be implemented before 2030, and carbon investment will provide 270-315 million dollars. additionally. In addition, it should be noted that such projects pay off for 5-6 years only due to the saving of natural gas exports as a result of energy conservation.

However, only the technological development, as a rule, is not enough, the policy of energy conservation should also focus on improving standards and standards in the field of energy use. For example, for the energy industry can be set as a target of law - to ensure efficiency of power plants fueled by natural gas, at the level of 35-37% until 2020, and in the future to 2030 - up to 40-45%, providing general specific fuel consumption for electricity 330-350 grams of fuel per 1 kW • h in 2020 and 280-300 grams of fuel per 1 kW • h in 2030.

At the moment, the country's regulatory framework is inadequate energy and has no direct action, therefore it requires a revision or development of additional regulations. Develop a national program for energy conservation, which will establish the main strategic objectives, for example, the annual reduction in energy intensity of GDP by 3-5%, 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 and renewable energy. 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. It is advisable to include in a national program of energy efficiency key performance indicators for the implementation of renewable energy, for example, increasing renewable energy in the country's balance of 1-2% over five years.

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.

An essential prerequisite for productive activities and energy efficiency strategies are effective institutional mechanisms. In this connection should be established in Turkmenistan, a national body which will be responsible for carrying out state policy on efficient use of energy resources and energy conservation. In the short term his priorities might be:
the establishment and functioning of a unified system rationing cost per unit of energy resources in various sectors of the economy;

- monitoring system energy consumption, improvement of accounting and control system for the consumption of energy resources;

- the development of energy efficiency measures and monitoring their implementation;
- increasing the share of renewables in the energy balance of the country.

3.3 Key uncertainties and methodological limitations

The key uncertainties in this project include the absence of an approved program of power development until 2020. Also, at the time of evaluation I&FF and O&M, there was no program of development of the industry with 2021 and 2030. In February 2010, the draft program is developed, which fully coincides with the expert evaluation used in this study.

Existing oil and gas sector and electricity sector legislation on energy conservation have been developed over 20 years ago. They are outdated and inconsistent with the realities of present time. It is therefore necessary to improve the rules and standards in the field of energy production and use.

Also, as the uncertainty can be noted a significant increase in the dollar against the national currency in 2007, which affected what cost evaluation-oriented period 2009-2030 years, based on data from 2008 and led to a change in the base year for assessment and I&FF O&M in this study.

4. Background

List of Sources

1. The Constitution of Turkmenistan (2008)
2. Law of Turkmenistan "On Nature Protection" (2004)
3. Second National Report on the UN Framework Convention on Climate Change (Ashgabat, 2009)
4. The national program "Development of power industry of Turkmenistan until 2020".
5. Expert assessment of "Development of power in Turkmenistan 2021 - 2030 years"
6. Proposals from Yarovitenergo Company Ltd and CARE-Holding to modernize power plants and the Mary power station Turkmenbashi thermal power station
7. Project proposals from the company Yarovitenergo and Chalikov-Energy to relocate the existing power plant to combined cycle.
8. The project proposal of the company «Geoetzpartnerz» for the construction of solar power
9. Annual reports and Power HBT "Turkmenenergo
10. Reference book on the energy third edition, revised and enlarged Moscow, "Energia" 1978
11. Handbook on designing power systems Second Edition, revised and enlarged Moscow-Energy 1977
12. The newspaper "Neutral Turkmenistan", edition of 01.05.2008

5. Acronyms and Abbreviations

IF	Investment Flows
FF	Financial flows
O&M	Operating expenses
I&FF	Investment and Financial Flows
CDM	Clean Development Mechanism
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
SNPZ	Seidi Refinery
LMZ	Leningrad Metal Plant
TDF	Taganrog Boiler Plant

Elektrotyazhmash	Kharkov heavy machinery
GE	U.S. company General Electric (General Electric)
VL	High-voltage power line
PS	Electrical Sub-stantstsiya
IES	condensing power station
TPP	Thermal Power Plants
VET	Production - Technical Department
Efficiency	Efficiency
PT / PTU	steam turbine
GTU	Gas Turbine
OJSC	Open Joint Stock Company
JSC	Joint Stock Company
LLC	Limited Liability Company
RES	Renewable Energy
GHG	Greenhouse gases
CO_2	Carbon dioxide (greenhouse gas)
Thousand	thousand
Million	Million
Billion	billion
gr.	Gram
tn.	Ton
m^2	square meters
m^3	cubic meter
m / s	A measure of wind speed (meters per second)
Km	Kilometer
kWh	A measure of electrical energy (kilowatt-hour)
MW	A measure of electrical power (megawatt-hour of 1 MW = 1000 kWh)
kV	A measure of electric voltage (kV)
°C	Degrees Celsius
Gcal	A measure of heat
Ata	A measure of pressure (1 atmosphere)
Manat	Currency of Turkmenistan
USD	U.S. Dollar
$	Money U.S. dollar sign
%	Percent sign

Annexes

Table 1 Emissions of CO_2 from combustion of natural gas, fuel oil and diesel fuel to Gaza "Electricity" for the period from 2000 to 2008

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Total CO_2 emissions (thousand tons)	6704,04	6940,73	7102,59	7424,01	7945,00	8409,00	9080,17	9539,11	10293,3

Table 2 The volume of the saving fuel and reducing CO_2 emissions from the modernization of existing power plants by 2030

