

**THE MAIN ADMINISTRATION FOR HYDROMETEOROLOGY  
OF THE REPUBLIC OF KAZAKHSTAN**

**U.S. COUNTRY STUDIES PROGRAM**

**SUPPORT FOR NATIONAL ACTION PLAN (SNAP) FOR  
THE REPUBLIC OF KAZAKHSTAN**

**Cooperative Agreement N 82252801**

**Final Report**

**October, 1996 - February, 1999**

**Main Coordinator**

**Head of Working Committee**

**Technical coordinator**

**Technical coordinator**

**Technical coordinator**

**A. Shamen**

**G. Chichasov**

**O. Pilifosova**

**S. Mizina**

**I. Yesserkepova**

February, 1999

## Table of Contents

<b>ACKNOWLEDGMENTS .....</b>	<b>3</b>
<b>LIST OF ACRONYMS, ABBREVIATIONS, AND UNITS.....</b>	<b>4</b>
<b>SUMMARY .....</b>	<b>6</b>
<b>I. CLIMATE CHANGE NATIONAL ACTION PLAN DEVELOPMENT.....</b>	<b>7</b>
1.1 INTRODUCTION .....	7
1.2 OBJECTIVES .....	8
1.3 METHODS .....	9
1.3.1 <i>Establishing the Planning Team</i> .....	9
1.3.2 <i>Evaluating and Developing Measures</i> .....	10
1.4 CLIMATE CHANGE NATIONAL ACTION PLAN OF THE REPUBLIC OF KAZAKHSTAN .....	11
1.4.1 <i>Proposed Greenhouse Gases Mitigation Measures</i> .....	12
1.4.2 <i>Proposed Adaptation Measures</i> .....	18
1.5 EDUCATION, TRAINING, PUBLIC AWARENESS AND NGOS .....	21
1.6 FOLLOW-UP ACTIVITIES.....	22
<b>2. TECHNOLOGY ASSESSMENT .....</b>	<b>23</b>
2.1 GHG MITIGATION STRATEGY AND MEASURES IN ENERGY SECTOR .....	23
2.1.1 <i>Overview of the Energy Sector</i> .....	23
2.1.2 <i>Carbon Dioxide Emission Projection</i> .....	27
2.1.3 <i>Energy Saving Potential</i> .....	28
2.1.4 <i>Heat and Hot Water Supply</i> .....	29
2.2 ADAPTATION IN AGRICULTURE (WHEAT PRODUCTION).....	37
2.2.1 <i>Scenarios</i> .....	2
2.3 WATER RESOURCES ADAPTATION .....	8
<b>REFERENCES.....</b>	<b>10</b>
<b>APPENDIX. LIST OF THE CCNAP PROJECTS IN KAZAKHSTAN.....</b>	<b>13</b>

## **AKNOWLEDGMENTS**

This work was funded by grant from the United States Agency on International Development through the US Support of National Action Plans Program. We appreciate the support of the United States Country Studies Program Management Team that makes this work being completed. We specially acknowledge assistance, discussions and comments made by Dr.Robert Dixon, Christopher Bordeaux, Joel Smith, Ron Benioff, Kenneth Strezepec.

## LIST OF ACRONYMS, ABBREVIATIONS, AND UNITS

### Acronyms and Abbreviations

AEP	Agency for Economical Planning
CCC	Canadian Climate Center
ENPEP	Energy and Power Evaluation Program
FSU	Former Soviet Union
GCM	general circulation model
GDP	gross domestic product
GEF	Global Environmental Facility
GFDL	Geophysical Fluid Dynamics Laboratory
GHG	greenhouse gas
GISS	Goddard Institute for Space Studies
GWP	global warming potential
HP	Heat Points
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KazNIIMOSK	Kazakh Institute for Environment Monitoring and Climate
MA	Ministry of Agriculture
MEIT	Ministry of Energy, Industry and Trade
MENR	Ministry of Ecology and Natural Resources
MFA	Ministry of Foreign Affairs
NAP	national action plan
NGO	nongovernmental organization
NREL	National Renewable Energy Laboratory
PPP	purchasing power parity
RK	Republic of Kazakhstan
SGP	Small Grant Program
UKMO	United Kingdom Meteorological Office
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WMO	World Meteorological Organization

### **Chemical Symbols**

CH <sub>4</sub>	methane
CO	carbon monoxide
CO <sub>2</sub>	carbon dioxide
N <sub>2</sub> O	nitrous oxide
NMVOOC	non-methane volatile organic compounds
NO <sub>x</sub>	nitrogen oxides

### **Units of Measurement**

°C	degree Celsius
bbl	barrel
Gg	gigagram
ha	hectare
km	kilometer
km <sup>2</sup>	square kilometer
kWh	kilowatt hour
m	meter
m/s	meter per second
m <sup>3</sup>	cubic meter
MW	megawatt
tce	tonne of coal equivalent
toe	tonne of oil equivalent
TW	terawatt
TWh	terawatt hour
W	watt

## **SUMMARY**

The report presents the final results obtained by Kazakhstan in 1996-1998 through the United States Support of National Action Plans Program with technical and financial assistance of the U.S. Agency for International Development.

First chapter describes the process used to develop Kazakhstan's Climate Change National Action Plan (CC NAP). The draft NAP has been submitted to the Kazakhstan's Government for consideration and approval. It includes national measures for mitigation of and adaptation to climate change, opportunities for implementation, and opportunities for cooperation with other ecologically sound plans and programs. Developing the NAP is one of the practicable steps Kazakhstan has taken to comply with its obligations as a Party to the United Nations Framework Convention on Climate Change (UNFCCC). The national main objectives in developing the NAP are to integrate climate change concerns into the other national development plans and programs; define mitigation and adaptation measures that will contribute to sustainable development; provide a framework for National Communication; and develop consensus, support, and an institutional structure for implementing climate change measures. Kazakhstan's long-term national priorities are to improve its physical infrastructure, increase economic growth and employment, increase self-reliance, promote rural development, and preserve the environment.

Second chapter is addressed to the technology assessment of mitigation potential of the main strategies in energy and non-energy sectors, and in-depth evaluation of selected mitigation and adaptation measures and technologies in the most important sectors.

The list of possible NAP projects are presented in Appendix. It contains a wide range of activities, such as energy efficiency, municipal district heating, renewable energy, reforestation, landfill gas utilization, and others.

Basic results of the project were included into the Initial National Communication of the Republic of Kazakhstan under the UNFCCC (1998).

# **I. CLIMATE CHANGE NATIONAL ACTION PLAN DEVELOPMENT**

## **1.1 INTRODUCTION**

Since 1993, fulfilling its commitments under the UNFCCC, Kazakhstan — through the U.S. Country Studies Program — has been involved in the following activities:

- Conducting vulnerability and adaptation assessments for important national economic sectors and ecosystems
- Developing a national inventory of anthropogenic emissions (by sources) and removals (by sinks) of all greenhouse gases (GHGs) not controlled by the Montreal Protocol
- Conducting an evaluation of the mitigation measures that control, reduce, or prevent anthropogenic GHG emissions in relevant sectors for the period through 2020.

### ***Vulnerability and Adaptation***

The vulnerability and adaptation assessment (Pilifosova et al., 1996, Pilifosova et al., 1997a Pilifosova et al., 1997b) addressed the impact of climate change on biophysical components that play an important role in the country's socioeconomic development. These biophysical components are agriculture (spring and winter wheat), grasslands, livestock, and water resources.

In general, the results of the study for wheat and grasslands showed that negative impacts — depending on both the scenario used and the area of Kazakhstan considered — are stronger than positive ones. The effect of rising temperatures on the breeding of sheep, the main type of livestock bred in Kazakhstan, is overwhelmingly negative. A water resources vulnerability study has been completed for several mountain and plain basins. Water runoff is likely to increase slightly by the year 2030 but, with a doubling of atmospheric CO<sub>2</sub>, a decrease in runoff could occur in all basins studied.

For the agriculture sector, more than 20 possible responsive and anticipatory adaptation measures were considered. The highest priority anticipatory measures include: improving legislation to take into account severe changes in the agricultural economy, developing and implementing technology to prevent soil erosion, developing and distributing long-term forecasts of pest infestations and disease outbreaks, and preserving and improving wheat diversity.

In the livestock sector, the adaptation measures considered were primarily those that are responsive to climate change. They include shifting lambing and sheep-driving to earlier dates, breeding different kinds of sheep, and moving livestock to higher mountain grasslands.

Concerning water resources, the development of additional resources, such as groundwater, and better management of international water resources were considered.

### ***GHG Emissions Inventory***

Kazakhstan's GHG emissions inventory for the base year 1990 (Monocrovich et al., 1995, Monocrovich et al., 1996a, Monocrovich et al., 1996b,) showed that total net emissions for 1990 were 64.579 Tg of carbon equivalent (CE). The most important emitting source is the energy sector, which accounts for 90% of emissions. The second most important source of GHG in Kazakhstan is agriculture, which accounts for 8% of

total emissions. Kazakhstan's emissions were slightly offset by an uptake of carbon by forests of 1.094 Tg CE, or 2% of the country's net emissions.

In the first National Communication (1998) these figures were refined. According to the results of the refined inventory, total net greenhouse gas emissions in 1990 were about 266 million tonnes of CO<sub>2</sub>-equivalent. Preliminary assessment showed that this value in 1994 was about 213 million tonnes. Thus, total GHG emissions in Kazakhstan during this period declined by more than 20%. Specific GHG emissions in Kazakhstan amounted to over 15.9 tonnes per capita: from this amount, about 13.6 tonnes are attributed to CO<sub>2</sub>. The national GHG inventories for 1990, and 1994, are subject to adjustment in accordance with new IPCC methodology and new initial data obtained.

### ***Mitigation***

The mitigation study (Pilifosova et al., 1997) examined measures in the energy, forestry, and livestock sectors. The total decrease of CO<sub>2</sub> emissions from energy sources is estimated at 37.9 Tg. Because there are extensive wind and hydro energy resources in Kazakhstan, the use of renewable energy has also been considered. Based on expert evaluation, CO<sub>2</sub> emissions declined 25% between 1990 and 1996 as a result of a general decline in economic activity. It is estimated that, in the reference scenario, emissions in the year 2000 will be 82% of those in 1990. Taking into account the availability of natural resources, and the existing scientific and technical studies, nine primary options for GHG mitigation were considered. For the integrated mitigation scenario, which includes all of the measures, the annual reduction in emissions amounts to 3% in 2000 and 11% in 2020 — when compared with the reference scenario. In the energy sector, small hydropower plants on existing channels and rehabilitation of thermal and electricity power plants are the most cost-effective and promising measures. In the other sectors, afforestation and reducing methane emissions from livestock are the most promising measures.

## **1.2 OBJECTIVES**

Development of the Climate Change National Action Plan (CC NAP) is one of the steps made by Kazakhstan to fulfill its commitments to the UNFCCC. It implies designing specific measures to mitigate climate change and to adapt to its negative impacts.

Implementation of actions like these is a comprehensive mission of a national scope and requires co-ordinated actions of Ministries and Governmental agencies, non-governmental organizations, scientists and general public. In Kazakhstan, as in any transition country, climate change is only a priority to the extent that it is related to another national objective. In major part reducing greenhouse gas emissions in Kazakhstan and adapting to possible climate change are a side-product of measures addressed to increasing energy efficiency, developing alternative sources of energy to ensure sustainable economical development of the country. Since such measures are very important for the national economy, mitigation strategies in the energy sector of Kazakhstan are directly connected with the general national strategy of the energy sector development. The Kazakhstan's CC NAP has been developed in accordance with the National Principles of Ecological Safety of the Republic of Kazakhstan and Conceptual Program on Agriculture and Industry Development of the Republic of Kazakhstan for the period 1993-1995 and through 2000, Energy Development Strategy until 2030 and others, and integrated with the National Environmental Action Plan for Sustainable

Development.

Thus, the main objectives in the development of the NAP are as follows:

- To integrate climate change concerns into other national development plans and programs
- To define mitigation and adaptation measures that will contribute to sustainable development
- To develop consensus, support, and an institutional base for implementing climate change measures
- To provide a framework for national communication

### **1.3 METHODS**

#### **1.3.1 Establishing the Planning Team**

At present, a national lead agency for coordinating activities both on the UNFCCC and the other ratified environmental conventions in Kazakhstan is the Ministry of Ecology and Natural Resources.

Since October 1993, the works on climate change issues in the framework of the UNFCCC have been carried out by the Main Administration on Hydrometeorology (Kazhydromet) and the Kazakh Scientific and Research Institute of Environmental Monitoring and Climate (KazNIIMOSK). The Climate Change Studies Laboratory (CCSL) of KazNIIMOSK conducted climate change studies and coordinated the activities relating to the CC NAP development. Experts and scientists from several related sectoral agencies were also involved in this work.

Other important ministries in this context are the Ministry of Agriculture (MA) — which includes departments dealing with water resources and forestry management — and the Ministry of Energy, Industry and Trade (MEIT).

Along with these governmental organizations, there are some nongovernmental organizations (NGOs) in Kazakhstan that deal with activities related to climate change and are supported mainly by international organizations. The intention is to involve some of these NGOs in the implementation of the NAP.

Since 1997, the Ministry of Ecology and Natural Resources became a coordinator of the works on UNFCCC. In February 1998, the Interagency Coordinating Committee was established for implementations of the UNFCCC provisions and decision-making procedures for climate change matters. It includes representatives from interested national ministries and other national entities and is led by the Ministry of Ecology and Natural Resources.

The functions of the Committee are as follows:

- approving the projects on GHG mitigation in the frame of Joint Implementation;

- considering and directing to the Government National Communications to the UNFCCC,
- participating in the development of the legislative and other normative acts of Kazakhstan on the issues of climate protection;
- introducing appropriate proposals on questions (particularly, approving of the NAP) requiring the decision of the Government.

The draft of the CC NAP was submitted for the governmental consideration to the Interagency Committee in November 1998. Then the NAP will be submitted to the Committee on Strategic Planning under the President of the Republic of Kazakhstan, and to the Government of the Republic of Kazakhstan, for endorsement.

### **1.3.2 Evaluating and Developing Measures**

Selection of the priority GHG mitigation and adaptation measures for each sector was based both on expert judgments from the lead agencies and the results of Kazakhstan Country Studies work. The team also evaluated existing economic development programs and plans to identify measures that could be integrated into the NAP. This information was discussed at several expert meetings. The final decision about high-priority GHG mitigation and adaptation measures and options was made at the First National Workshop on the CC NAP development in April 1997. Stakeholders from different ministries and departments took part in that meeting.

