REPUBLIC OF KAZAKHSTAN

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION

Supported by:

FOREWORD

The global climate change is one of the most important environmental issues facing the world today. Kazakhstan attaches great importance to climate change for implementation of the policy of national environmental security and sustainable development.

In May 2013 the President of Kazakhstan has approved the Concept for the Transition to a "Green Economy" which laid the foundation for systemic changes to be done. Measures for the transition towards the "green economy" will be implemented in such areas as: sustainable use of water resources; development of sustainable and highly productive agriculture; energy saving and energy efficiency; development of power industry; waste management system, reducing air pollution; and ecosystems protection and effective management.

Identification and prioritization of technologies to reduce greenhouse gas emissions and adapting to climate change, based on international methodologies, is an important step for Kazakhstan to develop low-carbon strategies sustainable for climate change. Assessment of technology options and resources, institutional mechanisms, interactions with stakeholders, and defining criteria for selecting priority sectors and technologies, are the key actions towards the implementation of climate -friendly technologies.

The Ministry of Environment and Water Resources believes that the Technology Needs Assessment on mitigation and adaptation to climate change is aimed at forming sustainability of the economy and at developing measures to be adopted and implemented.

We consider that the report on Technology Needs Assessment will assist Kazakhstan in fulfilling its commitments under the UNFCCC and that the process of technology needs assessment is an important contribution to the implementation of country's strategies for sustainable development and to development of a "green economy".

Vice-Minister

Talgat Akhsambiyev

ABBREVIATIONS

AIT	Asian Institute of Technology
CNG	Compressed Natural Gas
CH_4	Methane
CO_2	Carbon dioxide
COP	Conference of the Parties under the United Nations Framework onvention on Climate Change
DNA	Designated National Authority
GEF	Global Environmental Facility
GHG	Green house gases
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, Land use change and Forestry
MCDA	Multi Criteria Decision Assessment
N_2O	Nitrous oxide
PMU	Project Management Unit
REDD	Reducing Emissions from Deforestation and Forest Degradation
RES	Renewable energy sources
TAP	Technology Action Plan
TNA	Technology Needs Assessment
TPP	Thermal Power Plant
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
URC	UNEP Risoe Center

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

TECHNOLOGY NEEDS ASSESSMENT REPORT-MITIGATION

EXECUTIVE SUMMARY

The current process of Technology Needs Assessment (TNA) is a continuation of completed and current research on climate change in Kazakhstan, including the First and Second National Communications, National Human Development Report (on Climate Change), Principles of Kazakhstan's National Climate Change Adaptation Concept (draft) and the Concept of low-carbon development in Kazakhstan. In accordance with the general approach, the technology needs assessment process was developed in two directions - adaptation and mitigation.

This Technology Needs Assessment (TNA) focused on identifying and assessing the mitigation effects of climate change technology on the energy management sector by using the Multi-Criteria Approach (MCA). The results of technology prioritization were then selected and reviewed with stakeholder consultation to ensure that all considered technology options contribute to the country's low carbon development objectives.

The selection of sectors for mitigation technologies was summarized by the team on mitigation, project coordinator in cooperation with representatives of the Ministry of Environment Protection, in close cooperation with representatives of various interested stakeholders. While selecting sectors the team took into account strategic priorities of the country and general criteria, such as economic impact, social impact, environmental impact, and GHG mitigation potencies. As a result, two priority sectors were identified. The assessment included industrial and energy sectors and such sub-sectors as power production and cement production.

The current status of technologies in the energy and industrial sectors were estimated based on existing information. For power production, 6 technologies were considered, and **Small Hydropower** and **Pulverized Coal Combustion with higher efficiency** were prioritized as technologies having best potential for development in the country for mitigation purposes. For cement production, 5 technologies were considered, and **Energy Efficiency and Saving** and **Change from wet to dry production technology** were prioritized.

CHAPTER 1. INTRODUCTION

1. 1 About the TNA project

In late 2010 the Government of Kazakhstan approved the UNEP Project "Technology Needs Assessment". The Project started in 2011 and is being implemented by the Ministry of Environment of the Republic of Kazakhstan and Climate Change Coordination Centre. The project partners are the UNEP Risø Centre (URC) and Asian Institute of Technology (AIT), Bangkok the Regional Centre for Asia and CIS countries. The Project is funded by the Global Environment Facility (GEF).

The Technology Needs Assessment Project, under which this work is carried out, funded by GEF and implemented in cooperation with UNEP and the UNEP Risoe Centre (URC).

The main goal of the TNA Project is to assist participant countries to identify and analyze priority technology needs, which may serve as a basis for a portfolio of projects and programs on mitigation and adaption to climate change and provide access to selected measures.

The specific goals of the Project include:

1. identify priorities and technologies on adaptation and mitigation, and promote the national goals of sustainable development;
2. identify barriers to the acquisition, deployment and diffusion of priority technologies;
3. develop action plans on technologies (TACs) to overcome barriers and facilitate the transfer, adoption and diffusion of certain technologies in the participating countries.

The current process of Technology Needs Assessment (TNA) is a continuation of completed and current research on climate change in Kazakhstan, including the First and Second National Communications, National Human Development Report (on Climate Change), Principles of Kazakhstan's National Climate Change Adaptation Concept (draft) and the Concept of low-carbon development in Kazakhstan. In accordance with the general approach, the technology needs assessment process was developed in two directions - adaptation and mitigation.

1.2 Existing national policies about climate change mitigation and development priorities

In order to cope with climate change, both mitigation and adaptation measures and technologies are needed. The UN defines mitigation, in the context of climate change, as human intervention to reduce the sources or to enhance the sinks of greenhouse gases.

Recognizing the problem of climate change, Kazakhstan ratified the UN Framework Convention on Climate Change in 1995. In accordance with Articles 4.1 (c), (j) and 12 of the Convention, under which countries periodically submit reports on actions to address climate change to the Conference of the Parties, Kazakhstan has prepared and presented the first National Communication at the Fourth Conference of the Parties. At the same conference the voluntary quantitative commitments to reduce greenhouse gas emissions were announced. The Kyoto Protocol to the UNFCCC was signed by Kazakhstan in 1999 and ratified in March 2009.

Kazakhstan's main strategic document is the Strategy of Kazakhstan until 2030, which sets out the long-term priorities. The "Kazakhstan - 2030" Strategy has seven long-term priorities: national security, political stability and consolidation of society, economic growth based on an open market economy with extensive foreign investment and domestic savings, health, education and welfare of the citizens of Kazakhstan, energy resources, infrastructure, in particular transport and communications, qualified state. These priorities set up a basis for developing specific action plans for the further development of the country. Climate issues in this document are reflected in the health and welfare of the citizens of Kazakhstan and energy resources.

The next, most important, strategic document is the Strategic Development Plan untill 2020. The integration of this document with climate change issues is through economic diversification. This concerns both the mitigation and adaptation. Here the issue on climate change prevention is considered in the context of Kazakhstan's contribution to the global reduction of greenhouse gas emissions, the future development of the energy sector, namely the construction of a nuclear power plant, the development of small hydropower, wind power and the increased use of solar energy. The plan contains an indicator - increasing the share of alternative energy sources in total energy consumption by 3% in 2020. As an intermediate objective, to increase the share of alternative energy sources to 1.5% by 2015.

One of the target indicators is to reduce energy intensity. By 2020 it is planned to reduce it by no less than 25% compared with 2008 level. The intermediate target until 2015, provides for the reduction of energy intensity by at least 10%.

At the legislative level, the most interesting ones are related to the new provisions of the Environmental Code, adopted on 3 December 2012 and the Act of 13 January 2012 "On energy saving and energy efficiency." The first document provides for the launch in 2013, of the national system of quotation and trade in greenhouse gas emissions, similar to the European emissions trading scheme. This system will cover the major installations in the energy, manufacturing and transportation of oil and gas, chemical industry, mining industry. The second act introduces a package of mandatory measures for energy conservation and energy efficiency for the application-level at state agencies, state organizations, large energy users, designers and constructors of buildings, structures and facilities, manufacturers and suppliers of energy-consuming devices. The provisions of both documents have already been followed by further sub-law acts and instructions, that define procedures and specify the conditions for their application in practice.

At present, the Ministry of Environment Protection develops a strategy to transfer to the "green" growth pattern, which is expected to be adopted in mid-2013. Executing "green", "climate-friendly" economy requires to reduce greenhouse gas emissions and mitigate the impact of climate change, which should be based on assessing technology needs and implementing new technologies. This process is a complex activity, which will identify and determine the technological priorities of the country to ensure the mitigation of climate change. However, the level of stabilization or reduction of GHG emissions will be achieved by using technologies that are either currently available or expected to be commercially available in the following decades. In addition, it requires the presence of appropriate and effective incentives for the development, acquisition, deployment and diffusion of technologies and elimination of barriers.

The purpose of this report is to identify and assess the technology needs in order to identify climate-friendly technologies in the context of national priorities aimed at decreasing the impact of climate change and reducing greenhouse gas emissions. Kazakhstan is on the low carbon development path, as the Party to the UNFCCC and the Kyoto Protocol. Implementation of the technology needs assessment project is aimed at supporting the country to provide a basis for a portfolio of projects and environmentally friendly programs that will facilitate the transfer of and access to environmentally sound technologies and know-how on the basis of Article 4.5 of the UNFCCC.

CHAPTER 2. INSTITUTIONAL ARRANGEMENT FOR THE TNA AND THE STAKEHOLDER' INVOLVEMENT

2.1 Overview

In accordance with the requirements of the UNFCCC, all Parties shall cooperate in development, application and diffusion of technology transfer, practices and processes that reduce or prevent greenhouse gas emissions. To meet this requirement an integrated approach, at national and sectoral level, including cooperation between various stakeholders (private sector, government, donors, research institutions, NGOs, etc.) is required.