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021-2030**
Mary and Turkmenbashi HPP HPP													
Fuel economy m^3	-	-	55473,9	95070,2	166255,2	202304,7	273681,3	352017,4	416797,7	490650,3	558143,5	635649,7	635649,7
Reducing emissions of CO_2 thousand tons	-	-	**103,903**	**178,066**	**311,396**	**378,917**	**512,605**	**659,329**	**780,662**	**918,988**	**1045,403**	**1190,572**	**1190,572**

Table 3 Volume ekonomlennogo fuel and reduce CO_2 emissions by 2030 from the withdrawal from the work of the old turbo-generators, exhaust their lifespan, and their replacement by new power capacity

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021-2030**
Abadan GES and Turkmenbashi thermal power station													
Fuel economy m^3	-	123914,6	123914,6	123914,6	123914,6	123914,6	123914,6	123914,6	123914,6	123914,6	123914,6	123914,6	123914,6
Reducing emissions of CO_2 thousand tons	-	**232,092**	**232,092**	**232,092**	**232,092**	**232,092**	**232,092**	**232,092**	**232,092**	**232,092**	**232,092**	**232,092**	**232,092**

Table 4 Volume of the saving fuel and reducing CO_2 emissions through the transfer of existing gas turbine combined-cycle power plants in 2020 and the construction of combined-cycle power plants by 2030

	Year											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Fuel economy m^3	0	0	0	271180	271180	542360	542360	813540	813540	1084720	1084720	1355900
Reducing CO_2 tons	**0**	**0**	**0**	**507920**	**507920**	**1015840**	**1015840**	**1523760**	**1523760**	**2031681**	**2031681**	**2539601**

Table 4 (continued)

	Year									
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Fuel economy m^3	1355900	1627080	1627080	1898260	1898260	2169440	2169440	2440620	2440620	2440620
Reducing CO_2 tons	**2539601**	**3047521**	**3047521**	**3555441**	**3555441**	**4063361**	**4063361**	**4571281**	**4571281**	**4571281**

Table 5 Volume of the saving fuel and reducing CO_2 emissions by 2030 from the introduction of renewable energy

	Year											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Fuel savings from the introduction of wind turbines (million m^3)	-	-	3,85	7,70	11,55	15,40	19,25	23,10	26,95	30,80	34,65	38,50
Fuel savings from the introduction of solar power plants (million m^3)	-	-	-	1,36	1,36	1,36	1,36	2,72	2,72	2,72	2,72	36,67
Total, the saving of fuel (million m^3)	0,00	0,00	3,85	9,06	12,91	16,76	20,61	25,82	29,67	33,52	37,37	75,17
Reduction of CO_2 (thousand tons)	**0,00**	**0,00**	**7,21**	**16,97**	**24,18**	**31,39**	**38,60**	**48,36**	**55,57**	**62,78**	**69,99**	**140,79**

Table 5 (continued)

	Year									
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Fuel savings from the introduction of wind turbines (million m^3)	42,35	46,20	50,05	53,90	57,75	61,60	65,45	73,15	80,85	88,55
Fuel savings from the introduction of solar power plants (million m^3)	36,67	38,03	38,03	39,39	39,39	39,39	40,75	40,75	40,75	42,11
Total, the saving of fuel (million m^3)	79,02	84,23	88,08	93,29	97,14	100,99	106,20	113,90	121,60	130,66
Reduction of CO_2 (thousand tons)	**148,00**	**157,76**	**164,97**	**174,73**	**181,94**	**189,15**	**198,91**	**213,33**	**227,76**	**244,73**

Table 6 Power Generation Sector "Electricity production" for the years 2009-2030

Year Naima th	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Formulation, mln.kVt.ch	15800	16290	16840	17680	18550	19480	20470	21510	22620	23800	25050

Table 6 (continued)

Year Naima th	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Formulation, mln.kVt.ch	26380	27170	27990	28830	29700	30600	31520	32460	33460	34460	35500

Table 7 Emissions of CO_2 (thousand tons) in the sector "Electricity production" for the years 2009-2030

Year Scenario	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Baseline scenario	10860,78	11197,54	11575,7	12153,15	12751,2	13390,45	14070,91	14785,84	15548,71	16359,91	17219,24
Mitigation	10860,78	10965,45	11232,5	11218,1	11675,61	11732,21	12271,77	12322,29	12956,62	13114,36	13840,07

Scenario											
Reduction of CO_2	0	232,09	343,20	935,04	1075,58	1658,24	1799,14	2463,54	2592,08	3245,54	3379,16

Table 7 (continued)

Year / Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline scenario	18133,45	18676,43	19240,02	19817,46	20415,51	21034,16	21666,49	22312,67	23000,07	23687,46	24402,38
Mitigation scenario	14030,39	14566,16	14612,07	15182,31	15262,68	15874,12	15991,31	16627,74	16792,79	17465,75	18163,71
Reduction of CO_2	4103,05	4110,26	4627,94	4635,15	5152,83	5160,04	5675,17	5684,93	6207,28	6221,70	6238,67

Table 8 fuel economy (m^3) in the mitigation scenario for the years 2010-2030

Year / Scenario	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Saving gas	0	123914,6	183238,5	499224,8	574259,8	885339,3	960565,9	1315292	1383922,3	1732804,9	1804148,1

Table 8 (continued)

Year / Scenario	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Saving gas	2190634,3	2194484,3	2470874,3	2474724,3	2751114,3	2754964,3	3029994,3	3035204,3	3314084,3	3321784,3	3330844,3