Several criteria were used to screen and evaluate mitigation and adaptation measures.

The main criteria used to select mitigation measures included opportunities for integration with current sectoral and sustainable programs, the extent of the GHG mitigation potential, the cost of emissions abatement, the cost effectiveness of implementation, other environmental impacts, and ease of implementation.

Criteria used to evaluate adaptation measures included the priority of the measure for Kazakhstan, the effectiveness of the measure both in current and expected climate, the existence of other benefits stemming from the measure, implementation costs, and administrative, legislative, market and other barriers.

The methods of technology assessment include conducting a review of technology performance and implementation analysis of renewable energy (hydropower, wind systems, and solar energy) and energy efficiency in industry and power generation. A technology assessment, including a cost-benefit analysis, of chosen mitigation measures has been completed for selected measures in the energy production sector and district heating based on the ENPEP model.

An in-depth evaluation, including a cost-benefit analysis, of several selected adaptation measures has also been conducted in priority sectors. The methodology used is a cost-effectiveness analysis that incorporates several tools — including tables and decision matrices — for screening, evaluating, and selecting adaptation measures for sectors vulnerable to climate change. This methodology was provided through the US Country Studies Program.

## **1.4 CLIMATE CHANGE NATIONAL ACTION PLAN OF THE REPUBLIC OF KAZAKHSTAN**

Greenhouse gas mitigation and adaptation measures were evaluated and developed in accordance with Kazakhstan's long-term national priorities which are to improve its people's welfare, based on sustainable development, improvement of infrastructure, increase in economic growth and preservation of the environment.

Implementation of actions like these is a comprehensive mission of a national scope and requires coordinated actions of ministries and government agencies, non-government organizations and the public. In Kazakhstan, as in any transition country, climate change is only a priority to the extent that it is related to the general national conception of the sustainable development and preservation of the environment.

Tables 1 and 2 present the sectoral priorities for mitigation and adaptation measures that were recommended to be included in the CC NAP.

**TABLE 1 PRIORITY SECTORS AND MEASURES ON CLIMATE CHANGE MITIGATION**

<b>Priority sectors and subsectors</b>	<b>Measures</b>
Energy	To develop enabling mechanisms to implement the energy-saving policies
Energy production	To improve efficiency of fuel utilization at power stations To include renewable sources of energy into the energy balance To increase the natural gas share in the energy balance
Energy consumption	To increase the energy efficiency of energy savings in the industry Energy saving in residential sector and district heating improvements
Agriculture	To increase the livestock productivity and to optimize the livestock population To take less productive land out of crop rotation, to intensify grain production
Forestry	To increase the area covered by forests

**TABLE 2 PRIORITY SECTORS AND MEASURES ON ADAPTATION TO CLIMATE CHANGE**

<b>Priority sectors</b>	<b>Measures</b>
Agriculture	Clarification and drafting of legislation for transition of the agricultural sector of the Republic to a market economy Improvement of less productive lands in arid and semi-arid zones and reduction of soil erosion Development and distribution of long-term forecasts on agricultural pest and disease outbreaks for planning, procurement and pesticides utilization purposes

Establishment and maintaining at the modern level regional centers on genetic varieties for spring and winter wheat

Water resources

To support development of modern technologies for the sectors of economy, which use water resources

To implement water-saving measures

To mitigate the negative impact of the water resources vulnerability to the sectors of the economy

To implement nature conservation measures

To reduce social losses

To increase the decision-making efficiency

### 1.4.1 Proposed Greenhouse Gases Mitigation Measures

Kazakhstan has a high potential for reducing the amount of the GHG emissions. In the energy sector, which is the main source of GHG emissions, it is determined by the high energy-output ratio in the industry and the high energy-saving potential in all sectors of the economy. Non-energy sectors have certain reduction potential as well.

Guided by the priorities, set forth at the CC NAP development seminar, basing upon estimation of costs and GHG emissions mitigation potential for specific scenarios, as well as having analyzed barriers for their implementation, certain priority actions were proposed to be included into the CC NAP. At the given stage priority actions were chosen basing on the time frames provided in the Plan of Priority Actions of the Ministry of Ecology and Natural Resources, adopted by the Government.

#### Energy Sector

The GHG mitigation measures in the energy sector are directly connected with the overall energy sector development strategy and the National Program on Energy-Saving. The mitigation action plan in the energy sector will focus on electric power, district heating, households and industry. These subsectors were chosen on the basis of the following criteria: they have high rates of energy consumption, they have a viable future, they are important to the economic development of Kazakhstan, or they have export potential.

Table 3 presents a summary of the specific mitigation measures and information about current pilot projects in energy sector. Costs for some measures are preliminary; they are currently under determination. The annual reduction in gases is given in amounts of the specific greenhouse gas in question.

**TABLE 3 SUMMARY OF PRIORITY MEASURES IN ENERGY SECTOR**

Measures	Annual CO <sub>2</sub> Reduction Potential, million tonnes	Annual CH <sub>4</sub> Reduction Potential, million tonnes	Cumulative CO <sub>2</sub> Reduction over 2000–2020, million tonnes	Total Funding Required, Million USD

	2005	2020	2005	2020		
Development of mechanisms to implement the Law on Energy-Saving	NA	NA	NA	NA	NA	0.5
Energy efficiency increasing at fossil-fuel power plants, energy saving and district heating improvement:						
Modernization and rehabilitation of power plants	1.76	2.33	0.17	0.19	40	1,061
Energy saving and district heating system improvement:						
pilot phase	TBD	0.08	TBD	TBD	0.16	0.814 by 1999 <sup>a</sup>
set of measures	TBD	0.70	TBD	TBD	TBD	TBD
Small hydro	0.14	3.74	0.02	0.28	20	578
Wind	0.63	3.13	0.07	0.22	29	0.482 by 1999 <sup>a</sup> 937
Solar:						
Thermal systems	0.6	0.6	—	—	—	931
Photovoltaic systems	0.20	1.74	0.02	0.37	18	
Utilization of associated gas	TBD	2.7	TBD	TBD	TBD	TBD

Notes:

- <sup>a</sup> pilot phase implementation with GEF support;  
TBD = to be determined;  
NA = not applicable.

Below a short description of measures to reduce the GHG emissions in the energy sector proposed to be included into the NAP UNFCCC is given.

***Designing Enabling Mechanisms to Implement the Law on Energy-Saving***

One of the major barriers to development of energy-efficient and energy-saving technologies and renewable energy in developing and transition countries is the lack of the legislative framework or properly fine-tune enabling mechanisms for its implementation. In the case of Kazakhstan, the legislative framework is formed by the Law of the Republic of Kazakhstan on Energy-Saving adopted in December 1997. This Law declaratively covers all the aspects of energy saving in both energy production and energy consumption sector, including increase of energy efficiency and development of renewable energy. The Law defines the framework for governing the energy-saving policies at the national level. As of today, however, the enabling mechanisms for

implementation of the Law have not yet been fully developed, which is one of the priority objectives of the Energy-Saving Program implementation and the priority line in the GHG emissions reduction.

Enabling mechanisms for implementation of the Law should be developed in several stages. It should cover establishment of an authorized and implementing agency, development of the regulatory framework, designing details for the program implementation at the level of certain regions, the program implementation and monitoring, as well as replication of the learned experience in other regions of Kazakhstan. To develop the program design and implementation Kazakhstan will require technical support from international and donor institutions. Total cost required is estimated about 500,000 USD.

### ***Energy Efficiency Increasing at Fossil-Fuel Power Plants, Energy Saving and District Heating Improvement***

The most effective modern trends in *energy efficiency increasing at fossil fuel power plants* are as follows:

- further development of cogeneration of electricity and heat on the combined cycle (to replace the divided condensed cycle of electricity and heat generation). It could be achieved by construction of new power plants with modern efficient equipment; replacement of condensation turbines by thermal ones at operating power plants; and transference of condensation turbines for the lowering vacuum regime (that is, their modernization);
- improvement of thermal schemes of power plants and, in particular, establishment of steam and gas power plants through both construction of new power plants and construction of gas turbine block “superstructures” at the existing steam-turbine power plants.

According to the GHG mitigation assessment, these measures will allow to reduce annual CO<sub>2</sub> emissions by 1.6 million tonnes by the year 2005 and by approximately 2.3 million tonnes by the year 2020. Cumulative CO<sub>2</sub> emission reduction for the whole period will amount to 40 million tonnes. This scenario is characterized by relatively low cost of CO<sub>2</sub> emissions reduction. To implement the whole program of improving the efficiency of fuel utilization at the power plants, presented in the Strategy for the energy sector development, will require 400 million USD by the year 2005, amounting to 1 billion USD by the year 2020. This option was included as the main priority for medium and short-term measures in the electricity generation sector.

Studies showed that some of the best opportunities for *energy-efficiency savings and district heating improvement* and consequent CO<sub>2</sub> reductions come from improvements in heating boilers, district-heat distribution pipelines, heating system controls in buildings, and building insulation. The existing opportunities to save 25-35% are technically feasible and economically cost-effective.

According to studies on selected typical particular boiler house in Almaty, implementation of such measures in supply side as installation of a gas turbine cogeneration system, and automation and monitoring equipment, installation of heat

recording equipment, and energy efficiency upgrades of the steam and hot water heating distribution system could reduce CO<sub>2</sub> emission reductions by about 40% annually. The technology retrofits replication throughout Kazakhstan could lead to about 1 billion tonnes by the year 2020.

To estimate the total amount of CO<sub>2</sub> emissions reduction potential and the funds required for whole set measures both in supply and demand sides the pilot GEF project has been recently initiated.

### ***Increasing of the Use of Renewable Energy***

#### **Small Hydro Power Plants**

The energy sector development strategy up to the year 2030 outlines river basins and regions most promising for constructing small hydro power plants. Even at the present moment it is feasible to construct about 23 small hydro power plants with the 600 MW total capacity and annual production of 1.3–1.5 TWh. Besides, about 300 channels for small hydro power plants were identified for the possibility of establishing facilities with the total capacity of 1,600 MW and annual production of 5 TWh.

With the implementation of this measure, a GHG emission annual reduction potential is estimated at 0.2 and 3.7 million tonnes by the years 2000 and 2020 correspondingly. Small hydro power plants is the only option able to result in reducing the electricity prices and saving funds up to 0.4 billion USD during the period from 2005 through 2020, or 24 million USD every year in comparison with the baseline scenario. Total sum of all the necessary funds required to install all the small hydro power plants projected by the energy sector development strategy will amount to about 17 million USD in 2005 and to 578 million USD in 2020. Development of hydro energy has positive social impact. Thus, for instance, it will allow increasing the electricity stock in the Southern and SouthEastern parts of Kazakhstan experiencing great deficit of electricity.

The Government's Plan of Priority Actions — as one of the priority tasks of including small rivers hydro-energy resources into the Kazakhstan energy balance — identifies creation of infrastructure and construction of five demonstration small power plants in four oblasts of Kazakhstan: South-Kazakhstan, Almaty, East-Kazakhstan, and Zhambyl. Implementation of these measures is estimated to cost 10 million USD.

#### **Wind Energy**

According to the research works performed, nine regions were identified in Kazakhstan as the most suitable for development of the wind energy – these are the regions characterized with the wind speed exceeding 8 m/s. As for the wind resources of the Dzhungar Gate, the wind speed there sometimes exceeds 60 m/s. As one of the priorities, additional 7 wind power plants can be proposed with the 530 MW cumulative capacity and annual production of 1.8–2.0 TWh. In addition to opportunities of installation of large wind facilities there is a considerable potential small wind power facilities market with the capacity range from 3 to 50 kW, first of all, in the zones of decentralized water supply, in the remote areas characterized with the high costs of delivery of fuel for electricity and heating supply.

GHG emissions reduction potential of this measure is estimated to be from 0.7 to 3.1 million tonnes. Required funds total to 223 million USD and 1 billion USD by the years 2000 and 2020 correspondingly. Developing wind energy is one of the most supported and sustainable options for the long-term energy sector development program in Kazakhstan. Its development, though, requires strong governmental support. According to the energy sector development strategy, economies of scale are envisaged to reduce the cost of producing this type of energy and to move it closer to the traditional sources.

### **Solar Energy**

According to the estimates, implementation of the measures aimed to develop *photovoltaic technology* at the initial stage may annually reduce the amount of the GHG emissions by 0.9% of the baseline scenario. Installation of solar plants, besides, could reduce imports of electricity in the Southern regions. At the same time, it is a rather expensive option. The sphere of utilization of these plants, therefore, will be limited to remote and difficult to access areas and to consumers requiring small capacities.

*Solar water heaters* with the capacity of 1 kW in average per day may heat 80 liters of water to 40°. On the basis of these figures, the ultimate CO<sub>2</sub> emission reduction can be estimated as 331.7 tonnes/year. It is very promising and feasible option. The *Government Plan of Priority Actions provides for implementation of actions* aimed to develop solar energy, envisages identification of priority regions for development of solar energy and designing pilot projects.

### ***Increasing the Natural Gas Share in the Energy Balance***

At present, the amount of associated gas burnt in flares at oil fields is estimated to be approximately 740 million m<sup>3</sup>. Experts estimate the mitigation potential of associated gas utilization for energy purposes to be 2.7 million tonnes of CO<sub>2</sub> per year. Among the other priorities, the *Plan for Priority Actions* of the Ministry of Ecology declares projects for utilization of associated gas at the “Prorva” and “Kumkol” deposits through designing and constructing gas-turbine units using associated gas. Implementation of these plans will require attracting funds from both foreign owners of corresponding deposits and budgets of local and central governments.

### ***Energy Consumption Sector***

All the reviewed above actions, many of which relating to the energy generation sector, have certain energy consumption actions closely connected with them. The major consumers of energy in Kazakhstan are the industrial complex, municipal and utility services and agriculture. A significant factor to reduce the energy consumption in the industrial and utilities sectors — and thus to reduce the CO<sub>2</sub> emissions — is to implement the complex of fuel- and energy-saving measures (see Chapter 2).

The most energy-intensive industries in Kazakhstan are mineral fertilizer production and ferrous metallurgy; energy efficiency increasing measures in these sectors, therefore, could be seen as the most important actions for the energy consumption sector. In this area, the deep-in analysis of mitigation technologies and design of specific pilot projects for industrial enterprises is required. Technical programs in the housing and utilities sector envisage a complex of energy saving and district heating systems improvement

measures. This complex of measures will include installation of the heat and gas consumption control and recording systems in the housing sector, automation of the heating systems through installation of thermostats, improvement of isolation of buildings and adoption of new construction standards for newly constructed dwelling industrial buildings. The UN Development Program/Global Ecological Fund project having been implemented since July 1998 represents the first pilot stage of capacity building measures aimed to increase the efficiency of utilization of energy in the central heating and hot and cold water supply systems in Kazakhstan (see Chapter 2).