2.2 Institutional arrangement of Kazakhstan TNA project

Institutional arrangement of the Project is as follows:

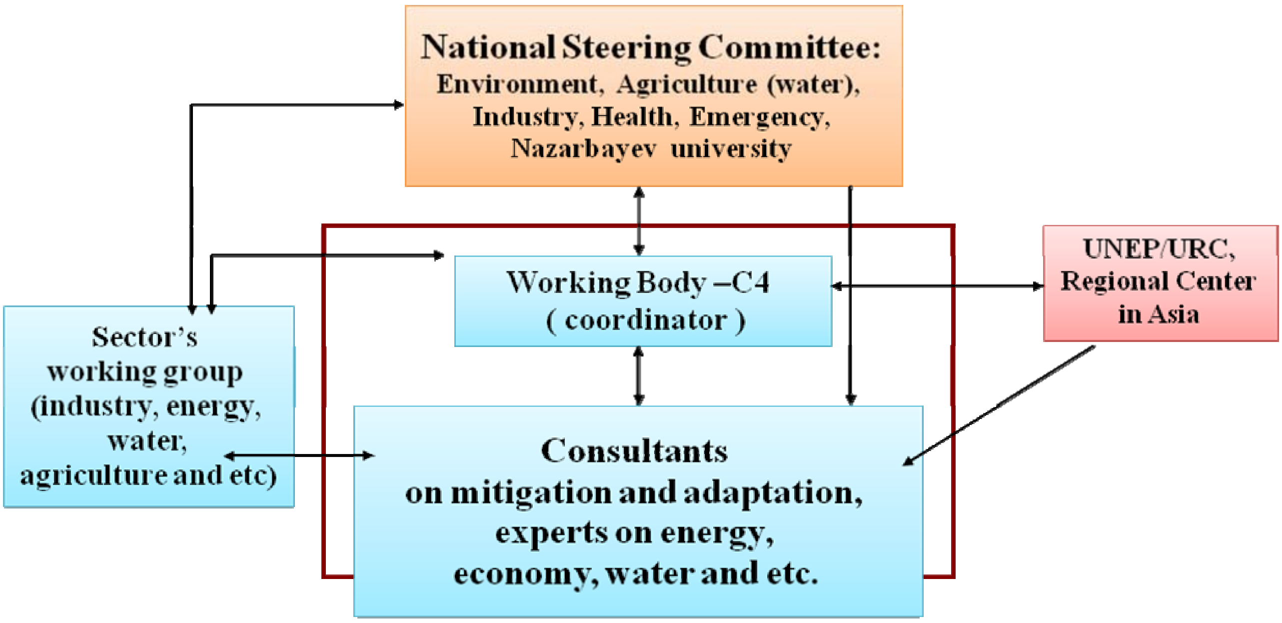


Figure 2.1 - Project Institutional Arrangement

National Supervising Agency: National Steering Committee.
National Executing Agency: Climate Change Coordination Centre (C4).

2.2.1. National Steering Committee

The TNA process was led by the National Steering Committee, which consists of representatives from the Ministries of Environment Protection, Agriculture, Industry and New Technologies, Health, Emergency Situations and Nazarbayev University. Practical implementation was performed by the Mitigation Consultant and his team under the guidance of the National Coordinator.

2.2.2. Project Management Unit

The Climate Change Coordination Centre, first Kazakhstani NGO that works in the field of the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol (KP) and Vienna Convention on Ozone Layer Protection, acted as the project management unit.

2.2.3 The cooperation of UNEP Risoe Center and AIT

Kazakhstan received the technical support from UNEP Risoe Center and AIT experts during the inception meetings with the Steering Committee members, through the two capacity building workshops, which trained country representatives the methodologies and processes on how to carry out the technology needs assessment through the close involvement of stakeholders.

Later in the process, an expert from the AIT was sent to Kazakhstan to support the national team in report preparation. CCCC met the AIT expert and discussed with him the main issues in preparing the TNA report such as the application of MCDA model, criteria for technology prioritization, etc.

After the draft of the report was completed, it was sent to the UNEP Risoe Center and AIT for comments.

2.3 Stakeholder Engagement Process followed in TNA

In order to attract a wide range of stakeholders to coordinate and support the implementation of the Project, the Project Steering Committee, headed by Vice-Minister of Environment Protection, was established. The Committee included representatives from the Ministries of: Healthcare, Industry and New technologies, Agriculture, Transport and Communications, Emergency situations; as well as Nazarbayev University (Center for Energy Researches). The full list of members of the Committee is given in Appendix 1.

An inception workshop under the Project was held on August 3, 2011 in Astana, where the following presentations were presented:

1. Project's goals and objectives;
2. Work Plan;
3. Policy documents: the basis for prioritization of sectors, subsectors of the economy, technologies;
4. Methodological approaches used to implement the Project.

The workshop was attended by 32 participants. Representatives of the Ministries of: Environment Protection, Industry and New Technologies, Agriculture, Transport and Communications, Emergency Situations, Healthcare, Foreign Affairs; as well as Agency for Statistics, Center for Energy Researches of Nazarbayev University, KAZENERGY Association, KazahCarbon, Kazakhstan Institute for Industry Development, Kazakhstan Business Association for Sustainable Development, Association for Water Supply and Wastewater Disposal "KazahstanSuArnasy", "Kazakh Scientific-Research Institute for Environment and Climate" RSE of the Ministry of Environment Protection and others. These institutions are closely engaged in developing low carbon or "green economy" strategy for Kazakhstan and introduction of new technologies are core for the stated goal.

The representatives of energy and industrial sectors were involved as consultants in order to write this report. Discussions of interim results were carried out in the working group on mitigation. The working group on mitigation included representatives from Climate Change Coordination Centre, Centre for Energy Researches of Nazarbayev University, NC "Samruk-Energo" and others.

The full list of Working Group is given in Appendix II.

CHAPTER 3. SECTORS AND SUBSECTORS SELECTION

3.1 An overview of sectors, projected climate change, and GHG emissions status and trends of the different sectors

Following the TNA handbook, as a first step in the sector prioritization process, sectors and subsectors with GHG relevance have been obtained from Second National Communication and other relevant reports.

According to the 2009 assessment, total GHG emissions in 2009 were 278.4 Mt CO_2-equivalent, including 245.9 Mt from energy, 14.3 Mt from industrial processes, 23.4 Mt from agriculture, and 6.2 Mt from waste.

In 2009, percentage contribution of each gas, with direct greenhouse effect, to the total national emissions was as follows: CO_2 - 82.8%, CH_4 – 17.3%, N_2O – 3.5%. The total contribution of HFCs, PFCs and SF_6 was less than 0.5%.

In 2009, total national GHG emissions without absorption amounted to 75.3% of 1990's level and increased by 6.1% vs. 2008 (Table 3.1).

Table 3.1 – GHG emissions, expressed as CO_2-equivalent, Mt

Gas	Years							
	1990	1995	2000	2004	2006	2007	2008	2009
CO_2	274.8	161.5	140.1	182.8	228.2	230.1	203.5	219.2
CH_4	75.7	46.2	35.4	39.8	43.1	44.4	48.6	48.2
N_2O	19.2	10.0	6.1	7.8	8.7	9.2	9.0	9.7
HFCs	-	0.0	0.2	0.2	0.4	0.4	0.4	0.4
PFCs	-	-	-	-	-	0.1	0.8	0.9
SF_6	-	-	-	0.0	0.0	0.0	0.0	0.0
Total	376.5	221.8	193.2	241.0	291.6	295.4	270.6	289.8
Source: National inventory report of anthropogenic emissions from sources and absorbtions by sinks of greenhouse gases not controlled by the Montreal Protocol for 1990-2009, Almaty, 2011								

As shown in Table 3.2, the greatest contribution to the total national GHG emissions in Kazakhstan is made by the Energy Sector. In 2009, the share of this category was about 92% of the total GHG emissions (excluding LULUCF). About 98.4% of emissions in 2009 in Energy Sector was from fossil fuel combustion and fugitive emissions - 1.6%. In 2009, total emissions from Energy sector was 17.7% less than the level in 1990 and increased by 9.7% vs. 2008.

The main sources of GHG emissions in this category are: production of heat and electricity 52.8%, manufacturing and construction 17%, transport 8%, other sectors and sources amounted to 21.1% of total emissions in this source category.

Table 3.2 Dynamics of GHG emissions by sectors in the Republic of Kazakhstan RK, Mt CO_2-equivalent

Sector		Years								
		1990	1995	2000	2002	2004	2006	2007	2008	2009
1	Energy (including, among others)	311.1	183.3	162.7	163.8	202.7	251.4	253.9	227.5	245.9
1.1	Power and heat	107.1	81.9	51.4	55.6	69.1	72.6	74.4	70.8	78.1

	production									
1.2	Oil extraction and processing	1.43	1.08	7.94	2.98	5.09	4.30	3.94	3.47	4.21
1.3	Hard fuel extraction and processing	4.99	2.08	2.88	3.87	5.76	10.28	6.36	6.43	5.06
2	Industrial processes (including, among others)	17.9	8.1	10.1	11.6	13.6	13.2	14.0	14.6	14.3
2.1	Cement Production	3.3	0.6	0.5	0.7	1.2	1.4	1.6	1.6	1.4
2.2	Chemical Industry	1.3	0.3	0.3	0.1	0.2	0.2	0.3	0.3	0.3
2.3	Metal Production	10.3	5.7	7.9	8.3	9.1	8.4	8.9	8.6	8.3
3	Agriculture	41.5	24.4	14.5	16.4	18.8	20.8	21.7	22.6	23.4
4	LULUCF (net absorbtion)	-6.9	-4.2	-11.6	-13.4	-10.4	-11.2	-11.2	-8.3	-11.3
5	Waste	6.0	6.1	5.9	5.8	5.9	6.2	5.8	6.0	6.2
6	Total (including net absorbtion in LULUCF)	369.6	217.6	181.7	184.2	230.7	280.4	284.2	262.3	278.4
7	Total (excluding net absorbtion in LULUCF)	362.7	213.4	170.1	170.8	220.3	269.1	273.1	254.0	267.1
Source: National inventory report of anthropogenic emissions from sources and absorbtions by sinks of greenhouse gases not controlled by the Montreal Protocol for 1990-2009, Almaty, 2011										

3.1.1. Energy

The country's territory occupies 1.8% of the Earth's land. There is concentrated about 0.5% of the world reserves of mineral fuel, which amounts to 30 Gtoe, including coal - 80%, oil and gas condensate - 13%, natural and associated gas - 7%.