## **Non-Energy Sector**

Priorities for reducing the GHG emissions not related to burning fuel were selected pursuant to the national programs and development strategies in the area of agriculture, forestry, ecology and environment protection. The information on mitigation measures in the non-energy sector is presented further below.

### ***Increase of the CO<sub>2</sub> Uptake from the Atmosphere***

The main opportunities for increasing the CO<sub>2</sub> uptake exist at the limited part of the Kazakhstan's territory between 51° and 57° N where about 40 million ha of arable lands and 10 million ha of forests are located.

#### **Afforestation and Forest Preservation**

In 1990 the forest covered 3.7% (9.6 million ha) of total territory of Kazakhstan. Based on the data available, Kazakhstan's forests sequestered 4,011 Gg of CO<sub>2</sub>. According to the Program "Forests of Kazakhstan", forest cover should be increased to 4.6% of the country by 2010, and to 5.1% by 2020. The areas (about 3.8 million ha) are to be planted mostly with mixed softwoods. This would eventually increase sequestration by forests up to about 6,000 Gg of CO<sub>2</sub>. The cost of implementing this option is estimated as 35 million USD. Foreign investment would be necessary to implement this measure.

Projects, approved by the Government for further development — "Organization of the Ecological and Resource Monitoring of Forests" and "Afforestation and Reforestation for the Sake of Biodiversity and Biocenosis Restoration and Preservation (at the area of 200 thousand hectares)" could be seen as pilot projects in increasing the CO<sub>2</sub> uptake from the atmosphere.

#### **Converting Low Productive Lands into Grasslands and Rangelands**

Soil and climatic conditions of the majority of regions in the northern oblasts of Kazakhstan support sustainable production of grain. In some regions, wheat is grown not only in the steppe and arid-steppe zones, but even in the desert-steppe zone on light-chestnut and gray-brown desert soils. The soil and climate of that area allows a wheat yield of no more than 0.5-0.6 Mg ha<sup>-1</sup>. Reducing arable areas at less productive lands with corresponding intensification of grain production will be economically profitable, the proper conditions being observed. The available areas should be planted with perennial grassy and bushy vegetation for 7 or 8 years. After that, carbon will re-accumulate in the

soil. The expected range of annual carbon re-accumulated in the soil varies from 308.7 Gg to 674.9 Gg depending upon the square of reduced arable area.

Less productive rangelands and grasslands between 45° and 51° N also possess certain CO<sub>2</sub> sinking potential. Extensive exploitation of natural resources without taking into account the balance interrelation between exploitation and preservation has resulted in various degree of degradation of over 60 million ha of rangelands, including 48 million ha because of uncontrolled grazing. There are two ways to bring these lands into economic utilization: to convert degraded pastures into planted grasslands, or to allocate these lands for natural restoration. In the first case, certain funds will have to be invested in order to have high productive planted grasslands in three years. Second option requires no additional costs, but it is too long, since the agrocenosis restoration period in deserts and semi-deserts takes over 50 years.

### ***Methane Emissions Reduction***

In 1990, agriculture-caused methane emissions accounted for approximately 8% of the total GHG emissions, or for over 45% of the total methane emissions in Kazakhstan. Measures like increasing the livestock productivity and optimization of the livestock population, biogas utilization, optimization of areas covered with rice would allow to reduce up to 20% of the methane emissions. Development and implementation of a project for improving the organic waste collection, utilization and storage systems, including wastes of husbandry complexes have been included into the Government Priority Action Plan for 1998–2000.

In 1990, almost 48% of the total methane emissions in Kazakhstan were produced by the coal-mining industry. At present, methane practically is not used any longer as a raw material for petroleum industry, some minor amount is burnt in various energy-producing systems, the rest being released to the atmosphere. Utilization of methane from the Karagandy basin coalmines has been included into the Government Priority Action Plan.

### **1.4.2 Proposed Adaptation Measures**

Study results showed high vulnerability of the wheat production and water resources of Kazakhstan to potential climate change impacts, therefore the adaptation measures in these sectors were assessed. Priority adaptation measures were selected on the basis of the results of the study, performed in KazNIIMOSK. Experts from the Kazakh Academy of Agricultural Science and Agricultural Research Center of the Ministry of Science / Academy of Science of the Republic of Kazakhstan being involved.

In developing and assessing the adaptation measures, flexibility and cost-effectiveness were taken as the main criteria. Flexibility means that adaptation measures should also take into account the wide range of potential climate change in the region, as well as the fact, that in the coming decades there may be no any significant impact of climate change to ecosystems and natural resources. Cost-effectiveness means, that the benefit is greater than costs. If adaptation measures are of high costs, they should be able to generate profit even under the existing climatic conditions, or the costs of these measures should not be significant in case there will be no benefits for several decades.

All the proposals to be included into the NAP UNFCCC will be efficient and useful even if under a wide range of potential climate change including no climate change. Under the

climate changes, however, the need in the timely implementation of these measures impetuously grows.

## **Wheat Production**

Four directions were chosen as priority for the work. While selecting the most priority options in addition to the main criteria the costs of the options and possible barriers to their implementation were taken into account. Adaptation costs were estimated basing on expert judgments. Table 4 presents the main information on the chosen priority measures. Cost estimates vary from 19.6 million USD for establishment and maintenance of the regional gene centers to 565 million USD for soil erosion reduction. Costs for pests control and seed banks establishment were estimated on the basis of costs in the USA and converted to costs in Kazakhstan using purchasing power parity adjustments and sizing of effort appropriate for Kazakhstan. Costs of transition to a free market were estimated based on the World Bank loan to Kazakhstan. Costs for soil erosion control were based on actual costs of 100,000 USD for a 3,000 ha test site, and assuming these costs would be applied to the entire wheat sowing area of 16 to 18 million hectares.

*1. Development and distribution of long-term forecasts on agricultural pest and disease outbreaks for planning, procurement, and pesticides utilization purposes.* It is necessary to have timely and reliable forecasts of this kind even under the existing climate in order to undertake the required protection measures or, vice versa, to save funds in case of a lack of the necessity to treat plants and insects. Under climate change, increase in frequency of pests and diseases outbreak is expected, and, therefore, need for this kind of forecasts will grow.

*2. Establishment and maintaining at the modern level regional centers on genetic varieties for spring and winter wheat.* Centers like these have already been established at the Southeast and North of the country. Overall amount of research in the field of the gene fund preservation in 1997 totaled to 15.8 thousand USD, which is clearly not enough to ensure the proper level of support for these works. Special attention should be focused on ensuring financial and administrative support to strengthen operations of these centers, since under the climate change the country will especially require to maintain sufficient fund of both existing and new wheat varieties.

*3. Clarification and drafting of legislation for transition of the agricultural sector of the Republic to a market economy.* Agricultural sector in Kazakhstan clearly requires legislative support during the transition to a market economy even at present, under the existing climatic condition. Under less favorable and less stable climate, however, which may present at the territory of Kazakhstan in the future, maintaining food security and sustainability of agricultural economy will be even more dependent on well-thought laws, regulating relations between farmers, private sector and the state.

*4. Improvement of low productive lands in arid and semi-arid zones and reduction of soil erosion.* About 22 million ha of arable lands from the total area of 32.7 million ha is located on the slopes up to 2 degree. Cultivation practices of dividing the land plot into square fields (production fields) 2 km x 2 km – that is 400 ha without taking into account the relief of the arable area, lead not only to deflation, but to increase of water erosion. At present, there exist a number of pilot proposals developed by leading research institutes

of Kazakhstan. The proposals concentrate at changing management and land use patterns to reduce and minimize soil loss from wind and water erosion by cultivating the land along natural contours, planting buffer strips of herbaceous and woody plants, and maintaining a constant crop cover. This expertise should be replicated as soon as possible and the country's research potential should be used for landscape and ecological designing.

**TABLE 4 ADAPTATION MEASURES IN WHEAT PRODUCTION**

Priority Actions	Investments, million USD
Clarification and drafting of legislation for transition of the agricultural sector of the Republic to a market economy	50.0
Improvement of less productive lands in arid and semi-arid zones and reduction of soil erosion	565.0
Development and distribution of long-term forecasts on agricultural pest and disease outbreaks for planning, procurement and pesticides utilization purposes	322.8
Establishment and maintaining at the modern level regional centers on genetic varieties for spring and winter wheat	19.6

Full-scale implementation of all these measures at all cultivated lands will clearly require substantial financial resources, but nevertheless these costs will be recovered in the future even if the climate does not change. Under climate aridization, the need to control erosion and to raise the soil productivity through implementation of the complex of the above listed measures will only grow and effectiveness of the proposed measures will increase. The shift to agrolandscape agriculture may be implemented through a long period of time and independently for all territories.

### **Water Resources**

For Kazakhstan as a whole, the proposed strategy of water resources sector adaptation comprises implementation of measures that can be divided into six groups:

- measures to support development of modern technologies for the sectors of economy, which use water resources;
- water-saving measures;
- measures to mitigate the negative impacts of water resources vulnerability to sectors of economy;
- nature conservation measures;
- social losses reduction measures;
- measures to expedite the decision-making process.

Full practical implementation of adaptation measures will require significant investments and long time period. Priority of measures that allow increasing the water resources

available for economic activity on the territory of north and east Kazakhstan was assessed for the basins of Irtysh, Ishim and Tobol rivers.

In setting up the priorities, preference was given, first of all, to the measures able to provide more water, to need less expenditures and not to require runoff diversion from the outside. On the basis of this estimate, adaptation measures for the Irtysh and Ishim river basins are ranged as follows: runoff regulation, a complex of water-saving measures, runoff shift, increasing underground water takeoff. For the Tobol river basin, from the two aggregated measures considered — water saving and underground water takeoff, — the priority is given to water saving.

### **1.5 EDUCATION, TRAINING, PUBLIC AWARENESS AND NGOS**

One of the general obligations of UNFCCC Parties is development of educational and public awareness programs on climate change and its effects, providing public access to information on climate change issues, and public participation, including NGOs, in addressing climate change and developing adequate responses. In Kazakhstan, as well as in many countries, the general public do not have a good understanding of the implications of climate change and the potential benefits of response measures in order to take part in the activity to achieve the ultimate objective of the Convention.

Therefore, the aim of educational and public awareness programs is informing the general public about the benefits of mitigation and adaptation measures, which are accompanied by other positive environmental effects. They lead to decline of harmful emissions into the atmosphere, increase in the agricultural productivity, and improve fresh water supply for population. Besides, additionally many social problems will be solved, new workplaces will be created, and unfavorable climate change impacts on human health will be decreased.

The public in Kazakhstan does not have good understanding of the implications of climate change and the potential benefits of response measures. Therefore, the programs of public awareness, public education, and media campaigns in newspapers, magazines, radio, and TV are an important part of the work under the UNFCCC.

The program of education and public awareness are divided into four parts: 1) educational programs for secondary schools, high education and training for teacher of secondary schools; 2) popularization campaign in mass media; 3) conducting workshops for general public and ecological NGOs; 4) conducting national workshops for the officials, policy and decision makers, who are responsible for plan development in different sectors of economy that influence on climate or depend on it.

To obtain the basic professional knowledge on climatology is possible in several universities of Kazakhstan. There is education course related to climatology in Kazakh State University. This course is planned to be added and extended by information on the latest climate change study results.

It is planned to put into education courses on ecology the climate change questions in the following universities that introduced programs on environment issues. These are Kazakh National Technical University, Pavlodar State University, Kazakh Woman's

Pedagogical Institute, Almaty State University and others. Program on climate change issues is expected to develop for courses on geography and natural history lessons.

Climate change study results in Kazakhstan are published in the quarterly science and technical journal “Hydrometeorology and Ecology” issued by Kazhydromet. The public can obtain information on climate change study activities from the newspaper “Ecocourier” issued by the Ministry of Environment and Natural Resources and from other periodical issues.

In April 1997, Kazhydromet hold the first national workshop on climate change national action plan. Representatives from Russia, Kyrgyzstan, the USA, and the Netherlands took part in plenary meetings. The main results of the workshop were identifying of priorities of the NAP and informing of the general public as well as policy and decision makers on the problems of climate change and possible GHG emission reduction measures.

A network of ecological NGOs in Kazakhstan is actively expanded. However, only some of them have climate change projects. In 1997, the NGO “Ecoproject” prepared two telecasts on climate change problems. In 1998, another NGO “Ana Umyty” started to implement a project in Aralsk district called “The light, born by the wind” financed jointly by the SGP/GEF and NGO “Isar”. The task of the project is to install a wind turbine for the maternity home in the town of Aralsk. The project includes a program on ecological education for the public and managers of the Aralsk region.

The role of NGOs will grow in the future. It is evident that a sufficient part of the work in the area of climate change on GHG reduction such as reforestation, using of renewable sources of energy, methane utilization and so on can be implemented by local NGOs. The other sphere of their activity can be participation in political dialogue with the government on different matters related to prices or tariffs on energy, demonstration projects, and clean energy. NGO activities can be realized in energy efficiency improvement projects, removing barriers for renewable energy using, and development of legislative base for introduction of the national policy in the area of global ecology issues.

## **1.6 FOLLOW-UP ACTIVITIES**

Formulating, implementing and regularly updating national programs containing measures to mitigate climate change and facilitate adequate adaptation to climate change impacts are the general commitments of all Parties in accordance with the Article 4 (1b) of the UNFCCC. These measures should be implemented on a constant base in all sectors of economy including energy, transport, industry, agriculture, forestry, water resources, and waste management.

The list of the projects in the NAP is defined by the long-term national development strategy “Kazakhstan – 2030”. The time frame of the NAP implementation is defined by the general commitments of the UNFCCC Parties. On the other hand the steps undergoing by the Government with the regard to the decision of the signing the Kyoto Protocol will request to define and certify of the planning GHG emissions for the period of 2000–2008. Clean Development Mechanism defined by the Article 12 of the Kyoto Protocol assists Kazakhstan as a Party not included in Annex 1 in achieving sustainable development and in contributing to the ultimate objective of the Convention. It implies banking projects in developing countries. At the same time CDM enables Parties included

in Annex 1 to achieve compliance with their quantified GHG emission limitation and reduction commitments under Article 3. Therefore, at the beginning of the NAP realization the preparatory stage for projects will take place. The aim of this works is to define a potential of GHG emission reduction in Kazakhstan and to estimate costs of 1 tonne CO<sub>2</sub> emission reduction. CDM create an opportunity for developed countries to start technology transfers as early as 2000, instead after 2012, as it was defined earlier.