Installed electric power capacity of plants of Kazakhstan is around 19 GW (thermal power plants - 87.5%, hydro - 12.4%), available capacity - 14 GW. As for January 1, 2010 40 energy producing organizations of various forms of ownership produce electric power in Kazakhstan, which include 63 power plants. Kazakhstan has a developed infrastructure of district heating. Installed electric power capacity of CHP is more than 6700 MW (38% of all power plants of the country). At the same time, they cover about 40% of heat consumption and about 46% of power consumption in Kazakhstan.

Energy sector of the country is focused mainly on the use of fossil fuels. Only about 12% of electric power is generated by hydropower plants and 87% - by thermal ones.

Power production sector is the largest source of greenhouse gas emissions in Kazakhstan, since coal is widely used to produce energy, which is characterized by high intensity emissions. Total emissions in this sector, including CHP, in 2010 amounted to 91 Mt of CO_2.

Table 3.4 Production of primary energy resources (Mtoe)

Year	**2006**	**2007**	**2008**	**2009**	**2010**
Oil, including gas condensate	80,21	82,83	87,21	94,38	98,33
Natural gas	23,28	26,26	29,9	33,14	34,99
Coal (including lignite)	59,18	60,29	68,5	62,03	67,85

Source: Fuel and energy balance for 2006 - 2010, Statistical Bulletin, Almaty, 2011, Agency for Statistics of the Republic of Kazakhstan.

Table 3.5 Electricity balance of the Republic of Kazakhstan (GWh)

Year	**2006**	**2007**	**2008**	**2009**	**2010**
Electric power generated	71 668,5	76 620,9	80 347,9	78 729,1	82 646,5
Import	4 880,4	3 268,7	2 768,0	1 709,6	2 913,6
Export	21 491,5	21 502,5	10 802,2	10 917,8	13 971,2
Consumption	48 268,2	51 016,8	65 193,3	63 049,4	64 955,6
Losses	6 789,2	7 370,3	7 120,4	6 471,5	6 633,2

Source: Fuel and energy balance for 2006 - 2010, Statistical Bulletin, Almaty, 2011, Agency for Statistics of the Republic of Kazakhstan.

Electrical power is the basic economic sector in Kazakhstan. As can be seen from table 3.5 above, electricity production and consumption has a growing tendency with a small fall in 2009, caused by economic crisis. Transmission lines and distribution networks of Kazakhstan are split into 3 parts: two in the north and one in the south. Each of them is connected to a foreign power system (Russian power system in the north and united power system of Central Asia in the south). However, these systems are connected with each other by just one line. The northern networks which service coal-operated power stations and make up most of the rated capacity export part of electrical power to Russia, while the southern power system, connected with the united power system of Central Asia, had to import electrical power from neighboring Kyrgyzstan and Uzbekistan due to lack of rated capacities.

Strengths of power sector are:

- high proportion of electric power production by thermal power plants, that use cheap coal (about 74% of total production in 2009);
- advanced scheme of backbone transmission lines of 220-500-1150 kV;
- centralized operational dispatch control system;
- significant potential of renewable energy (more than 1.0 trillion KWh);
- parallel operation of UPS (Unified power system) of Kazakhstan with IPS (Integrated Power System) of Central Asia and IPS of Russia;
- regulatory framework for the effective functioning of wholesale and retail electricity market;
- possibility of electricity exporting and availability of transit potential;

- significant reserves of fuel and energy resources.

Weaknesses of the power industry are:

- significant wear and tear of generating equipment that limits the ability of existing power plants (National Thermal power plants have residual economic life from 18 to 30%);
- shortage of generating capacities to cover peak loads e.g., low share of Hydro Power Plants (12%) in the generating mix;
- uneven distribution of generating capacities (42% of installed capacity of UPS of Kazakhstan is concentrated in Pavlodar region);
- high degree of deterioration of power networks of Regional Grid Companies (~ 65-70%);
- dependence of the Western zone of UPS of Kazakhstan (West Kazakhstan, Atyrau regions) on supply from Russia due to the lack of electrical connections to the UPS of Kazakhstan.

Currently, about 41% of generating capacities has worked for over 30 years. In order to meet the increasing demand for capacity and electric power it is planned to develop power plants in the following main areas:

- renovation and reconstruction of existing power equipment;
- commissioning of new facilities at existing power plants;
- construction of new power plants (CHP, TPP, HPP, GTPP);
- commitment of renewable energy sources (WPP, SPP).

It is expected that the electricity generation capacity can increase to 15.4 MW by 2014. In order to meet the growing electrical demand, it is necessary to expand and upgrade the existing power plants and to build new ones. Activities to renovate the National Power Network, as a backbone infrastructure of the sector, are to be undertaken. Also it is necessary to rehabilitate the switchyard of 500 kV of Ekibastuz GRES-1, which is an important node of UPS of Kazakhstan, and which is in poor condition due to the lack of investment over the previous period. Many of the existing power plants work with low efficiency, usually 10-15% lower than a new coal plant.

Energy sector is a source of direct emissions (CO_2, CH_4, N_2O) and indirect (CO, NOx,) greenhouse gases. The analysis of emissions of direct greenhouse gases (CO_2, CH_4, N_2O) in the Energy sector has shown that emissions of carbon dioxide (CO_2) were 82.8%, methane (CH_4) - 11,8%, and nitrous oxide (N_2O) - 5.4%.

3.1.2 Industry

Industrial production is an economic foundation for Kazakhstan with the mineral resource industry experiencing sustained growth since 1999. Among the CIS countries Kazakhstan is the second biggest oil producer after Russia. The manufacturing industry also has a significant share in the industrial production structure (Table 3.6).

Table 3.6 The structure of industrial production by economic activity for 1998-2005 (% of total)

Branch of industry	**Share in total industrial production**				
	2006	**2007**	**2008**	**2009**	**2010**
All industry	100	100	100	100	100
Mineral resource industry	57,8	56,9	61,1	60,3	61,3
Manufacturing industry	37,0	37,8	33,6	32,3	31,7
Production and distribution of electricity, gas and water	5,3	5,3	5,3	7,4	7,0

Source: Statistical Yearbook of Kazakhstan.

Increases in the country's mineral resource industry in 2010 were achieved primarily through the growth of natural gas production (by 8.9%), coal and lignite (by 18.1%), iron ore (by 8.6%), crude oil and associated gas (by 25.2%). High production rates in the industry would bring the average growth rate over the past five years up to 49.3 %.

The dynamics of growth rate of industrial production is shown in Figure 3.2. The manufacturing industry rapidly increases the production of coke. The growth of industrial output of the companies of mineral resource industry and the development of western regions of the country have had a significant impact on the increase of cargo traffic.

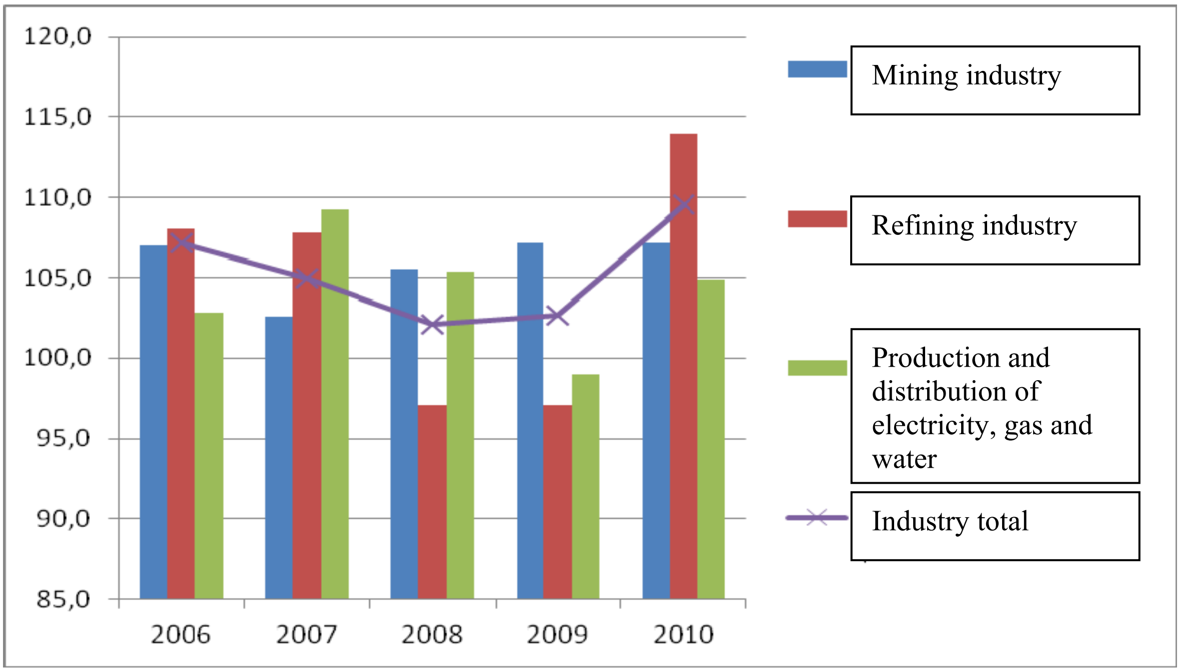


Figure 3.1 Trend of industry growth rate in the Republic of Kazakhstan between 2006- 2010 (percentage change vs. previous year)

Source: Statistical Yearbook of Kazakhstan.

Kazakhstan is a major producer of iron and steel in the region and is one of thirty leading manufacturers in the world. Most production is concentrated at the Temirtau Electrometallurgical Plant, production capacity of which, in principle, is 5 million tonnes per year, there are also small electric arc furnaces.

In Kazakhstan in addition to crude steel production, ferroalloys are produced. In recent years, this industry has been witnessing significant investment increase, there are also plans to expand and modernize facilities. According to available data, energy intensity of production, compared with international standards, is high.

The cement industry still has a small share in Kazakhstan's GDP and is characterized by increasing production. In 2002, Kazakhstan has produced 2.1 million tonnes, in 2006 the production increased more than 2 times and reached 4.9 million tonnes, in 2010 the production totaled 6.7 million tonnes.

Table 3.7 Cement production in Kazakhstan, thousand tonnes

Type of product	2006	2007	2008	2009	2010
Cement	4 880,2	5 698,6	5 837,3	5 694,1	6 682,6
Cement clinkers	903,8	1 134,3	1 870,3	1 772,4	1 948,3

Source: Statistical Yearbook of Kazakhstan.

However, these volumes do not meet the needs of the market. The increasing demand for cement is due to the construction, as well as implementation of state housing programs.

Most of the cement production capacities in Kazakhstan use outdated production technologies and their energy intensity is much higher than the new advanced plants. Prior to the economic downturn in 2008 there were a number of projects under construction for new cement plants, but many of them have been postponed or have not been held at all.

In 2009, GHG emissions from Industrial processes sector reduced by 27.7% vs. 1990 and by 3.3% vs. 2008. From 1990 to 1999 there was a steady reduction of greenhouse gas emissions in the Industrial processes sector due to the overall decline in industrial production in Kazakhstan, as well as closure of many businesses associated with planned production. Since 2000, there have been recorded an increase in production of basic products and overall yield of the country's economy from the economic crisis and increase in industrial production. Accordingly, since 2000, emissions from the industry have gradually increased until 2006-2007, when the highest amount of emissions in CO_2-equivalent was recorded, it almost reached the 1990 level. In 2009, there was decrease in production, mainly in the steel industry because of the global crisis and decrease in demand and prices for products. Taking into account the current rates of growth in production it can be expected that emissions would significantly increase and exceed the level of 1990.

Industrial processes are sources of CO_2, CH_4 emissions, and the only source of PFCs, HFCs and SF_6 emissions. Methane emissions are associated only with the production of coke and less than 0.5% of total GHG emissions in the industrial processes sector. Emissions of PFCs, HFCs and SF_6 occur when they are used as refrigerants and in aluminum production (CF_4 and C_2F_6).

3.1.3 Agriculture

The agriculture is the important sector of the economy of the country. In relation to grain production Kazakhstan is the third country in C.I.S. after Russia and Ukraine. Crop growing is the main branch of agricultural production securing food products for the population, forage for the stock-breeding and raw material for the industry. The major area of crop lands in the country is used for grain crops. The spring wheat, oats, barley and grain crops are grown mainly in the north of the country, since the climatic conditions of the region are favorable for cultivation of these husbandry products. The south region of the country is favorable for cotton plant, sugar beet, rice, tobacco, garden and vineyards growing.

The area under cultivation of grain and leguminous crops, including under wheat as a whole tends to increase in the republic. In 2010 the area under grain crops increased by 16.7% and under leguminous plants – by 11.9%, under wheat – by 14.8% in contrast with 2006.

Table 3.8 Area under cultivation of agricultural crops in the Republic of Kazakhstan

thous.ha

	2006	2007	2008	2009	2010
Total crop area	18369.1	18954.5	20119.2	21424.9	21 438.7
Grain and leguminous crops	14839.8	15427.9	16190.1	17206.9	16619.1
Wheat	12425.5	12892.3	13476.1	14751.0	14261.7

The productivity of grain and leguminous crops, first of all, depends on weather conditions, and accordingly it is fluctuating from year per annum in a broad range. For instance, the average wheat productivity in the country varied from 7 to 13 centner/ha for the last 5 years.

The stock-breeding sector constitutes 47 % of the GDP in agriculture and has significant development potential, which not fully used. The stock-breeding has been a key economic activity in Kazakhstan for centuries and remains to be the main source of employment, feeding and income for the rural population. The vast pasture lands and hay fields of Kazakhstan secure important production base.

At present the sheep-breeding and cattle-breeding remain to be the leading sectors in the republic. In the period from 1990 to 1998 the number of cattle decreased from 9.8 mln to 3.9 mln of animals, and sheep and goats - from 35.7 mln to 9.5 mln of animals. In 2010 the number of sheep and goats reached nearly 18.0 mln, cattle – 6.2 mln of animals.

Table 3.9 Number of animals and poultry, thous.

Year	Cattle	Sheep and goats	Pigs	Horses	Camels	Poultry, mln
1990	9 757.2	35 660.5	3 223.8	1 626.3	143.0	59.9
1998	3 957.9	9 526.5	891.8	986.3	95.8	17.0
2010	6 175.3	17 988.1	1 344.0	1 528.3	169.6	32.8

The changes in the number of cattle and poultry have led to changes in the production of stock-breeding products. At present the volume of stock-breeding products hasn't reached the level of 1990 (Table 3.3).

Table 3.10 Production of main stock-breeding products

Year	Meat (in slaughter weight), thous.t	Milk, tous. t	Eggs, mln pieces	Wool (in physical weight), thous.t	Karakul, thous. pieces
1990	1 559.6	5 641.6	4 185.1	107.9	1 821.4
1998	636.3	3 364.3	1 388.4	25.2	214.3
2010	937.4	5 381.2	3 720.3	37.6	49.4

The total emissions of greenhouse gases from agriculture sector in 2009, including methane and nitrogen compounds, estimated at 23,407.02 Kt CO_2-equivalent, which is 8.4% of total national emissions. Most of it is methane – 14,937.41 Kt CO_2-equivalent or 64% of the total. Emissions of nitrogen compounds (direct and indirect) were 8470.20 Kt CO_2-equivalent or 36% of the total emissions from the sector. Total emissions from the sector increased by 824.46 Kt CO_2-equivalent or by 3% from the level in 2008. Since 1993, the share of methane in the total emissions from the sector have increased up to 62-64% from 56-57% in 1990-1992.

Total emissions from the sector have changed a lot since 1990. They dropped up to 13.920.03 Kt CO_2-equivalent until 1998, which was only 33% of the 1990 level. Since 1999, they have been increasing on average by 1000 Kt per year and by 2009 reached 54% of the 1990 level.

In 2009, emissions of gases within the sector were distributed by major sources in the following descending order:

- internal fermentation of animals - 13813.73 Kt CO_2-equivalent, or 59.10% of the total emissions from the sector;
- systems of collection and storage of manure - 5094.28 Kt CO_2-equivalent, or 21.76%;
- animal manure in pastures and grazing - 3369.6 Kt CO_2-equivalent, or 14,39%;
- treated soils (direct and indirect emissions) - 1020.37 Kt CO_2-equivalent, or 4.36% of the total;
- rice fields (checks) - 109.62 Kt CO_2-equivalent, or 0.46%.

3.1.4 LULUCF

The Republic of Kazakhstan is the ninth country in the world in relation to its occupied area (272.5 mln ha) including partially-wooded, steppe, semi-desert and desert zones.

The great areas of lands of sandy-mechanical composition (81, 6 mln ha) and unsystematic use of pastures have preconditioned the development of wind erosion, particularly in sand areas and in the soils of desert zones. Along with the wind erosion, the water erosion has developed covering the area of 4.3 mln ha in the republic.

The deserts and semi-deserts occupy 64% of the country area. The partially-wooded and steppe zone covers 27.3 mln ha, the dry steppe and semi-desert zone – 99.6 mln ha and the desert zone – 112.1 mln ha. The desertification process including soil and vegetable cover degradation has covered, practically, the whole territory of the republic and tends to acceleration.

The level of organic fertilizers use in Kazakhstan is very low. In the North Kazakhstan over 70% of crop lands are under grain crops, where monocrops of the spring wheat prevail. The nutrients losses are great, much humus has been lost.

At present the soils with low content of humus prevail in Kazakhstan. For the period of 30 years the content of humus has decreased by 5-20% nearly in all subsoils of North Kazakhstan as a result of land plowing without sufficient application of organic fertilizers for many years, development of water and wind erosion processes and other factors. For the period of virgin land use for 35 years 0-25 cm of arable layer humus have been lost forever as a result of organic substance mineralization, release with the crop, and at water and wind erosion 1.2 bln t. or 28.3% of 4.3 bln t.

Table 3.11 Land use in Kazakhstan

Land use in Kazakhstan			
Indicator	**Year**	**Value**	**Measurement units**
Total area	2012	2 724 900	km^2
Population density	2011	5.7	People per km^2
Land area	2012	2 699 700	km^2

Water area	2012	25 200	km^2
Agricultural lands	2007	2 078 980	km^2
Arable lands	2007	227 000	km^2
Perennial plantings	2007	1 000	km^2
Permanent pastures and meadows	2007	1 850 980	km^2
Forests	2007	33 258	km^2
Other lands	2007	587 462	km^2

The territory of Kazakhstan is mostly unfavorable for forest vegetation because of little amount of precipitations. It is dominated by steppe, semi-desert and desert landscapes. The exception is the mountain east, south-east and north regions of the republic, where woodlands are concentrated.