Besides, for the realization of Kazakhstan's obligations on UNFCCC, it is planned to continue scientific, socio-economic and others studies, to carry out observations of climate system, to support of created climate data bases, which are necessary for understanding of climate change causes. These are tasks of research institutes and groups. Climate change monitoring is a task of the National Meteorological Service and must be financed both by the government and international organizations.

Studies and assessments of measures on adequate adaptation to climate change will also be continued. For the moment, adaptation is recognized to be important as mitigation measures in effort to combat climate change. Adaptation assessments of the Caspian Sea coastal zone and mudflow and snow avalanche study for the mountains of the South and Southeast of the country are being developed within the Netherlands Climate Change Studies Assistance Programme during 1998–1999.

The NAP UNFCCC projects development and monitoring will be conducted by a special entity – National Ecological Center for Sustainable Development under the Ministry of Ecology and Natural Resources. This group is responsible for the development of strategies, action plans, and projects on all international conventions ratified by the Republic of Kazakhstan, including UNFCCC.

## **2. TECHNOLOGY ASSESSMENT**

### **2.1 GHG MITIGATION STRATEGY AND MEASURES IN ENERGY SECTOR**

#### **2.1.1 Overview of the Energy Sector**

##### **Resources**

Kazakhstan has huge reserves of energy resources, which is sufficient to meet the domestic needs as well as to export the resources in their natural form and in the form of electricity to the other regions.

In 1990, the total output of the primary energy resources in Kazakhstan amounted to 119.4 million toe or 170.7 million tce (Table 5).

There was prevalence of hard and, in less degree, brown coal (lignite) in the energy resources balance in 1990. The share of the coal was 80% in the energy production sector, and 40-50% – in the residential sector. The total coal consumption was about 91 million tonnes, of which 11 million tonnes were imported from Russia and Central Asian countries. The energy and residential sectors consumed 76 million tonnes of coal and industry used 15 million tonnes.

In 1990, the crude oil and gas condensate output in the republic was equal to 26.6 million tonnes, whereas 12.66 million tonnes was imported for complete needs of refineries. The Republic of Kazakhstan is a large oil exporter, as it annually export is about 20 million

tonnes of crude oil.

The current natural gas output in Kazakhstan is about 7.9 billion m<sup>3</sup>, and only 2.9 billion m<sup>3</sup> is refined locally, about 0.65 billion cubic meters of associated gas is burned in the torches. The rest of the gas amount is exported for refining to Russia. The country meets its basic needs in gas (about 16 billion cubic meters) at the expense of import from the other regions, mainly, from Russia and Uzbekistan. The import approximately makes 12.8 million cubic meters. In the country fuel balance, the share of gas is less than 15%.

The renewable energy (RE) resource potential in Kazakhstan is significant but was largely neglected. RE resources development would be suitable for electricity production at the national and local level and is suitable to serve small distributed loads.

Kazakhstan's hydro potential is quite large amounting to an estimated 170 TWh/year, of which only about 23.5 TWh/year has been exploited. Within the total, small hydro potential, defined as units of less than 10 MW, is significant. Based on existing studies, there is at least 453 potential small hydroelectric power projects with 1,380 MW of total installed capacity and 6.3 TWh of mean annual production. Some of them consist of existing irrigation channels, which makes them more readily available for implementation (at lower cost and shorter time period).

**TABLE 5 PRODUCTION AND CONSUMPTION OF PRIMARY ENERGY RESOURCES IN 1990**

Primary Energy Resource	Production, million toe	Share of Total Primary Energy Resources, %	Consumption, million toe
Coal	58.90	49.30	49.30
Crude oil	25.80	21.60	19.95
Gas	6.16	5.20	11.56
Nuclear fuel	27.90	23.40	0.58
Renewable sources	0.63	0.50	0.63
Total	119.40	100.00	81.02

Kazakhstan has a great possibility of the wind power use, especially in the regions of Dzhungar Gates and Chillik wind corridor, where the annual average wind velocity is estimated in the range of 7 to 9 m/s and of 5 to 9 m/s correspondingly. Close proximity of existing high-voltage transmission lines, good correlation of the windy seasons and the high demand for the electricity provide the conditions to use these resources effectively.

In spite of the geographical location, Kazakhstan has sufficient solar energy resources potential. There are between 2,200 and 3,000 hours of sunshine per year and insolation energy is 1,300–1,800 kWh per square meter per year. This allows using of the sun water-heater and sun batteries, in particular portable photovoltaic applications in the rural area on the cattle farms.

In 1990 the total renewable-based energy production (including hydro energy) was 7.35 billion kWh, or 8.4% of total energy production. Current share of the RE amounts 0.3% of total energy production, 80% of which accounts for small hydro.

## **Energy Transformation and Distribution**

Energy sector plays a significant role in the future economic development of the country. However, with the large energy resources, Kazakhstan has serious electricity deficits, which have to be covered by imports from Russia and other Central Asian countries. Furthermore, the size of the country's territory and its geography (desert land dividing north from south) together with the concentration of coal deposits in the north, require high investments in transmission systems with attendant high losses and low reliability. The power sector needs considerable rehabilitation and serious upgrading if the country is to decrease its heavy reliance on electricity imports.

Ten energy distribution systems were formed in Kazakhstan by the late eighties. They provided energy connection with Russia and the central Asian republics. The vast territory of the republic predetermined the huge total length of electricity transmission network, which was about half a million kilometers.

The management structure and forms of property of the distribution system have been radically changed recently. In transition from the planned economy to the market one indivisible power engineering system, all the generators and the transit and energy distribution networks being its indispensable parts, were reorganized. To develop the competitive conditions, all the generators got independence as joint-stock companies, some of them have been sold to the foreign investors, and the rest are in the process of selling. The regional energy distribution networks have also been reorganized into joint-stock companies and are nominated for the auctions. The national energy system company "Kazakhstanenergo" has been reorganized into Kazakh Electricity Grid Operation Company ("KEGOC") which is joint-stock venture, but it is preserved as the state property. Thus, the power sector of Kazakhstan is going out of the governmental subordination. The government preserves the regulatory functions in accordance with the Law on the Power Engineering.

## **Consumption**

As a result of the process of profound economic reforms, crises of the transition period and disintegration of the industry and economy complex of the former USSR, the demand for energy in Kazakhstan has been decreased over past several years. Since 1990 to 1997, the energy consumption has fallen by 47.6 billion kWh or on about 45% of the level of 1990. It should be noted that the share of hydropower energy increased because its total electricity production remained practically the same.

Electricity demand projections by 2030 under the "maximum" and "minimum" scenarios, according to the "Energy sector development strategy until 2030" project are presented in Table 6. It can be seen from the table that electricity demand level of 1990 will be reached in 2015 and 2010 according to "maximum" and "minimum" energy demand scenarios respectively. It would be possible to meet the increasing electricity and heat demand by restoration of the energy production up to the level of 1990 on the existing modernized power plants, as well as by installation of new turbines on a number of power stations. It is expected besides, that the total energy production on the renewable energy resources will reach 10.7 TWh (including wind energy) in 2030. The total share of these resources (mainly hydro and wind resources) in the overall energy production will amount

to 7% in 2030.

**TABLE 6 ELECTRICITY DEMAND PROJECTIONS ACCORDING TO DIFFERENT ENERGY DEVELOPMENT SCENARIOS UNTIL 2030 (TWH)**

Scenario	1990	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020	2030
Maximum	104.7	74.4	66.2	57.1	60.0	65.0	80.0	95.0	110.0	120.0	130.0	145.0
Intermediate	104.7	74.4	66.2	57.1	56.0	57.0	60.0	80.0	95.0	105.0	115.0	130.0
Minimum	104.7	74.4	66.2	57.1	54.6	55.5	57.0	67.5	78.0	88.0	98.0	115.0

Source: Energy Development Strategy until 2030 (June 1998).

### **Energy Strategy**

The Energy Strategy in Kazakhstan is elaborated in accordance with the President's Strategy of the Development of Kazakhstan up to the year of 2030, and is based on the analysis of the world power engineering market development and the domestic potential of the country.

The main goal of the Energy Strategy of Kazakhstan is definition of the ways and development of the means for the most efficient use of the energy resources and power production complex, in order to rise the living standards of the population and the socio-economic development of the country.

The most important objectives of the Energy Strategy are as follows:

- to reduce significantly the impact of the fuel and energy production complex on the environment;
- to preserve and strengthen energy independence and security of the country.

The highest priority of the Energy Strategy is increase of energy efficiency and energy-saving improvement. In accordance with the developed strategy, rational energy consumption will prevent an increase of the energy demand, which is ruinous for the country and beyond the possibilities of the fuel and energy complex. It will also give an economic effect of fivefold return on energy-saving expenditures.

Energy saving will make it possible to reduce the detrimental emissions into the atmosphere by 15-20%. Saved energy resources should be the main source to provide the necessary fuel and energy export.

The strategy in the area of development of structure of the energy sector for the nearest 15-30 years is addressed to the following action:

- to increase the share of oil in the national energy balance and export, and increase efficiency of its use;
- to increase the share of natural and associated gas in the energy balance and efficiency of its use;
- to have a profound refinery and combined use of the raw hydrocarbons as a high priority;

- to improve coals quality through their profound enrichment and electrochemical refinery, the confinement of the high-ash beds exploitation, stabilization and then the increase of the coal mining volume (mainly, using the strip mining method) in the course of development of ecologically fit technologies;
- to intensify the local power resources development (hydro energy, small deposits of hydrocarbons, etc.);
- to increase use of nontraditional renewable energy sources (wind, solar, geothermal waters, coalbed methane, biogas, etc.).

The highest priority of the Energy Strategy is improvement in energy efficiency and energy saving. The main way to achieve the goals and implement the priorities of the Energy Strategy is to develop a power and energy market regulated by the Government.

### 2.1.2 Carbon Dioxide Emission Projection

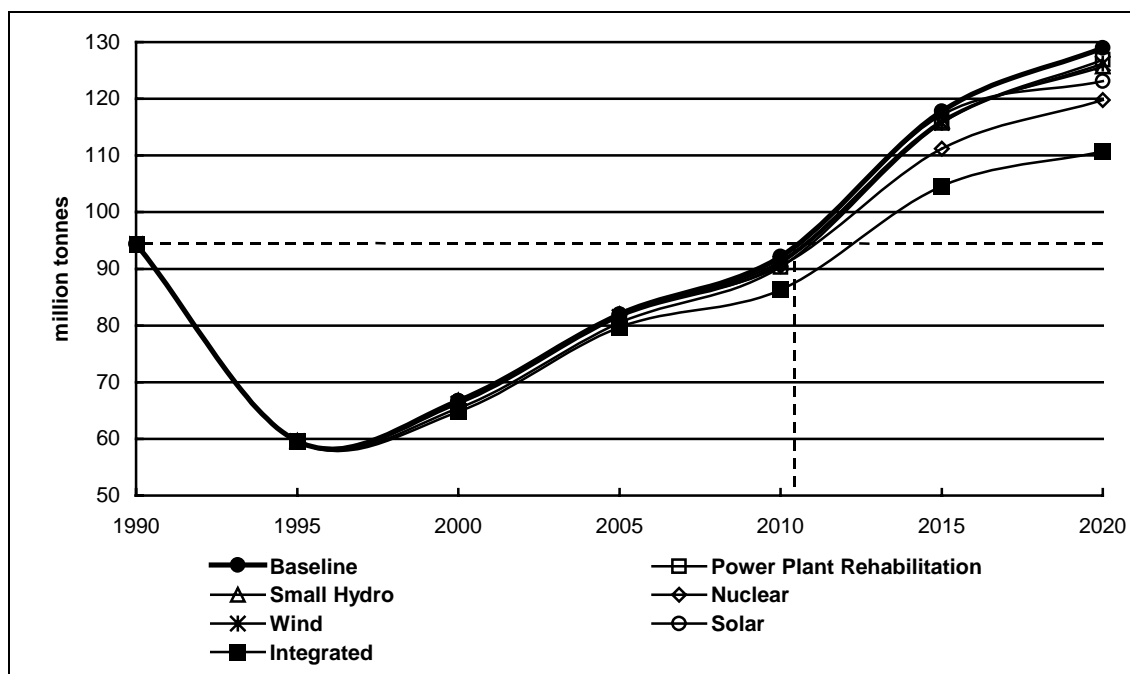
At the moment, it is difficult to provide a reliable long-term projection of GHG emissions. Baseline scenario of CO<sub>2</sub> emissions, that is the emissions dynamics, which assumes no mitigation measures to be implemented, for Kazakhstan, as a transitioning country, will not be consistent with long-term trends. This projection will be determined, first of all, by long-term projections of the Kazakhstan’s economy development and of the energy use efficiency, construction of these projections, in its turn, is a rather complicated task. A projection of CO<sub>2</sub> emissions from the energy producing sector until 2020 was constructed with the use of the energy planning model ENPEP, developed by Argonne National Laboratory (USA). In a general view, the projection of CO<sub>2</sub> emissions is based on the long-term projection of socio-economical development. It is a function macro-economic indicators such as GDP, energy use efficiency in industry (specific energy consumption per GDP), demand on different types of energy-carriers and factors of CO<sub>2</sub> emissions caused by the use of these energy-carriers. In other words, some assumptions in projecting of the economy development, structure and volumes of energy use in the national economy are inevitable. CO<sub>2</sub> emissions from energy production sector are presented in Table 7.

**TABLE 7 CO<sub>2</sub> EMISSIONS FROM ENERGY PRODUCTION SECTOR (MILLION TONNES)**

Actual emissions		Projected emissions				
1990	1994	2000	2005	2010	2015	2020
94	74	67	83	93	118	129

Below is refined CO<sub>2</sub> emissions projections obtain with use of ENPEP model and new energy development strategy (Fig. 1).