The dry sharp continental climate of Kazakhstan is the main reason of greater sensitivity of forest ecosystems to various threats, and the expected climate change in the region will lead to increase of forest sector vulnerability. The main coniferous sorts - the pine, spruce, fir, larch and cedar growing in south border of their habitat area, and treelike varieties are growing in the north border of the habitat area are able to respond to changing climate conditions.

The observed and further expected average air temperature increase practically in all seasons will lead to shifting of climatic zone borders northward, and in mountain areas - upwards and, as effect, to deviation in the stability of forest ecosystems. In Kazakhstan, the majority of main forest-forming wood sorts are growing on the borders of their natural habitat area.

In general, Land use, Land-use Change and Forestry (LULUCF) is a sink of CO_2. The maximum absorption was 9319 Kt in 2003, and the lowest - 1118 Kt in 1991. Figure 3.3 shows the dynamics of CO_2 absorption from Land use, Land use Change and Forestry sector for selected years in the period from 1990 to 2009 in the Republic of Kazakhstan. Net absorption of CO_2 has increased since 1990 mainly, due to the withdrawal of agricultural land from use. In recent years, absorption of CO_2 by forest land reduced because the forest has been aging and the average stock of timber per ha has been reducing.

Net absorption of CO_2 in this sector varied across the time series between 4 - 8% of the total annual GHG emissions excluding LULUCF.

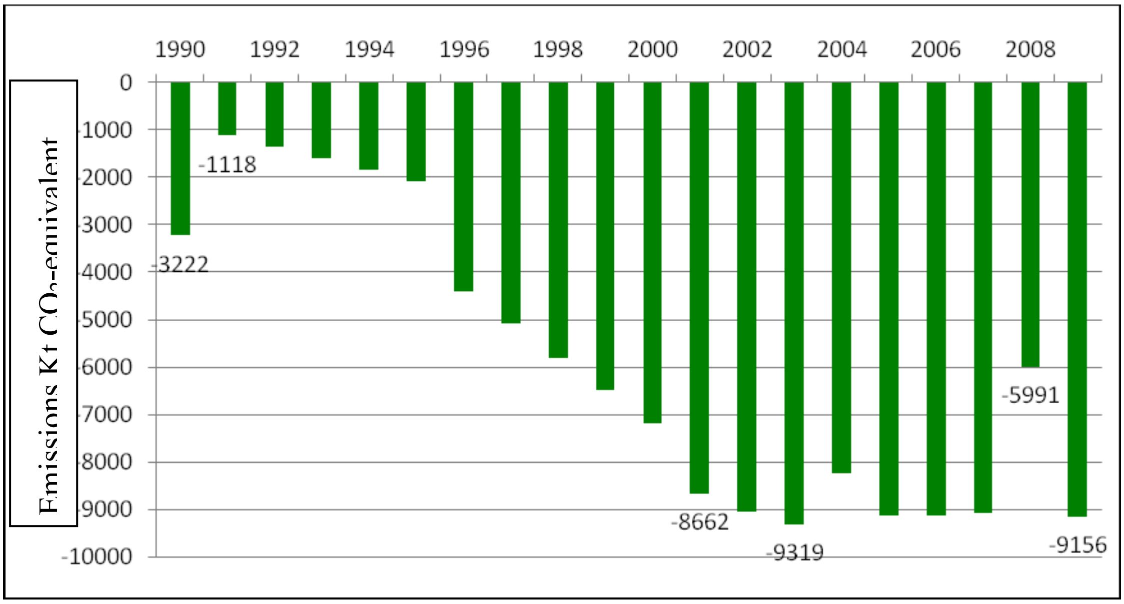


Figure 3.2 - Total sinks / emissions of greenhouse gas (Kt CO_2-equivalent) from Land use, Land use change and Forestry sector

Source: National inventory report of anthropogenic emissions from sources and absorptions by sinks of greenhouse gases not controlled by the Montreal Protocol for 1990-2009, Almaty, 2011

3.1.5 Wastes

Solid domestic wastes (SDW)

43 bln tons of solid domestic wastes have been accumulated on the territory of Kazakhstan. Of which 600 mln tons are toxic wastes. Along with that the volume of accumulated SDW increases by 700 mln tons per annum. Their utilization to receive secondary raw material is a perspective activity, both in relation to economic attractiveness, and environmental safety.

At present in Kazakhstan there are 2 thousand tons of wastes per annum per each inhabitant. According to the data of the Ministry of Environmental Protection only 3-5% of them are recycled, i.e approximately 2.15 bln tons of wastes. The remaining amount without sorting on components is taken to and stored at open dumps, the number of which in Kazakhstan reaches 4 525 (according to the data of the Agency of the RK on Construction and Housing-public Sector). So, accumulation of industrial and domestic wastes is becoming one of the urgent ecological problems in Kazakhstan.

The classical way of wastes disposal (a container – a garbage truck - a dump - reclamation) currently is inefficient and, besides, it is potentially dangerous since even a carefully processed dump covered by soil is a source of "landfill gas" leading to a greenhouse effect.

Utilization of wastes containing toxic substances including - fluorescent lamps, mercury-containing instruments (thermometers, batteries and etc.) remains to be an urgent problem. There are no especially established points on elimination of used products. At present, the solid domestic wastes, practically, are not recycled on the territory of the Republic of Kazakhstan.

Industrial and toxic wastes

Owing to the developed resource-raw material trend in the nature use industry in Kazakhstan, about 50 tons of various substances are mined per capita per annum. Over 20 bln t of industrial wastes with about 1 bln tons generated per annum have been accumulated on the territory of Kazakhstan. 95 % of the total volume of mined ore finally are treated as wastes, which are often extremely toxic and disposed in the areas not suitable for their storage. The amount of wastes of the non-ferrous, black metallurgy and gold-mining industry is 14 bln tons and occupy 50 thousand ha.

In 2009, total greenhouse gas emissions from the waste sector were 6178.95 Kt CO2-equivalent, which represents an increase of 223.46 Kt CO2-equivalent, or 3.7%, from the 2008 level. This sector witnessed a slight increase in emissions. In 2009, emissions from the Waste sector has increased by 3.45%, or by 205.83 Kt of CO2-equivalent from the level in 1990.

Shares of methane emissions from solid waste disposal on managed landfills were 48.31% in 1990 and 49.25% in 2009. In unmanaged landfill methane emissions contributed 32.21% in 1990, which in 2009 increased slightly – up to 32.83%. There was a slight decrease of contribution from the treatment of municipal wastewater - from 8.46% to 7.92% between 1990 - 2009. The share of emissions from industrial waste water amounted to only 0.73% of total emissions in the sector in 1990 and 0.36% in 2009.

In 1990 the contribution of nitrous oxide from human activities, expressed in CO2-equivalent, to total emissions from the sector amounted to about 10.29% and, decreased slightly, reaching 9.40% by 2009 due to a decrease in population. CO2 emissions from medical waste incineration represented a very small proportion in the overall emissions from this sector - less than 1% in 2006, when the practice officially began in Kazakhstan. Then, with the increasing of mass of disposed medical waste, its contribution to total emissions from the sector began to grow relatively rapidly and in 2009, it increased 12 times since 2006, though it still has not exceeded 0.25%, which is a very insignificant quantity.

3.2 Process, criteria, and results of sectors selection

Sector prioritization process and criteria for subsequent assessment of mitigation technology needs were carried out in accordance with the *Handbook on conducting technology needs assessment for climate change* by the UNFCCC and the United Nations Development Programme (UNDP), published in November 2010.

Sectors identified for mitigation are based on their GHG relevance, their potential for feasible GHG mitigation options, their capacity to employ low-carbon technologies, and their contribution to overall national development goals. An important element in the choice of technologies is their compliance with national development strategies with an emphasis on reducing greenhouse gas emissions and vulnerability to climate change. Technology transfer and use of scarce resources would be unstable without considering the country's development priorities, therefore, the first step is to determine the country's priorities in the light of climate change. For this purpose, the following strategic documents were taking into account by the group during the evaluation process:

- State Program for Accelerated Industrial and Innovative Development of Kazakhstan for 2010-2014 (SPAIID);
- Strategic Development Plan of the Republic of Kazakhstan by 2020;
- Concept of Transition of Kazakhstan to Sustainable Development for 2007 -2024 (CSD-24)
- Power Sector Development Program of the Republic of Kazakhstan for 2010 – 2014;
- Plan for Transition of the Republic of Kazakhstan to the low-carbon development by 2050;
- "Zhasyl Damu" Program for 2010-2014
- Light Industry Development Program of the Republic of Kazakhstan for 2010 – 2014;
- Housing Sector Modernization and Development Concept of the Republic of Kazakhstan;
- Innovation Development and Technological Modernization Support Program of the Republic of Kazakhstan for 2010 -2014;
- "Performance 2020" Program;
- Environmental Security Concept of the Republic of Kazakhstan for 2004-2015;
- Agro industrial Complex Development Program of the Republic of Kazakhstan for 2010-2014;

- Construction Industry and Building Materials Production Development Program of the Republic of Kazakhstan for 2010-2014;
- Mining Industry Development Program of the Republic of Kazakhstan for 2010-2014;
- Mechanical Engineering Development Program of the Republic of Kazakhstan for 2010-2014.

Based on methodology provided in the TNA Handbook and in accordance with the abovementioned strategic documents, the working group on mitigation agreed on 4 priorities for prioritizing the sectors, namely:

1. **Economic priorities** (including, but not limited to):
   - Contribution to sustainable economic development;
   - Promotion of investments;
   - Energy security;
   - Infrastructure development
   - "Green" economy.

2. **Social priorities** (including, but not limited to):
   - Increase of income;
   - Creation of work places;
   - Public participation and awareness-raising;
   - Food security;
   - Favorable living conditions.

3. **Environmental priorities** (including, but not limited to):
   - Reducing air, land and water pollution;
   - Protection of forests;
   - Combating desertification;
   - Climate change prevention;
   - Biodiversity conservation;
   - Prevention of soil degradation;

4. **GHG reduction**

The method of giving points to sectors was being considered by experienced experts/stakeholders. The points based on characterization of how the deployed low emission technology (direct and indirect) could bring improvements to sectors. The improvements hereby means contributions to all criteria above and level of mark are:

0 – no benefit
1 – faintly desirable
2 – fairly desirable
3 – moderately desirable
4 – very desirable
5 – extremely desirable

After all reviews and opinions were collected from experts/stakeholders in written or oral forms, sectors were further prioritized according to their respective benefits by the mitigation team in consultation with the rest of TNA team and national stakeholders using a Multi Criteria Decision Analysis (MCA) framework. The priority points were summed for each sector.

Meanwhile, each point of each criterion, each sector was average approximate point from experts/stakeholders.

Table 3.12 Performance matrix of prioritizing sectors for mitigation

Sectors	Economic priority	Social priority	Environmental priority	GHG reduction	Total benefit
Energy	5	5	5	5	20
Industry	5	5	5	5	20
Agriculture	3	4	4	3	14
LULUCF	1	2	5	1	9
Waste	2	4	5	2	13

Based on the given scores, the bellow criteria contribution graph has been prepared:

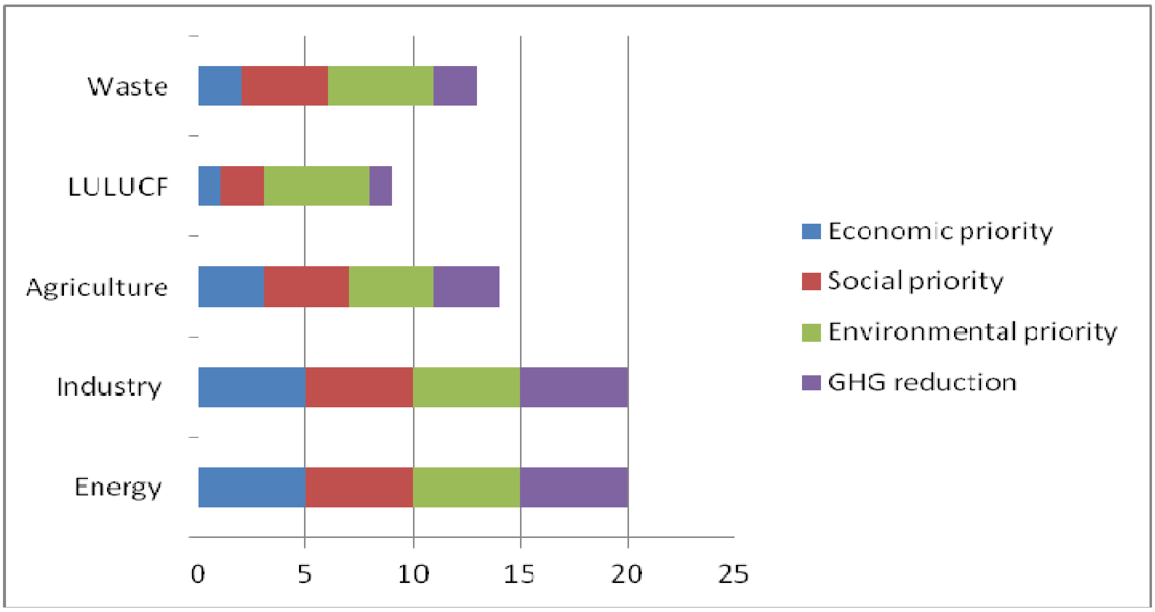


Figure 3.3 – Sectors criteria contribution graph

The criteria contribution graph is prepared basing on the scoring for the sectors under different criteria to give an overview of the contribution of each sector on the criteria. Based on the criteria contribution graph, the group judged the sectors. The sectors having strongest contribution development priorities have been defined as the priority ones - in this case, energy and industry sectors.

Following the sectors prioritization, the experts/stakeholders group considered different subsectors for prioritization, using the approach used for sectors selection. For energy sector the following subsectors were considered:

- Power production
- Heat production
- Oil extraction and processing
- Hard fuel extraction and processing

Table 3.13 Performance matrix of prioritizing subsectors for energy sector

Subsectors	Economic priority	Social priority	Environmental priority	GHG reduction	Total benefit
Power production	5	5	5	5	20
Heat production	4	5	5	5	19
Oil extraction and processing	5	4	4	3	16
Hard fuel extraction and processing	4	3	4	3	14

Based on the given scores, the bellow criteria contribution graph has been prepared:

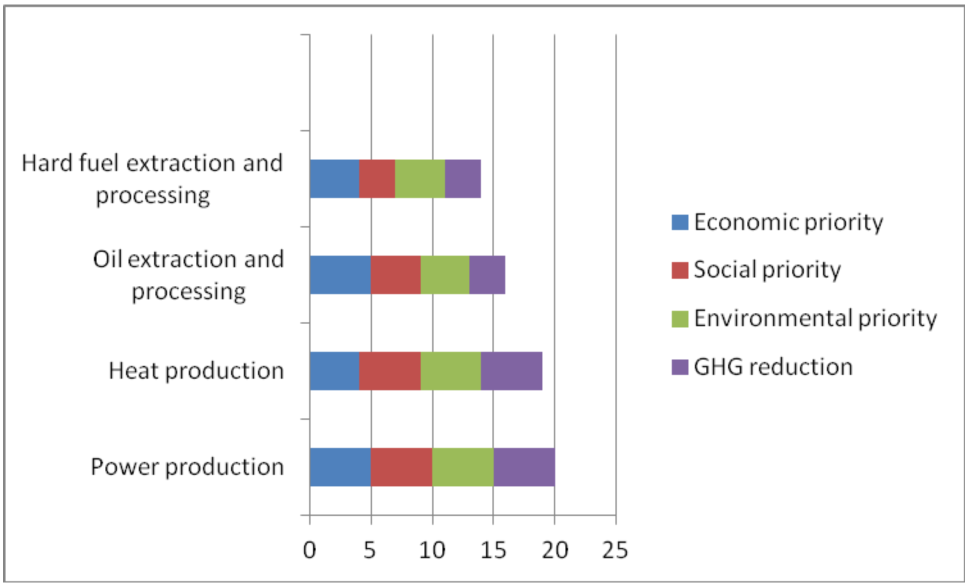


Figure 3.4 – Energy subsectors criteria contribution graph

Based on the criteria contribution graph, the group judged the subsectors. The subsectors having strongest contribution development priorities have been defined as the priority ones - in this case, power and heat production. Following the TNA format requirements, the power production subsector was prioritized for following consideration of possible mitigation technologies.

For the industrial sector, the following subsectors were considered:

- Cement Production
- Chemical Industry
- Metal Production
- Construction industry
- Machinery

Table 3.14 Performance matrix of prioritizing subsectors for energy sector

Subsectors	Economic priority	Social priority	Environmental priority	GHG reduction potential	Total benefit
Cement Production	4	5	5	5	19
Chemical Industry	3	3	4	3	13
Metal Production	5	4	4	4	17
Construction industry	4	5	4	3	16
Machinery	3	4	4	3	14

Based on the given scores, the bellow criteria contribution graph has been prepared:

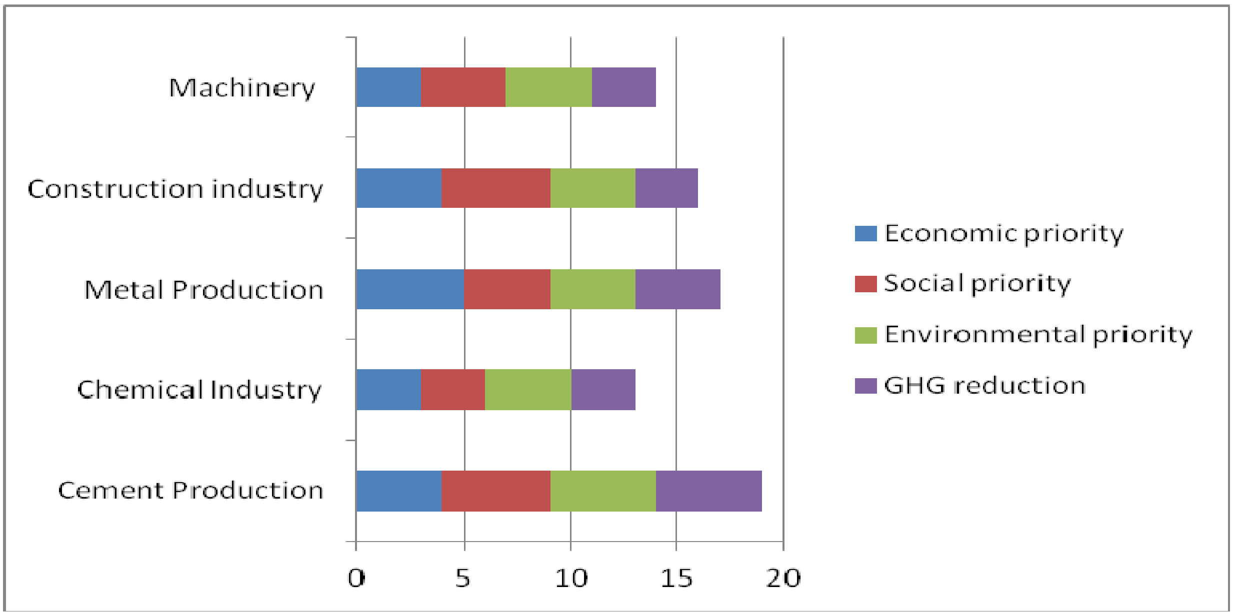


Figure 3.5 – Industry subsectors criteria contribution graph

Based on the criteria contribution graph, the group judged the subsectors. The subsector having strongest contribution development priorities has been defined as the priority one - in this case, cement production, as one of the most priority sectors from development point of view and mitigation potential.