**FIGURE 1. CO<sub>2</sub> EMISSIONS FOR THE BASELINE AND MITIGATION SCENARIOS**



As it could be seen at the picture, according to the baseline scenario CO<sub>2</sub> emissions reduction will reach about 40% of the 1990 level by 1998. The baseline CO<sub>2</sub> emissions projection shows that the emissions will reach the 1990 level in 2011 and exceed this level on 37% in 2020. Development of the nuclear-based energy sector may result in the most significant reduction in the CO<sub>2</sub> emissions. According to the "Nuclear power station" scenario, in comparison with the baseline scenario, the annual emissions abatement will amount to 1.9%, 3.8%, and 7.1% in the years 2010, 2015, and 2020 correspondingly. Power plants rehabilitation may reduce the CO<sub>2</sub> emissions to 1,609 Gg in 2000 and to about 2,330 Gg in 2020, which equals to 2% of the baseline level. The "Small Hydro" and "Wind" scenarios' annual CO<sub>2</sub> emissions reduction potential equals to 0.2 and 2.6% in 2000 and 2020 correspondingly. The total annual potential for CO<sub>2</sub> emissions reduction due to implementation of all the options ("Integrated scenario") considered increases from 3% in 2000 to 11% in 2020.

Total cumulative CO<sub>2</sub> emissions reduction potential for the period 2000–2020 is about 158 million tonnes. Costs of implementation of all the measures would amount to about 5 billion USD. Rehabilitation of power plants and introduction of small hydro power plants are the most cost effective measures. Nuclear energy development is the most expensive one, but it has high GHG emissions mitigation potential.

Total GHG emission projections will be justified with taking into account new macro-economic projections.

### 2.1.3 Energy Saving Potential

A significant factor to reduce CO<sub>2</sub> emissions will be implementation of comprehensive fuel-saving or energy-saving measures. The energy-saving potential is immense in Kazakhstan. The absolute value of the energy-saving potential is calculated as the difference between the specific energy intensity in Kazakhstan and that in developed countries multiplied by the value of the gross domestic product (GDP). The specific energy intensity of the GDP in Kazakhstan equals to 1.03 tce/1,000 USD; specific energy intensity (average weighted) in the OECD countries equals to 0.39 tce/1,000 USD. If the

level of the specific energy intensity in the developed countries being achieved, the absolute energy-saving potential of the Republic of Kazakhstan will amount to 61.51 million tce, it means prevention of about 170 million tonnes of CO<sub>2</sub> emissions.

In Kazakhstan, in co-operation with USAID, the National Energy-Saving Program was developed and approved by the Resolution of the Government, provisions of the Program being taken into account in assessing the perspective demand for electricity.

Implementation of actions already outlined in the National Energy-Saving Program of the Republic of Kazakhstan could allow to reduce the fuel consumption by 25% as the result of implementation of the short and medium-term action program and by 40% – as the result of implementation of the long-term program.

The first stage of realization of the energy-saving potential (1995–2000) should be provided primarily through streamlining nominal regime operations of enterprises and eliminating direct waste in energy utilization. This stage will not require any substantial investments. The desired impact will be achieved by proper organizational and technical arrangements. The following-up periods will require crucial restructuring.

Thus, energy-saving potential due to elimination of direct waste of electricity and thermal energy is estimated to amount to 0.7 million tonnes of coal equivalent, the emissions abatement potential amounting to 2.1 million CO<sub>2</sub>, in the electricity and energy generation — over 10 million tonnes of CO<sub>2</sub> (3.7 million tonnes of coal equivalent) with 2.7 million tonnes of CO<sub>2</sub> emissions reduction due to lowering electricity consumption for the electricity transportation along the grid-lines, due to rehabilitation of the existing equipment — about 1 million tonnes CO<sub>2</sub>. Cumulative energy-saving potential requiring minimum implementation costs is estimated as 15.8 million tonnes CO<sub>2</sub>.

#### **2.1.4 Heat and Hot Water Supply**

##### **Technology Assessment of Energy Efficiency Improvement**

This section shortly describes the results of in-depth evaluation for improving energy efficiency at a typical boiler house in Kazakhstan. The share of centralized district heating in Kazakhstan amounts to about 72 %. The principal objective of this project, which have been completed with support of USAID, was to evaluate the “bankability” of the project for increasing energy efficiency at Almaty Northeast Boiler House (NBH). Other objectives include assessment of the GHG reduction potential of the proposed measures and mitigation strategies for the specific project and development of a mitigation analysis for a country-wide implementation.

This project was developed by Hagler Bailly Services, Inc. with financial and technical support of U.S. Agency for International Development. Kazakh Institute for Environment Monitoring and Climate and Kazakh Power Engineering Institute were also involved in this work.

The activity on preparation of bankable project on increasing energy efficiency focuses on selected boiler house that is typical for providing municipal services and has typical technologies used and efficiency problems of whole district heating system in the country.

There were defined five possible energy efficiency options:

### **1. Installation of a gas turbine cogeneration system**

Electricity is used for heat production and transportation at the NBH and HPs. A specific electricity consumption is 20 kWh/Gcal. Annual electricity consumption for internal uses of the NBH and HPs varies from 2,200 to 2,500 MWh. Nowadays, NBH has to buy the electricity, which is produced at coal-burning power plants.

One of the principal measures to increase efficiency of fuel use and reduce cost price of heat energy is implementation of combined cycle of heat and electricity production through advanced gas turbine with capacity 3 MW with an annual electricity production of 17,500 MWh. This electricity production will meet electricity demand of the NBH. The surplus of electricity will be sold to other consumers. Electricity price in combined cycle production will be competitive on electricity market particularly for nearby consumers.

Required gas turbine could be bought in Russia, the US or in other countries. Estimated cost of such turbines is about \$US 1.5 million.

### **2. Decentralization of the heat supply system**

With centralized heat supply system, heat from one large source (boiler house) is transmitted through heat points to large inhabited districts, which sometimes located on significant distance from the main source of heat. Transportation of the heat to large distances causes significant, up to 40 percents of thermal capacity, losses of heat. This leads to the over expenditure of fuel and increases cost of heat. As an alternative to the centralized heating system can be an installation of individual sources of heat in those big apartment buildings, which are located far from the NBH. It is necessary to provide 18,750 Gcal/year to cover heat demand for these apartment buildings. This option can lead to fuel saving of 1256 TCE/year due to the transportation losses eliminating.

The main barriers to wide application of individual sources of heat are high cost of such individual sources (from 150 up to 300 USD per kW) and use of expensive liquid fuel, with cost of about 200 dollars per tonne.

### **3. Installation of automation and monitoring equipment**

Heat and hot water are supplied through Heat Points (HP). Steam from the NBH through steam pipe-lines is transported to the HPs, where it is converted into hot water and then the hot water is transported to heat consumers through heat distribution system. The total number of HPs is 13.

Currently HP operators maintain temperature regime of the heat system manually. The automation of system of temperature regime regulation will allow to save approximately 3 % of heat due to more accurate maintenance of temperature diagram, and also will allow to reduce expenditures for HPs personnel.

Assuming that annual heat production is 100 thousand Gcal, the economy of fuel will be about 502.5 TCE/year.

An estimated cost of automation of HPs is about 600,000 US dollars. The equipment could be bought in Russia or the USA.

#### **4. Installation of heat recording equipment**

Nowadays consumers pay for heat and hot water in accordance with the norm of hot water and heat consumption, that does not stimulate economy of heat by the consumers. Installation of the measurement and control equipment will allow to stimulate economy efforts of heat by the consumers and will provide more accurate calculation of consumed heat.

It is proposed to install the measurement equipment at the first stage at 50 large apartment buildings and at the second stage - at 250 apartment buildings. The estimated efficiency of this measure is approximately 7 %. Assuming that annual heat production is 100 thousand Gcal, the economy of fuel will be 1172.5 TCE/year.

An estimated cost of the installation of measurement equipment at 250 apartment buildings is about 800000 US dollars. The equipment could be bought in Russia or in a number of Eastern European countries.

#### **5. Energy efficiency upgrades of the steam and hot water heating distribution system**

Currently, heat losses in the transportation system reach 40 %, whereas normative losses are set up to 15 %. The excess of normative losses is caused by a bad condition of the steam and hot water heating distribution system. Some equipment needs to be repaired and other - to be replaced. As estimated, about 30 % of thermal networks needs to be repaired.

It is expected in the result of this measure that heat losses of 40 % are being reduced to about 25 %. The economy of fuel with annual heat production of 100 thousand Gcal is about 2512.5 TCE/year.

The estimated cost of prime repair is about 850000 US dollars.

#### ***Prioritization of the Options***

We used a simple approach to screen the measures. 14 screening criteria were selected based on project criteria for US IJI, added with some criteria that reflect specific local conditions. Marks for every option through all the criteria were determined by expert judgment method, then we summarized marks to get total scores for the options. The marks are set on non-numerical scale varying from “X” to “XXX”. A dash sign “-” means that the option does not meet the criterion. Screening of proposed options is presented in Table 8.

**TABLE 8. SCREENING MATRIX**

№	CRITERIA	TECHNOLOGY				
		I	II	III	IV	V
1.	Is acceptable to the Government of Kazakhstan	X	X	X	XX	X
2.	Provides data and methodological information sufficient to establish a baseline of current and future greenhouse gas emissions	XX	XX	XX	XX	-
3.	Contains adequate provisions for tracking the greenhouse gas emissions reduced or sequestered resulting from the project, and on a periodic basis, for modifying such estimates and for comparing actual results with those originally projected	X	X	X	X	X
4.	Contains adequate provision for external verification of the greenhouse gas emissions reduced or sequestered by the project	X	X	X	X	X
5.	Has non-GHG environmental benefits	XX	XX	XX	XX	XX
6.	Provides adequate assurance that greenhouse gas emissions reduced or sequestered over time will not be lost or reversed	XX	XX	-	-	-
7.	The potential for the project to lead to changes in greenhouse gas emissions elsewhere in country	X	XX	XX	XX	XX
8.	The potential positive and negative effects on the project apart from its effect on greenhouse gas emissions reduced	X	X	-	X	X
9.	Target of Opportunity	-	-	X	X	X
10.	Low Capital Costs	X	XX	XX X	XX	XX
11.	Low Operational Costs	XX X	-	XX X	XX X	XX X
12.	Low Sensitivity to Type of Fuel	-	-	X	X	X
13.	Payback Potential	XX	-	X	X	X
14.	GHG Reduction Potential	X	XX	X	X	XX
	TOTAL	18	16	20	20	18

As a result of screening analysis, options #1, #3, #4 and #5 were selected for further consideration.

Thus, the first option will include the installation of 3 MW gas turbine (GT) cogeneration system to produce 17,500 MWh/year to cover internal NBH needs and to sell the surpluses. The GHG mitigation effect will be achieved by replacing electricity made by coal power plants to electricity produced by gas turbine. The second option will include automation of work of the thirteen HPs and that will allow to increase their efficiency. The distribution network that presently delivers steam heat to the apartment blocks will be replaced with new, better insulated pipes in the forth option. It is planned to replace about 800 m of the pipelines. Also, with installation of more efficient pipes, the plant will deliver hot water with less hot losses.

#### ***Summary of GHG Mitigation Analysis***

The mitigation analysis shows an estimation of GHG emissions reduction by means of the energy efficiency improvements and gas turbine installation in NBH which will reduce on-site as well as off-site emissions. The latter are currently produced by the coal-fired power plant to provide electricity for operation needs of NBH.

For this purpose baseline and mitigation scenarios of GHG emissions were constructed. For the analysis the ENPEP model, developed by the Argonne National Laboratory, was

chosen. In this study only two modules of ENPEP were used, BALANCE and IMPACTS.

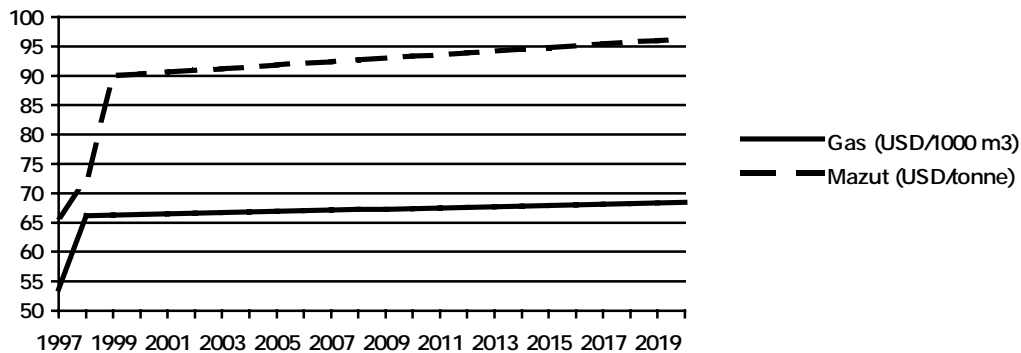
The boiler house was simulated based on the basic assumptions given below from the base 1997 year through 2020 in the BALANCE module. BALANCE calculates energy flows and price for the energy in each link for each year. Then, baseline emissions were calculated in the IMPACTS module based on the energy flow data provided by BALANCE and using the default emission factors included in the IMPACTS module's database.

### *Scenario Assumptions and Input Data*

The information for the 1997 base year was used as input to the ENPEP model. The following key assumptions were used for the baseline scenario:

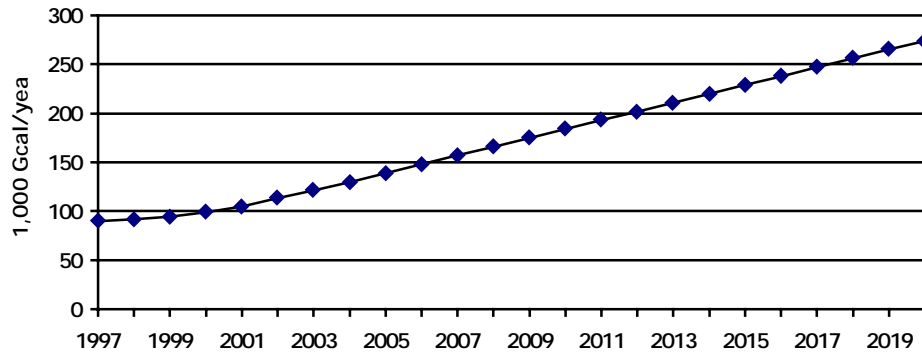
1. The share of fuels used at the boiler house, i.e. 25 % of gas and 75 % of fuel oil, will remain the same for the whole period.
2. Growths of gas and mazut prices are shown in Figure 2. Rates of price growth will not be uniform. The projections are based on assumption that prices will be increased to reach the world market price in the next few years and then they are expected to be steady. In Almaty region fuels are primarily imported from neighboring countries and therefore, they are very sensitive to world price levels, in spite of the fact that Kazakhstan posses its own oil and gas deposits, which are located far away in the western part of the country.