3.3 Current status of technologies in the selected sub sectors

3.3.1 Power industry

A specific feature of Kazakhstan's power industry is the predominant use of fossil fuels, mainly coal, for energy production at the Thermal Power Plants (TPPs). TPPs accounted to 87% of total power generated in Kazakhstan, the share of Hydro Power Plants - 13%. 84% of power generated at TPPs (or about three-quarters of total power generated in Kazakhstan) were based on coal combustion and only 16% by combustion of oil and gas. A significant increase in the share of power (in the context of a significant increase in the total volume of production) generated from non-carbon energy sources is not expected due to the planned construction of new units at GRES-2 and possible start of construction of Ekibastuz GRES-3 and construction of Balkhash GRES .

Coal reserves will be enough to last for 150-200 years, gas reserves - for 70-90 years with regard to exports at current levels. In addition, the main risks for the gas-based power generation is the increase in gas prices, as for coal, the government plans to tighten the requirements on the quality of coal, most of the resource base will not meet the regulations.

While increasing the share of coal-based power generation leads to increased negative impact on the environment (including greenhouse gases) the application of innovative technologies in coal generation could reduce this impact.

Power industry of Kazakhstan is characterized by outdated equipment, low efficiency (34%), and also has a significant negative impact on the environment.

By 2014 it is expected to increase the electrical installed capacity up to 15.4 MW. In order to meet the growing electrical capacity needs it is necessary to expand and renovate existing power plants and to build new ones.

In order to meet the increasing demand for capacity and electric power it is planned to develop power plants in the following main areas:

- repair and replacement of existing power equipment;
- commissioning of new facilities at existing power plants;
- construction of new power plants;
- commitment of renewable energy sources in the balance.

The main solution to the power generation sector would be a modernization of power plants based on modern high-performance and environmentally friendly technologies to increase the efficiency, as well as using the technologies for carbon capture and storage. Examples of such technologies are presented in Appendix I.

3.3.2 Cement production.

Depending on the preparation of raw mix, there are two basic ways to produce portland cement: wet and dry. In Kazakhstan, wet process of cement production is used on five major cement plants, namely:

- Bukhtarma Cement Company, LLC (capacity - 1600 tonnes);
- Semey Cement Plant, LLC (capacity - 1200 tonnes);
- Karcement and Central Asia Cement (capacity - 3560 tonnes);
- Shymkentcement, JSC (capacity - 2100 tonnes);
- SAS-Tobe technologies, LLC (capacity - 450 thousand tonnes).

Average fuel consumption per tonne of clinker in case of wet process of production is 240 kg, in case of dry - 183.9 kg. This means replacing the wet process with dry process can save 56.1 kg of fuel for each tonne of clinker production. For example, in Kazakhstan to produce 1 tonne of cement, the fuel consumption is 100 kilograms of fuel equivalent and 900 kWh of electricity more than in foreign countries.

Currently, it is necessary to introduce efficient technology of raw material and cement grinding in a closed loop. This technology can improve the quality of cement and reduce costs for cement grinding by 15-20%. It is especially effective in combination with additives - superplasticizers and accelerators of hardening.

There are a number of already proven technology solutions that can significantly reduce the fuel consumption for clinker burning in wet process. Reserve fuel saving is the application of slurry thinners, as each percent of decrease in moisture content of sludge can reduce fuel consumption for clinker burning on average by 117-146 kJ / kg or 7-2%.

The use of more effective insulation materials for lining of preparatory areas of rotary kilns will also reduce fuel consumption by 2-3 kg per tonne of clinker.

In order to develop the cement industry in Kazakhstan it is expected to convert the existing cement plants in Kazakhstan with capacity of 5.65 million tonnes / year from "wet" to "dry" process of production increasing the capacity by 3.26 million tonnes.

As a result of the conversion of the existing plants from "wet" to "dry" process of production output of cement by dry process on the renovated facilities will reach 8.91 million tonnes.

The transition to a more modern method of production of cement using high-tech equipment will reduce GHG and other pollutant emissions and comply with international environmental standards.

.

CHAPTER 4. TECHNOLOGY PRIORITIZATION FOR THE SELECTED SUBSECTORS

4.1 Criteria and process of technology prioritization

According to UNEP guidelines on TNA, the Multi Criteria Decision Analysis (MCDA) methodology was used to assess the needs of technologies for mitigation. The MCDA provided a framework for prioritizing technologies within sectors using stakeholder consultations These stakeholder consultation were facilitated by the consultants.

When applying MCDA at first a set of criteria was decided. Each technology's contribution to GHG mitigation was included as one of the criterion in the assessment. Criteria were based on current research that estimated potential effects of criteria on searching suitable technologies.

The mitigation expert group agreed on a set of criteria for assessing priority mitigation technologies in energy and cement subsectors, including:

- Costs:
  - Capital;
  - Operation and maintenance.
- Benefits:
  - Amount of GHG emissions reductions (in the long term perspective) ;
  - Environmental: reducing air, land and water pollution;
  - Social: work places and income increase, improved living conditions;
  - Economic: contribution to sustainable economic development, saving energy, balance of payments, promotion of investments.

Based on criteria above, technologies were given score and weighted for each criterion and arranged in priority order. The scores were given by the mitigation work group members at the joint meeting of the group held at Climate Change Coordination Centre premises followed by further electronic consultations. The more the point was, the higher rank was. To assess the benefits of the proposed technologies the prioritization matrix has been used. The assessment was conducted on a scale from 0 to 100 points, and the weighting factor (w), from 0 to 1, of each criterion was considered.

Weight (W): reflects importance of each criterion in decision-making. It considered differences between the upper and lower of the elevation of point and the level of group interest (namely 'changeable weighted method'). Once all options had been weighted, the criteria became important. This is necessary to ensure independence when giving point to one criterion. For example, 100 points for environment is different from 100 point for society. Taking into account the lack of "factual" information about actual costs and benefits from introducing selected technologies in Kazakhstan, the group decided to range the criteria from mitigation point of view.

Giving point: in order to evaluate expected productivity of technology based on its contribution to the criteria. The productivity of technology is considered by categorized information in selecting technology, knowledge and views of experts.

The experts were asked to give point from 0-100 in TNA Table (0 means least preferable option). The best and least options are identified first and issued in order from 100-0, then come other points.

4.2 Results of technologies prioritization for power subsector

The national mitigation consultant prepared technology fact sheets for 6 pre-selected technology options (pre-selection process was conducted through consultations with the stakeholders and taking into account national power sector development goals, stated in governmental documents and peculiarities of the country's power sector conditions). Based on the technology fact sheet, provided at Annex I, the mitigation work group evaluated technologies based on multi-criteria analysis as stated in the table 4.1 bellow.

Table 4.1 Scores of technologies for power production

№	Technology	Benefits				Costs		Benefits considering W
		Economic	Social	GHG reduction	Environmental	Capital	Operation and maintenance	
	Weighted coefficient, W	0.1	0.1	0.3	0.2	0.2	0.1	1
1	Coal gasification technology	50	40	50	50	50	50	49
2	Pulverized Coal Combustion with higher efficiency	80	60	0	80	100	90	59
3	Small hydropower	100	20	80	100	80	100	82
4	Wind energy: on-shore, large scale	10	0	90	70	20	60	52
5	Fuel change from Coal to Natural Gas	0	50	70	60	40	30	49
6	Nuclear energy	30	100	100	0	0	0	43

4.3 Results of technologies prioritization for cement subsector

The national mitigation consultant prepared technology fact sheets for 5 pre-selected technology options (pre-selection process was conducted through consultations with the stakeholders and taking into account national cement sector development goals, stated in governmental documents and peculiarities of the country's cement sector conditions). Based on the technology fact sheet, provided at Annex I, the mitigation work group evaluated technologies based on multi-criteria analysis as stated in the table 4.2 bellow.

Table 4.2 Scores of technologies for cement production

№	Technology	Benefits				Costs		Benefits considering W
		Economic	Social	GHG reduction	Environmental	Capital	Operation and maintenance	
	Weighted coefficient, W	0.1	0.1	0.3	0.2	0.2	0.1	1
1	Energy Efficiency and Saving	100	70	70	70	60	90	73
2	Carbon Capture and Storage	0	100	100	100	0	0	60
3	Blast furnace slag granulation	70	90	0	80	100	70	59
4	Fuel change	90	80	60	0	30	100	51
5	Change from wet to dry production technology	80	0	90	10	50	80	67

CHAPTER 6. CONCLUSION

In the result of consultations, two economic subsectors were chosen and approved for energy and industry sectors. These are power production and cement production. Expert groups for each subsector held discussions with stakeholders in each segment.

Multi-criteria analysis was conducted in accordance with the handbook for conducting technology needs assessment. Details of this assessment are presented in Chapters 3, 4 and 5 presented above, as well as in Annex III.

As a result of the technology needs assessment process 11 technologies (6 for energy and 5 for cement sector) were presented for the approval of the Project Steering Committee. The selected technologies are presented in Table 6.1.

Table 6.1 List of priority technologies for power and cement subsectors in Kazakhstan

	Technologies	Sector	Comments
1.	Pulverized Coal Combustion with higher efficiency	Energy	Project proposal
2.	Small hydropower	Energy	Project proposal
3.	Energy Efficiency and Saving	cement production	Project proposal
4.	Change from wet to dry production technology	cement production	Project proposal

These technologies are related to a wide spectrum of economic, social, environmental and political factors. The barrier analysis and development of Technology Action Plans for these selected technologies will reflect the need for technology actions in chosen subsectors. In general, there is a need to develop a comprehensive technology database for consumer and policy maker decision making, as well as to support local technology and expertise development.