**FIGURE 2. FUEL PRICE PROJECTIONS**



3. The ratio between input fuel quantity and output quantity of heat in the boiler house (71 %) does not change during the whole period of 1997-2020. Transportation heat losses also will remain at the base year level (40 %) during the whole period. Also, for the baseline scenario, no change for capital expenditures is expected in 1997-2020. Operational and maintenance costs grow on 1-2 % annually (not taking into account inflation). It is expected that significant energy efficiency measures and new equipment installation will not be implemented as a result of lack of funds.
4. The heat demand will grow by 2-8 % annually, according to projection given in Figure 3.

**FIGURE 3. BASELINE HEAT DEMAND PROJECTION**



According to the national development strategy the national energy demand will reach up the level of 1991 in 2010 (National Strategy Program of the Republic of Kazakhstan until 2030). This projection is based on this general strategy. Heat demand will reach the level of 1991 (about 200 thousand Gcal/year) in 2011-2012.

5. Profit factor will be changed from 10 % in 1997 to 15 % in 2004, as shown in table 9.

**TABLE 9. PROFIT FACTOR CHANGE IN 1997 - 2020**

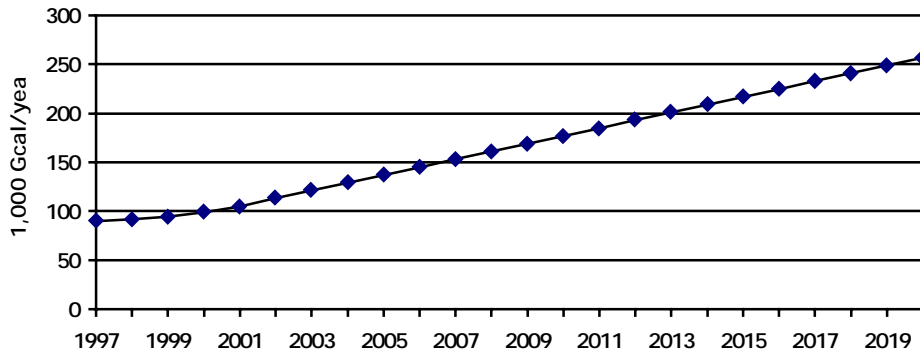
	Years				
	1997-2000	2001	2002	2003	2004-2020
Profit factor, %	10	12	13	14	15

6. Off-site GHG emissions from coal-fired power plants are included in a baseline scenario.

Mitigation scenario was made based on the baseline one with the following assumptions:

1. All the selected options were integrated in mitigation scenario.
2. The share of fuels is not fixed as in the baseline scenario. The share of gas will be increased up to 45 %, because of gas turbine installation.
3. Transportation heat losses will be decreased since 1999 from 40 % to 15 % in 2011 due to implementation of the mitigation options. Capital expenditures will increase on 10,049 USD in 2001 due to installation of new equipment, implementation of energy saving options and installation of heat meters. Operational and maintenance costs will be a bit lower in comparison with the baseline scenario in accordance to heat demand decreasing.
4. The mitigation heat demand projection slightly differs from the baseline one (Figure 4).

**FIGURE 4 HEAT DEMAND PROJECTION FOR MITIGATION SCENARIO**

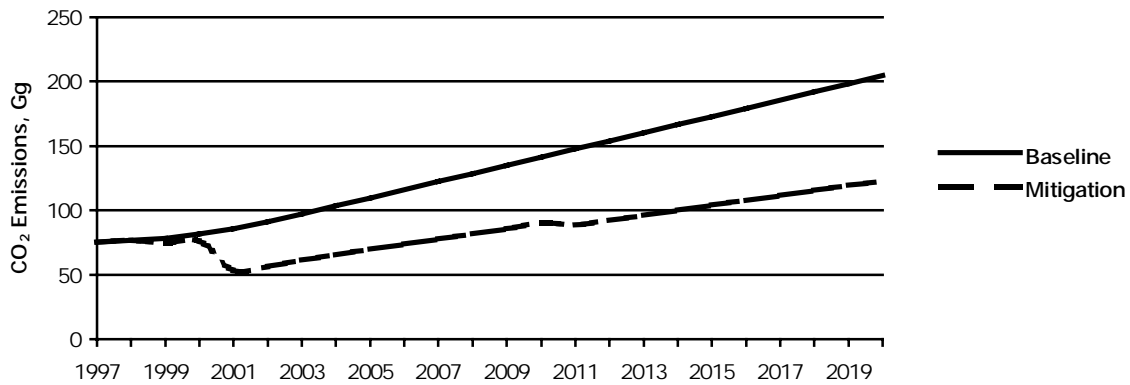


In the mitigation scenario we assumed that heat energy demand will slightly decrease due to the installation of heat meters in apartment buildings. Thus, it is expected that total heat demand will be 257 thousand Gcal/year in 2020, i.e. on 6 % less than in the baseline scenario.

**GHG Emissions**

GHG emissions from the boiler house were projected using the IMPACTS module of ENPEP package. Projections were made for CO<sub>2</sub>, CH<sub>4</sub>, NO<sub>x</sub>, CO, as well as for SO<sub>2</sub> and particulate emissions. Both scenarios have the same emissions in the base 1997 year. The resulting CO<sub>2</sub> emissions are presented in Figure 5.

**FIGURE 5. CARBON DIOXIDE EMISSIONS**



The baseline carbon dioxide emissions are going up, reflecting the heat demand projection. In the alternative scenario there is an abrupt decrease in 2000-2001 which is explained by the gas turbine unit installation. Annual CO<sub>2</sub> emissions under the mitigation scenario are increasing slower, that is caused by the energy efficiency improvements and installation of meters in buildings that would lead to less heat demand. Total estimated CO<sub>2</sub> emissions reduction in the 1999-2020 period is 1,129 Gg or about 37 % of the baseline emissions. Annual reductions would be 40 Gg or 36.6 %, and 82 Gg or 40.2 % of the baseline level in 2005 and 2020, respectively.

Reduction of CO<sub>2</sub> and NO<sub>x</sub> emissions is going to be most significant. Annual reduction of NO<sub>x</sub> is estimated to be 4.8 to 92.2 tonnes in 1999 and 2020 respectively. In less degree CO and CH<sub>4</sub> emissions will be reduced. An annual carbon oxide emissions reduction will

vary from 1.2 in 1999 to 27.7 in 2020. Methane emissions will be reducing only since 2000. The total methane reduction is estimated to be about 104.5 tonnes for the whole period.

**Assessment of CO<sub>2</sub> Mitigation Potential for a Country-Wide Implementation**

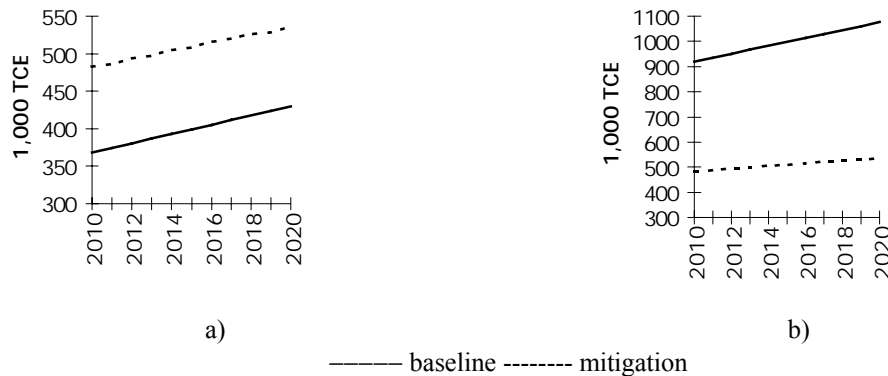
There are 70 heat plants and distributed heating systems similar to NBH in Kazakhstan. All of the considered measures are worth to be implemented to increase energy efficiency and increase profitability of the boiler houses. However, in the northern part of Kazakhstan lack of fuel could be a restrictive factor for wide implementation of gas turbines for combined heat and power generation.

Taking into account this fact estimated heat production in Kazakhstan is about 1.4 billion Gcal due to natural gas combustion, and 3.5 billion Gcal due to mazut combustion in the base 1997 year. Total fuel consumption in the boiler houses was accounted for about 1004.4 thousand TCE (287,000 TCE of gas and 717,500 TCE of mazut) in the base year. The base year CO<sub>2</sub> emissions from all considered boiler houses is estimated to be about 2,039,135 Gg.

**Baseline and mitigation scenarios**

Fuel consumption projections since 2010 year according to the baseline and mitigation scenarios are presented in the Figure 6.

**FIGURE 6. NATURAL GAS (A) AND MAZUT (B) CONSUMPTION PROJECTIONS FOR BASELINE AND MITIGATION SCENARIOS**



To develop fuel consumption projections for the baseline scenario expert judgments and main directions of the national strategy of energy sector development were taken into account. Fuel consumption will increase by 1.5 times by the year 2020 in comparison with the year 1997.

To develop fuel consumption projections for the mitigation scenario the following main assumptions were made:

1. All the selected mitigation options were integrated in mitigation scenario.

2. The share of fuels is not fixed as in the baseline scenario. The share of gas will be increased up to 50 %, because of gas turbine installation.
3. Transportation heat losses will be decreasing from 40 % to 20 % due to implementation of the mitigation options.
4. Heat energy demand will decrease up to 5 % to the year 2020 due to the installation of heat meters in apartment buildings.
5. The mitigation measures implementation will start in 2010.

The resulting CO<sub>2</sub> emissions reduction since the year of implementation of the mitigation options is presented in Table 10.

**TABLE 10. ESTIMATED CO<sub>2</sub> EMISSIONS REDUCTION UNDER THE MITIGATION SCENARIO IN COMPARISON WITH THE BASELINE SCENARIO**

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Reduction, Gg	818	849	862	897	912	945	961	988	1011	1044	1061

The annual reduction varies from 818 Gg in 2010 to 1,061 Gg in the end of the period. The total sum of CO<sub>2</sub> emissions reduction for the whole period under the mitigation scenario is estimated to be about 1,034,800 Gg or about 50 % of base year CO<sub>2</sub> emissions. Cost of CO<sub>2</sub> emissions abatement is estimated to be 8 to 15 USD per tonne of reduced CO<sub>2</sub>.

#### ***Summary of economic analyses***

Under the business plan cash flow projections, the company required 17 years to repay loans, accumulated \$16.9 million in cash for debt repayment and equity disbursement, and earned 3.4 % rate of return. Thus, the initial analysis did not show a favorable rate of return on investment. Nevertheless, if financial assistance for a portion of the project cost is obtained from an international donor organization e.g. the Global Environment Fund (GEF), the remaining costs may be financable through international lending institutions.

This will require a proposal to submit to the GEF grant application for US\$2 million dollars. In this case the debt is repaid in 13 years and a total **of \$23.6 million** is accumulated. The project shows a 9.8 % leveraged internal rate of return assuming a 20 % discount rate.

## **2.2 ADAPTATION IN AGRICULTURE (WHEAT PRODUCTION)\***

Agriculture is a very important part of Kazakhstan's economy and should climate change threaten long-term production, there could be significant economic harm to the country.

---

<sup>1</sup>This section is the result of a collaboration between Kazakh (Svetlana V. Mizina, Erwin Gossen) and American (Joel B. Smith, Karl F. Spiecker, Stephen L. Witkowski) researchers. This work was funded under contract PCE-5743-C-00-207300 between the U.S. Agency for International Development and Hagler Bailly Services, Inc. (Mizina, et.al., 1999).

Agriculture in Kazakhstan may be highly vulnerable to climate change. Agriculture produces 40% of net material product and employs 25% of the labor force. The major crops are wheat, barley, and forage crops. Grain and cotton are the most important crops for export. Most of the 35 million hectares of land devoted to agriculture are rainfed, and only about 2 million hectares, or 6%, are irrigated.

About one-half of the total land area of the country is desert or semi-desert, and the climate is strongly continental. This makes agricultural production in Kazakhstan sensitive to climate variations and change. In addition, poor management of agricultural lands has increased the susceptibility of Kazakh agriculture to climate change. During the infamous “virgin lands” campaign of the 1950s, 25 million acres of steppe were put under the plough. This resulted in humus losses of 5 to 30%, soil erosion, and degradation of soil quality. Further, overexploitation of grasslands for livestock production has resulted in decreased quality of vegetation in three-fifths of pasture lands. Extensive use of fertilizers and pesticides has also degraded soils.

The transition from collectivized agriculture to a free market based system has been difficult. With few monetary resources and institutions such as extension programs available to help farmers, and with virtually no experience with the free market, agricultural production has fallen considerably. Agricultural production fell 23% just between 1993 and 1994.<sup>2</sup> Production from grains to livestock fell. The production of grain, the most important export crop, fell by 23% in 1994, while production of fruits, sugar beets, rice and maize fell even more (Kazakh Academy..., 1994).

The increased concentration of greenhouse gases in the atmosphere may already be changing climate, and it is predicted to result in an increase in average global temperatures of 1 to 3.5 C by 2100 (Houghton et al., 1996). This change in climate could have a dramatic effect on natural resources around the world. Agricultural production patterns are predicted to change, with some areas facing a possible decline in yields. Flood frequency could increase in many areas, and droughts could also increase. Climate zones for natural ecosystems could shift hundreds of kilometers, possibly disrupting many ecosystems, and the potential range of many diseases could shift significantly (Watson et al., 1996).

Mizina et al. (1997a) found that under various scenarios of climate change that could happen over the next century, spring wheat yields in Kazakhstan could change dramatically (see Table 11). In the 2×CO<sub>2</sub> scenarios (Geophysical Fluid Dynamics Laboratory and Canadian Climate Centre), yields were estimated to decline by up to 70%. In contrast, the GFDL transient model results estimate increases in yields.

Are there steps that could be taken now to reduce the potential negative effects of climate change and take advantage of the positive effects on Kazakh agriculture? Do these steps make sense even if climate does not change? In the transition from a socialist economy to a market economy, many decisions are being made on the future of Kazakh agriculture.

---

<sup>2</sup> The entire economy declined 35% between 1992 and 1994.

These decisions may have a long life time and will affect the ability of Kazakh agriculture to cope with climate change.

**TABLE 11. AGGREGATION OF CERES-WHEAT VULNERABILITY RESULTS FOR SPRING WHEAT**

(Change from baseline is shown as a percentage)

Oblast	Site	Soil Group	Percent of Total Wheat Production	Change in Wheat Yield (%) under Climate Change Scenario		
				GFDL	CCCM	GFDL-T
Northern Kazakhstan	Bulaevo	Typical chernozem	4.10	-24.2	-43.8	+81.1
	Petropavlovsk	Typical chernozem	4.10	-24.5	-36.3	+109.4
Kostanai	Komsomolets	Typical chernozem	7.00	-16.4	-28.2	+75.0
	Kostanai	Southern chernozem	9.00	-73.2	-41.6	+34.1
	Karasu	Southern chernozem	9.00	-39.2	-50.4	+36.7
Kokshetau	Krasnoarmeisk	Typical chernozem	4.00	-19.7	-45.3	+74.6
	Ruzaevka	Typical chernozem	5.00	-48.4	-26.5	+50.1
	Kokshetau	Southern chernozem	4.90	-33.7	-38.6	+8.4
Akmola	Akmola	Dark chestnut	6.25	-32.3	-29.4	+16.7
	Atbasar	Dark chestnut	6.25	-27.7	-16.7	+31.1
Pavlodar	Mihailovka	Southern chernozem	1.00	-16.3	-29.7	+30.8
	Fedorovskaya	Dark chestnut	1.00	-25.2	-44.9	+5.8
	Pavlodar	Dark chestnut	1.60	0.1	-13.7	+12.1
Western Kazakhstan	Uralsk	Dark chestnut	7.50	-62.6	-44.1	+32.6
Aggregation				-27.1	-27.1	+31.5

Source: Mizina et al., 1997a

---

---

The evaluation began with the selection of climate change scenarios. We then identified adaptation options to evaluate. After these were screened for those most likely to be effective, we evaluated the cost-effectiveness of four options. These options were also evaluated for their ease of implementation.

### 2.2.1 Scenarios

In selecting scenarios for analysis of adaptation policies, it is critical to reflect a wide range of potential climate changes for a region. Using a limited range of scenarios such as only wet or only dry to analyze policy risks selecting policies that may work only under a narrow range of climate conditions. Using a wide range of scenarios helps in selecting measures that perform well under a wide range of conditions.

Based on the assessment of vulnerability, three scenarios of climate change in Kazakhstan were selected (Dolgikh et al., 1997; see also Pilifisova et al., 1997). The scenarios are:

- Geophysical Fluid Dynamics Laboratory (GFDL; Mitchell et al., 1990). Average monthly changes between doubled CO<sub>2</sub> and single CO<sub>2</sub> temperature and precipitation were used. This model estimates that average annual temperature over Kazakhstan will increase by 4.9°C and precipitation will increase by 24%. This results in significant drying of soils because the increased evapotranspiration from the higher temperatures outweighs the increased precipitation. For example, the wheat cultivating area could be decreased by more than 10%.<sup>3</sup>
- + 3°C and +20% precipitation. In this incremental scenario, in which the temperature and precipitation changes are the same in each month, soil moisture increases. It can be considered a “wet” scenario.
- + 3°C and no change in precipitation. This incremental scenario decreases soil moisture, but more than GFDL. The area suitable for wheat cultivation would be reduced by more than 50%. The three scenarios chosen were combined with 30 years of observed climate data from 1951-1980 to yield 30 year scenarios of changed climate (Pilifisova et al., 1996).

### Identification of Adaptation Options

Since the regional nature of climate change is uncertain and significant climate change impacts most likely will not happen for decades, adaptations that are put in effect in anticipation of climate change should be flexible and economic. Flexible means that the adaptation measures perform well (i.e., substantially meet policy objectives) under a wide range of potential climate changes (e.g., wet and dry), including no climate change. Economic means that the present value of benefits is greater than costs. This can mean that adaptation options either can have significant costs when there are significant benefits under current climate or can have only minimal costs when benefits are not realized for decades (Smith, 1997).

---

<sup>3</sup>We used the P:PET ratios to demonstrate whether the scenarios lead to drier or wetter conditions. Wheat cultivation is possible where P:PET $\geq$  0.7.

---

---

The following adaptation options for agriculture in Kazakhstan were identified (see Mizina et al., 1997b for more details):

- 1) Provide information to farmers about potential climate change impacts and adaptation measures
- 2) Develop long-range weather forecasts to be used in making decisions on snow reserving,<sup>4</sup> choice of planting date, etc.
- 3) Develop forecasts on agricultural pest and disease outbreaks
- 4) Develop regional centers to provide information to farmers about coping with climate variability and climate change
- 5) Offer regular local workshops for training on different techniques for growing wheat
- 6) Develop regional centers to store genetic varieties for wheat that may be needed to continue growing wheat under climate change
- 7) Make seed banks sustainable; i.e., have wide varieties available, particularly if re-sowing is necessary.
- 8) Develop long-term wheat reserves (stocks) to be used to meet dietary needs in poor crop production years.
- 9) Cultivate wheat only on the most fertile lands
- 10) Provide farmers with mid- and long-term loans to aid them in the transition to a free market economy
- 11) Improve the transition to a market economy by strengthening and clarifying laws relating to the free market and agriculture and improving institutions that oversee free market activities
- 12) Change land management to reduce soil erosion.

The last option involves two components. The first aims at changing management and land use patterns so as to reduce and minimize soil loss from wind and water erosion. This is accomplished by cultivating the land along natural contours, planting buffer strips of herbaceous and woody plants, and maintaining a constant crop cover. The second is aimed at identifying soil-protecting crop rotations and effective buffer strip intervals for different types of soils and erosion potential. These highly erodible lands would then be planted with long-term grasses for hay and pasture.

With the exception of the first adaptation option, all of these can be argued to have significant benefits if climate does not change. The potential adaptation measures for Kazakh agriculture can be considered to be “no regrets” measures. That is, these measures will pay off even if climate does not change (or does not change as predicted).

---

<sup>4</sup>Snow reserving is the use of windbreaks such as vegetation planted to accumulate snow on fields.

## Screening of Options

Our objective was to examine the relative cost-effectiveness of the adaptation measures. Examining 12 measures in detail would be a very trying task. We used a simple approach to screen the measures. For each option, we indicated whether: (1) the adaptation options need to be implemented in advance of climate change to be effective because they address irreversible or catastrophic effects, involve construction of long lived infrastructure, or offset trends that may make it harder to adapt to climate change in the future (Smith, 1997); (2) a decision is being made now that could incorporate climate change (target of opportunity); (3) the adaptation option has benefits even if climate does not change (other benefits); (4) the option has low costs; and (5) there are low barriers to implement the option.

Table 12 displays the results of this evaluation. One could sample different researchers, policy makers, stakeholders or others to assess the robustness of these answers. The following options received four “yeses:”

- develop forecasts on agricultural pest and disease outbreaks
- develop regional centers on genetic varieties for wheat
- improve rules and laws for transition to market economy
- reduce soil erosion.

**TABLE 12. SCREENING MATRIX FOR AGRICULTURE OPTIONS**

Adaptation	Must Implement in Advance	Target of Opportunity	Other Benefits	Low Costs	Low Barriers
1. Inform farmers about climate change	No	No	Yes	Yes	Yes
2. Develop forecasts on snow reserving	No	No	Yes	Yes	Yes
3. <i>Develop forecasts on pests and diseases</i>	Yes	No	Yes	Yes	Yes
4. Develop regional consultation centers	No	No	Yes	Yes	Yes
5. Provide permanent local workshops for training on wheat growing	No	No	Yes	Yes	Yes
6. <i>Develop regional centers on genetic varieties for wheat</i>	Yes	Yes	Yes	No	Yes
7. Make seed banks sustainable	Yes	No	Yes	No	Yes
8. Develop long- term wheat reserves	Yes	No	Yes	No	Yes
9. Cultivate wheat on most fertile lands	Yes	No	No	Yes	No
10. Provide farmers with mid- and long-term loans	Yes	No	Yes	No	No
11. <i>Improve rules and laws for transition to market economy</i>	No	Yes	Yes	Yes	Yes
12. <i>Reduce soil erosion</i>	Yes	No	Yes	Yes	Yes

The rest of the analysis involved a more detailed examination of the cost-effectiveness and

barriers to implementation for these options.

### **Analysis of Cost-Effectiveness**

The analysis of cost-effectiveness used the Adaptation Decision Matrix (ADM) described in Benioff and Warren (1996) and Smith et al. (1996b). The matrix involves subjective measures of weights of policy objectives and scores of how well each adaptation option performs in meeting each objective under different scenarios. We used scores between 0 and 5 (although any range is acceptable). The matrix multiplies the scores by the weights to estimate “benefits.” The scores are treated as if they are a cardinal scale, although it is not clear if individuals filling out the matrix consider a score of 4 to implicitly have twice as much benefits as a score of 2. No attempt is made to equate scores with monetary benefits. Total benefit scores are compared to costs by putting costs in the numerator of a fraction and scores in the denominator. The lower this result, the more cost-effective an option is (i.e., that option’s score can be raised one point for fewer dollars).

The scoring is purely subjective and was not based on modeling or other quantitative analysis of the efficacy of adaptation options in fulfilling the policy objectives. It is entirely possible that different researchers, policy makers, or others could have given different scores.

### **Identifying Policy Objectives and Weights**

The first task in using the ADM is identifying policy objectives and giving them weights. The identification and weighting was done by the Kazakh researchers. The objectives and weights they selected presented in Table 13.

The selection of policy objectives is subjective because usually specific objectives are not clearly stated. The selection of weights is very subjective because numeric weights are usually not given to policy objectives and the assignment of weights will most likely vary among decision makers and others. We did not present these objectives or weights to government officials or stakeholders (such as farmers organizations) to determine whether there is agreement or disagreement about them. Use of different objectives and weights could well have resulted in a different ranking of options.

**TABLE 13. WEIGHTS FOR OBJECTIVES**

<b>Objective</b>	<b>Weight</b>
Maintain Food Security	5
Maximize Agricultural Production	3
Maximize Exports	2
Sustainable Agriculture	5
Protect the Environment	2
Prevent Desertification	3
Maintain Genetic Diversity	1
Maximize Employment	4

---

---

## Scoring and Results

Each adaptation option was then given a score based on how well it met each policy objective under each scenario and current climate.

Table 14 displays the scores and results. The column “Score” is the scores for each policy objective multiplied by the respective weight, summed for a single scenario. The score has no meaning on its own (e.g., it is not a measure of monetary value), but a higher score indicates higher benefits. The column “Total Score” is the sum of scores for each scenario. By simply adding up scores, we imply that each scenario has the same probability. By including current climate as one of the “scenarios,” we weight the benefits of current climate the same as each scenario. We could have assigned probabilities to each scenario based on perceptions about climate change. Since regional climate change is so uncertain, we saw no point in assigning probabilities.

All of the adaptation options were given higher total scores than current policy.<sup>5</sup> Thus each one could be considered to produce more benefits under current climate than the current policy. The highest scores were given to the option of reducing soil erosion so it had the most benefits, followed by free market reforms, pest forecasts, and then regional centers.

We then compared the benefit scores with costs to determine cost-effectiveness. Costs for the adaptation options were developed by the Kazakh team after consultations with specialists on related issues. The cost estimates are displayed in the cost column. They vary from \$20 million for opening and maintaining regional centers to over \$565 million for soil erosion. Cost estimates for pest control and seed banks are based on costs in the United States and converted to costs in Kazakhstan using purchasing power parity adjustments and sizing of effort appropriate for Kazakhstan (Spiecker, 1997). Costs for converting to a free market are based on a World Bank loan (R. Southworth, World Bank, personal communication). Costs for soil erosion control were based on actual costs of \$100,000 for a 3,000 hectare test site. We assumed these costs would be applied to the entire wheat sowing area of 16 to 18 million hectares.

---

<sup>5</sup>Any policy option with benefits lower than current policy would be dismissed because it makes society worse off than no change in policy. Given that changes in policy are costly, either in terms of capital costs or psychic costs, one can argue that there is no point in considering an alternative policy that does not increase benefits.

TABLE 14. ADAPTATION DECISION MATRIX

Measures	Scenario:	Objective #1: Food Security	Objective #2: Exports	Objective #3: Maximize Production	Objective #4: Sustainable Agricult.	Objective #5: Protect Env.	Objective #6: Prevent Desertification	Objective #7: Genetic Diversity	Objective #8: Employment		Total Score	Annual Cost of Measure (\$M)	Cost Effectiveness (cost/incremental unit of benefit) \$M
		5	2	3	5	2	3	1	4	Score			
<b>Current Policy</b>	Current	4,00	0,70	1,00	2,00	4,00	4,00	4,50	4	74,9	224,3		0
	GFDL	1,00	0,50	0,50	1,00	2,00	3,00	3,00	1	32,5			
	+3; 0%	1,5	0,7	0,5	1,5	3	3	3	2	43,9			
	+3; +20%	3,5	1	1	2,5	4	4	4	3,5	73			
<b>Pest Forecast</b>	Current	5	2	3	3	4,5	4,5	4,5	4	96	282,6	322,8	5,536878216
	GFDL	2	1,5	0,7	1,5	2	3,3	3	1,1	43,9			
	+3; 0%	2,5	1,5	0,7	2	3	3,3	3	2,1	54,9			
	+3; +20%	4,5	2	1,5	3,5	4	4,3	4	3,6	87,8			
<b>Regional Centers</b>	Current	5	1,5	2	2,5	4	4	5	4	87,5	244,5	19,6	0,97029703
	GFDL	1,00	1,00	0,50	1,00	2,00	3,00	5	1	35,5			
	+3; 0%	1,5	1	0,5	1,5	3	3	5	2	46,5			
	+3; +20%	3,5	1,5	1	2,5	4	4	5	3,5	75			
<b>Rules for Free Market</b>	Current	5	3	3,5	3	4	4	4,5	4	97	300,7	50	0,654450262
	GFDL	1,3	1,1	0,8	2,5	2,5	3,5	3	1,3	47,3			
	+3; 0%	2	1,1	1	3	3,5	3,5	3	2,3	59,9			
	+3; +20%	4,5	1,7	2	4,5	4,5	4,5	4	3,9	96,5			
<b>Reduce Soil Erosion</b>	Current	5	3	5	5	5	5	4,5	4	116,5	349,5	565	4,512779553
	GFDL	2,5	1,5	1,5	3	4	3,5	3	1,2	61,3			
	+3; 0%	3,2	1,5	1,5	3,5	4,5	3,7	3	2,2	72,9			
	+3; +20%	4,3	2	2,2	4,5	5	5	4	3,8	98,8			

The cost-effectiveness scores are in the right-hand column of Table 14. This column displays the cost of raising the benefits one unit above the benefits already received from current policy. The lower the cost-effectiveness, the more desirable the policy option is because society wishes to invest the fewest resources to raise the benefits score one unit. The free market adaptation option received the lowest score, making it the most cost-effective option in this analysis.<sup>6</sup> Regional centers come out less cost-effective, while in contrast to the ranking of options by benefit score, the soil erosion reduction option is next to last in ranking of cost-effectiveness. Pest forecasts are the least cost-effective with a score of \$5.5 million.

Using a set of decision making tools, supporting free market reform option was identified as the most cost-effective option for adapting to climate change. The free market option has many barriers to implementation. Since establishing regional centers is close in cost-effectiveness and more feasible, it can be the most attractive adaptation options. Reducing soil erosion option is third in cost-effectiveness and it has many barriers to implementation. Developing pest forecasts ranks last in cost-effectiveness, but has few barriers to implementation. These latter two options appear to be less attractive.

The application of the adaptation decision matrix appears to be a useful tool for obtaining a preliminary ranking of cost-effectiveness of different options. However, the subjective nature of the scoring of benefits necessitates further analysis to quantify, and if feasible, monetize benefits to provide more rigorous information to policymakers before significant resources are committed to implementation of policies. This implies that more analysis should be done, perhaps of the policies that received the highest cost-effectiveness scores. Models could be used to estimate benefits or a more transparent and detailed process can be used to develop scores.

### **2.3 WATER RESOURCES ADAPTATION**

For Kazakhstan as a whole, the proposed strategy of water resources sector adaptation comprises implementation of measures that can be divided into six groups:

- measures to support development of modern technologies for the sectors of economy, which use water resources;
- water-saving measures;
- measures to mitigate the negative impacts of water resources vulnerability to sectors of economy;
- nature conservation measures;
- social losses reduction measures;
- measures to expedite the decision-making process.

Full practical implementation of adaptation measures will require significant investments and long time period. Priority of measures that allow increasing the water resources available for

---

<sup>6</sup>The costs of raising the benefits score one unit are meaningless on their own since no value is ascribed to the benefits score. The costs only have meaning in comparison to other costs of raising benefit scores.

economic activity on the territory of north and east Kazakhstan was assessed for the basins of Irtysh, Ishim and Tobol rivers. Main indicators of the chosen adaptation measures are given in Table 15.

**TABLE 15 MEASURES TO INCREASE THE AVAILABLE WATER RESOURCES IN THE BASINS OF IRTYSH, ISHIM, AND TOBOL RIVERS**

Measure	Priority	Additional Amount of Water, million m <sup>3</sup>	Estimated Investments, million USD
<b>Irtysh River Basin</b>			
Runoff regulation	1	3,610	182
Water saving	2	1,699	3,470
Runoff diversion	3	250	1,071
Increasing use of underground water	4	402	3,304
Total		5,961	8,027
<b>Ishim River Basin</b>			
Runoff regulation	1	135	90
Water saving	2	132	107
Runoff diversion	3	105	126
Increasing use of underground water	4	43	309
Total		415	632
<b>Tobol River Basin</b>			
Water saving	1	301	574
Increasing use of underground water	2	55	635
Total		356	1,209

In setting up the priorities, preference was given, first of all, to the measures able to provide more water, to need less expenditures and not to require runoff diversion from the outside. On the basis of this estimate, adaptation measures for the Irtysh and Ishim river basins are ranged as follows: runoff regulation, a complex of water-saving measures, runoff shift, increasing underground water takeoff. For the Tobol river basin, from the two aggregated measures considered — water saving and underground water takeoff, — the priority is given to water saving.

---



---

## REFERENCES

1. Benioff, R. and J. Warren. 1996. Steps in Preparing Climate Change Action Plans: A Handbook. Washington, DC: U.S. Country Studies Program.
2. Dolgikh, S.A., I.B. Yesserkepova and Shamen A. 1997. Evaluation of global warming impact on desertification process in Kazakhstan. Hydrometeorology and Ecology, vol. 3. Almaty, Kazakhstan.
3. Houghton, J.T., L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell. (eds.). 1996. Climate Change 1995: The Science of Climate Change, contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, England: Cambridge University Press.
4. Initial National Communication of the Republic of Kazakhstan under the United Nations Framework Convention on Climate Change, 1998. Almaty, Kazakhstan, pp. 74.
5. Kazakh Academy of Agricultural Sciences, 1994: Conceptual Program of the Republic of Kazakhstan Agricultural and Industrial Complex Development for 1993-1995 till 2000. Kazakh Academy of Agricultural Sciences, Almaty, Kazakhstan, pp. 314, (in Russian).
6. KazNIIMOSK, 1995: Greenhouse Gases and the Regional Climate Change of the Republic of Kazakhstan. Final Report on the scientific research work, No 0196 PR 00737, Almaty, Kazakhstan, pp. 195, (in Russian).
7. KazNIIMOSK, 1996: Assessment of the greenhouse gases emission reduction options. Final Report on the scientific research work, No 0196 PR 00737. Kazakh Research Institute for Environment Monitoring and Climate, Almaty, Kazakhstan, pp. 96, (in Russian).
8. Mitchell, J.F.B., S. Manabe, T. Tokioka, and V. Meleshko. "Equilibrium Change." in Houghton, J.T., G.J. Jenkins, and J.J. Ephraums (eds.). 1990. *Climate Change: The IPCC Scientific Assessment*. New York: Cambridge University Press.
9. Mizina S.V., I.B. Eserkepova, and V.R. Sutyushev. 1997a. *Wheat Vulnerability Assessment under Possible Climate Change in Kazakhstan*. Hydrometeorology and Ecology. vol. 3. Almaty, Kazakhstan
10. Mizina S.V., J.B. Smith, and E.F. Gossen. 1997b. *Development of Wheat Management Strategy Taking into Account Possible Climate Change in Kazakhstan*. Hydrometeorology and Ecology. vol. 3. Almaty, Kazakhstan
11. Mizina, S.V., I.B. Eserkepova, O.V. Pilifosova, S.V. Dolgikh, and E.F. Gossen, 1996: Model-Based Climate Change Vulnerability and Adaptation Assessment for Wheat Yields in Kazakhstan. In: *Adapting to Climate Change. Assessment and Issues* [Smith, J.B., N. Bhatti, G.V. Menzhulin, R. Benioff, M. Campos, B. Jallow, F. Rijsberman, M.I. Budyko, R.K. Dixon (eds.)]. Springer-Verlag, New York, NY, pp. 148-163.
12. Monocrovich, E., D. Danchuk, O. Pilifosova, O. Semenov, T. Temertekov, Z. Korneeva, E. Gossen, A. Starsev, G. Papafanasopulo, and N. Inozemtseva, 1996a: Inventory of Kazakhstan Greenhouse Gas Emissions and Sinks: 1990. In:

- Greenhouse Gas Emission Inventories. Interim Results from the U.S. Country Studies Program [Braatz, B.V., B.P. Jallow, S. Molnar, D. Murdiyarsso, M. Perdomo, J.F. Fitzgerald (eds.)]. Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 289-297.
13. Monocrovich, E., O. Pilifosova, E. Gossen and A. Startsev, 1995: GHG Emissions from Agriculture, Land Use Change and Forestry in Kazakhstan. *Idojaras*, 99, pp. 345-352.
  14. Monokrovich, E.I., O.V. Pilifosova, D.Y. Danchuk, and G.A. Papafanasopulo, 1996b: Estimating the Potential of Greenhouse Gas Mitigation in Kazakhstan. Special Issue: Methods for Assessing Greenhouse Gas Mitigation for Countries with Economies in Transition. *Environmental Management*, 20, Supplement 1, pp. S57-S64.
  15. Pilifosova, O., et al. 1996. "Vulnerability and Adaptation Assessments for Kazakhstan." In: Smith, J.B., S. Huq, S. Lenhart, L.J. Mata, I. Nemesova, and S. Toure. 1996. *Vulnerability and Adaptation to Climate Change: Interim Results from the U.S. Country Studies Program*. Boston: Kluwer Academic Publishers.
  16. Pilifosova, O.V., I.B. Eserkepova, and S.A. Dolgih. 1997. "Regional Climate Change Scenarios Under Global Warming in Kazakhstan." *Climatic Change*. 36:23-40.
  17. Pilifosova, O., D. Danchuk, T. Temertekov, S. Izdebsky, T. Mandaria, 1997: Mitigation Technologies and Measures in Energy Sector of Kazakhstan. *Applied Energy*, 56, pp. 341-350.
  18. Pilifosova, O., D. Danchuk, T. Temertekov, S. Mizina, I. Eserkepova, 1997: Mitigation Assessment for Kazakhstan. In: *Global Climate Change Mitigation Assessment: Results for 14 Transitioning and Developing Countries* [Meyers, S., B. Golberg, J. Sathaye, K. Simeonova (eds.)]. Dordrecht/Boston/London, Kluwer Academic Publishers, pp. 97-108
  19. Pilifosova, O., I. Eserkepova, S. Dolgih, 1997: Regional Climate Change Scenarios under Global Warming in Kazakhstan. *Climatic Change*, 36, pp. 23-40.
  20. Pilifosova, O., I. Eserkepova, S. Mizina, P. Kozhametov, G. Chichasov, L. Lebed, S. Dolgikh, V. Golutsov, I. Skotselyas, V. Lee, K. Berentaev, N. Fedorova, E. Gossen, 1996: Vulnerability and Adaptation Assessment for Kazakhstan. In: *Vulnerability and Adaptation to Climate Change. Interim Results from the U.S. Country Studies Program* [Smith, J. B., S. Hug, S. Lenhart, L. S. Mata, I. Nevesova and S. Toure (eds.)]. Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 161-181.
  21. Pilifosova, O., S. Mizina, I. Eserkepova, G. Chichasov, A. Shamen, 1997: Kazakhstan. In: *National Climate Change Action Plans: Interim Report for Developing and Transition Countries* [Benioff, R., E. Ness, J. Hirst (eds.)]. *Enviro-Management & Research, Inc.*, Arlington, Virginia, pp. 94-109.
  22. Smith, J.B. 1997. "Setting Priorities for Adapting to Climate Change," *Global Environmental Change*. 7:251-264.
  23. Smith, J.B., S. Huq, S. Lenhart, L.J. Mata, I. Nemesova, and S. Toure. 1996a. *Vulnerability and Adaptation to Climate Change: Interim Results from the U.S. Country Studies Program*. Boston: Kluwer Academic Publishers.

24. Spiecker, K. 1997. "Kazakhstan Agricultural Cost Estimates." Internal Memorandum. Boulder, CO: Hagler Bailly Services, Inc. September 15.
25. Statcommittee of the RK, 1997: National Counting of the Republic of Kazakhstan (Statistical Collection) 1990-1996. Statistical and Analysis Committee, Almaty, Kazakhstan, pp. 86, (in Russian).

---



---

**APPENDIX. LIST OF THE CCNAP PROJECTS IN KAZAKHSTAN**

	<b>Project Title</b>	<b>Responsible Organizations</b>	<b>Project Duration</b>	<b>Alleged Cost</b>
1.	Development of solar energy engineering in order to mitigate air pollution produced by energy enterprises in the Republic of Kazakhstan	MENR, MEIT, Akimats	3 years	6.0 million USD
2.	Reduction in energy consumption in the municipal sector for mitigation of anthropogenic impacts of energy sources on the environment	MENR, MEIT, Akimats	3 years	5.0 million USD
3.	Introduction into RK energy balance of hydroelectric power resources of small rivers and construction of a pilot microhydroelectric power station to reduce air pollution with traditional energy sources	MA, MENR, Akimats	3 years	10.0 million USD
4.	Introduction of wind rotor electric power stations of small capacity for individual consumers	MENR, MEIT, MA, Akimats	3 years	10.0 million USD
5.	Introduction of wind rotor electric power stations to generate power for group consumers and for the distribution network as illustrated by wind power resources assimilation in Jungar gate	MENR, MEIT, Akimats		20.0 million USD
6.	Mitigation of the negative impact of road transport in Almaty on environment and population health	MENR, Akimats, enterprises	3 years	16.6 million USD
7.	Involvement in the energy balance of the Republic of Kazakhstan from thermal water energy for reduction in demand for use of ecologically hazardous sources of heat and electric power	MENR, MA, Akimats	3 years	1.8 million USD
8.	Rehabilitation of the water protection zone of the Syrdarja River	MA, MENR	3 years	1.2 million USD
9.	Improving the management of the Balkhash and Alackol river basin water resources	MA, MENR	3 years	7.0 million USD
10.	directed to saving ecosystem balance of transboundary waters	MA, MENR, AEP, MFA	3 years	3.0 million USD
11.	Reduction of water consumption and fresh water losses in municipal sectors (demonstration project on the example of Almaty)	MENR, Akimats	3 years	20.0 million USD
12.	Development and realization of the	MA, MENR,	3 years	14.06

	measures for improving arable land fertility (pilot projects in South-Kazakhstan, Kyzylorda, North-Kazakhstan and Akmola oblasts)	Akimats		million USD
13.	Inventoring arable lands and taking ecologically violated and low productive lands out of tillage	MA, MENR, Akimats	3 years	1.37 million USD
14.	Expansion of forest areas for restoration and saving biodiversity and biocenoses	MA, MENR, Akimats	3 years	14.06 million USD
15.	Improving system of rational using of pastures and creation of sowed grasslands for prevention of the process of desertification in Kyzylorda, South-Kazakhstan and Almaty oblasts	MA, MENR, Akimats	3 years	7.35 million USD
16.	Rehabilitation of Almaty cogeneration power plant (CPP-2) 330 Gg/year	KazNIPIEnergoprom Institute		TBD
17.	Rehabilitation of the Balkhash cogeneration power plant 390 Gg/year	KazNIPIEnergoprom Institute		TBD
18.	Small hydro power plants in Bartogai and Almaty channels 100 thd tonne/ year	KazNIPIEnergoprom Institute		TBD
19.	Energy Saving Measures at North East Boiler House 6,025-8,434 tonnes of CO <sub>2</sub> per year.	KazNIPIEnergoprom Institute		TBD
20.	Developing use of alternative sources of energy for heating purposes 13 Gg/1 MW of electric power per year.	KazNIPIEnergoprom Institute		TBD
21.	Utilization of associated gas of Prorva oil field 50 Gg/year.	KazNIPIEnergoprom Institute		TBD
22.	Replacing coal to gas on power plant in Uralsk 270 Gg/year	KazNIPIEnergoprom Institute		TBD
23.	Rehabilitation of Zheskazgan cogeneration power plant 490 Gg/year	KazNIPIEnergoprom Institute		TBD
24.	Landfill gas utilization	Almaty Akimat		TBD