REFERENCES

1. United Nations Development Program, 2010: *Handbook for conducting TNA for Climate Change.*
2. Statistic Office. *Statistic Yearbooks 2000, 2005, 2010, 2011*
3. Multi-criteria analysis: a manual, DecideWise, 2009
4. Statistics Agency of Kazakhstan - www.stat.kz.
5. Kazakhstan's Second National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change. Astana. Agroizdat LLC, 2009
6. Statistical bulletin "Environmental protection and sustainable development of Kazakhstan" / under. ed. A. Smailova. - Astana: Agency on Statistics of RK, 2009.
7. National report on the state of the environment in the Republic of Kazakhstan in 2009, "KazNIIEK" RSE, Almaty, 2010
8. Web-site of the Ministry of Environment Protection of the Republic of Kazakhstan: http://www.eco.gov.kz
9. On the State Program on Forced Industrial-Innovative Development of Kazakhstan for 2010-2014 and Decree of the President of Kazakhstandated March 19, 2010 № 958
10. On approval of the program for the development of electric power industry in the Republic of Kazakhstan for 2010 - 2014. Government of the Republic of Kazakhstan dated October 29, 2010 № 1129
11. On approval of the program for the development of mining industry in the Republic of Kazakhstan for 2010-2014. Government of the Republic of Kazakhstan dated October 30, 2010 № 1144
12. On approval of the program for the development of innovation and promote technology upgrading in the Republic of Kazakhstan for 2010 - 2014. Government of the Republic of Kazakhstan dated November 30, 2010 № 1308
13. On Approval of the development engineering in the Republic of Kazakhstan for 2010-2014. Government of the Republic of Kazakhstan dated September 30, 2010 № 1002
14. On approval of the Programme for the development mineral complex in the Republic of Kazakhstan for 2010 - 2014. Government of the Republic of Kazakhstan dated December 31, 2010 № 1530
15. On approval of the program for the development of the construction industry and building materials in the Republic of Kazakhstan for 2010 - 2014. Government of the Republic of Kazakhstan from September 30, 2010 № 1004
16. The Law "On the Support of Renewable Energy Sources Use" *dated 4 July 2009 #165-IV.*
17. The UNDP/GEF Project on the Prospects of Wind Power Development in the Republic of Kazakhstan
18. On the Approval of the Program on the Atomic Sector Development in the Republic of Kazakhstan for 2011-2014 with the prospect of the development till 2020. *The Resolution of the Government of the Republic of Kazakhstan dated 29 June 2011 #728*
19. On the Strategic Plan of the Agency of the Republic of Kazakhstan on the Atomic Energy for 2012 - 2016. *The Resolution of the Government of the Republic of Kazakhstan dated 29 December 2012 #1806.*
20. The UNEC Project "Capacity Building for Air Quality Management and the Application of Clean Coal Combustion in Central Asia", 2007.
21. Materials of the workshop: "Strengthening the Capacity for Air Quality Management and the Application of Clean Coal Combustion in Central Asia", Almaty city, 12-14 October 2005.

Annex I. Technology Factsheets

1.1 Priority subsector: Power production

1.1.1 Coal gasification

Coal is one of the most widely used energy sources in Kazakhstan, and remains to be one of the key segments of the national economy. Sustainable development of the coal industry along with carbon dioxide emissions reduction is of mutual interest, both for business representatives and authorities. The Government of the Republic of Kazakhstan demonstrates its full adherence to the reduction of impacts on the environment through the introduction of clean coal technologies.

The share of Kazakhstan, with its developed industry and high dependency on coal as the main energy source is 43.7% of air pollutants emission in Central Asia.

Status

It is not applied in Kazakhstan.

In the world: pilot projects in Europe, Japan, Uzbekistan and the USA.

Social and economic benefits:

- The application of the technology envisages the reduction of prices for electric power;
- The development of the technology will require creation of new jobs, specialists will become of demand.

Environmental benefits:

The main ecological benefits of a complex gasification multifunction cycle are related to the opportunity for cleaning of about 99% of pollutants in admixtures created from received gasses.

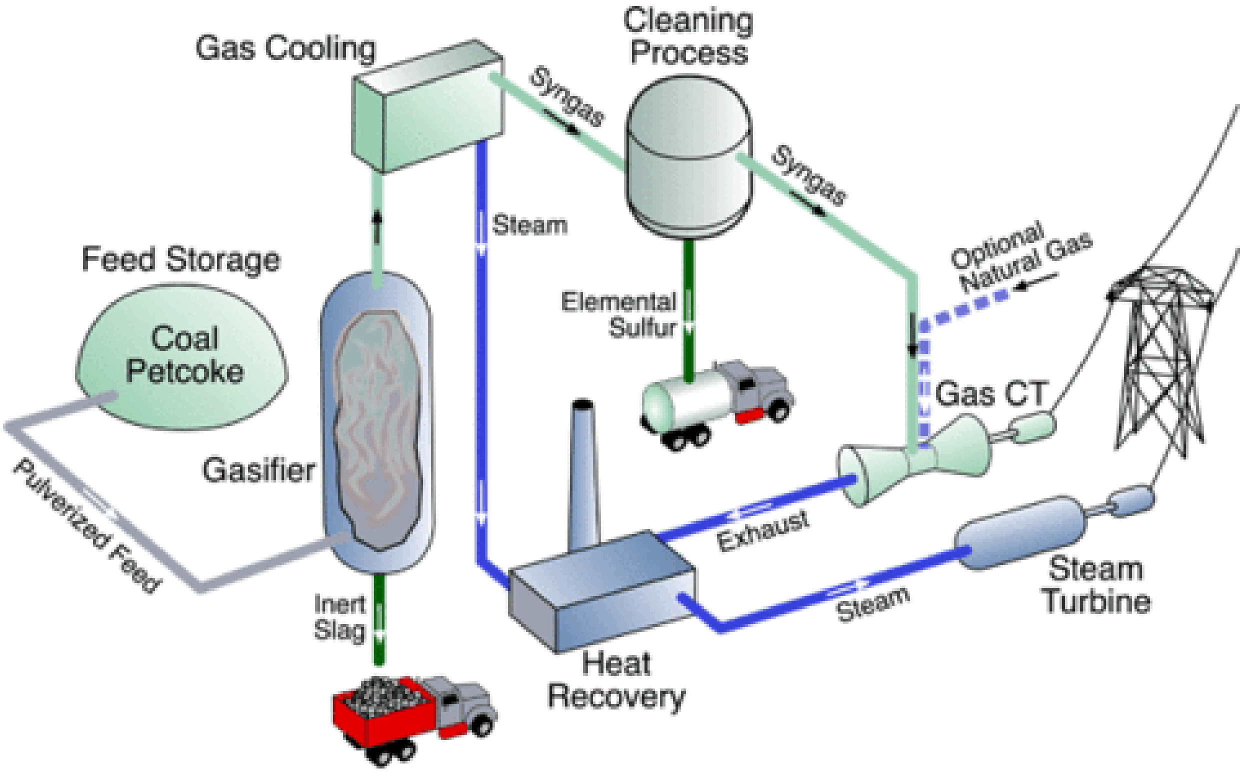
Technology potential

Kazakhstan has enormous coal resources that precondition the development of gasification technology.

Barriers:

- Lack of experience in application of the technology;
- Insufficient governmental support;
- Lack of financial incentives and subsidies from the state.

The scheme of coal gasification



1.1.2 Efficient coal combustion

Status

In Kazakhstan: The technology is used in Kazakhstan, but the efficiency is rather low compared to other countries.

In the world: widely used

Social and economic benefits:

- Efficiency: reduction of prices for power and heat energy by 60-65%;
- Reduction of prices for power, additional employment opportunities.
- Increasing of cost-effectiveness of coal power generating units by 10-12%, and their coefficient of efficiency - by 4.5-6,7% and increasing of coefficient of efficiency from 37-38% to 42-44 %.
- The technology of efficient combustion allowing reducing hazardous substances in the atmosphere is the cheapest and safe process of all known process on their reduction.

Environmental benefits:

The main advantage of supercritical technologies for the environment is less amount of coal used per unit of production capacity in contrast with pre-critical coal technologies and, consequently, leads to the reduction of the level of environmental pollution.

The technology allows maintaining NO_X emissions on the level of 220-300 mg/m^3 and SO_2 emissions on the level of no more than 400 mg/m^3.

If to assume that at the average in Kazakhstan the NO_X content in smoke gasses is 1.1 mg/nm^3, the total NO_X emissions will be approximately 390 thousand tons per annum. The reduction of NO_X content in smoke gasses to 0.6 mg/nm^3 will allow reducing the total emissions to thousands of tons/year i.e the amount of hazardous NO_X emissions emitted in the atmosphere at combustion of Ekibastuz coal dust will be reduced by 180 thousand tons.

Along with that the reduction of mechanical under-combusting at the average by 1% will allow reducing the consumption of Ekibastuz coal approximately by 500 thousand tons/year. This will lead to the reduction of ash emissions in the atmosphere approximately by 1000 tons/year.

- The program on re-equipment of existing coal stations to improve their efficiency will allow considerably reducing CO_2 emissions.
- The measures on after-combusting and rational use of natural resources for production processes will allow reducing the amounts of coal mining.

Technology potential

The application of "clean" coal technologies as well as improvement of coal combustion efficiency will contribute to the implementation of the plan on the transition to "green" technologies and, consequently, to the improvement of Kazakhstan's potential and produced products in the international community

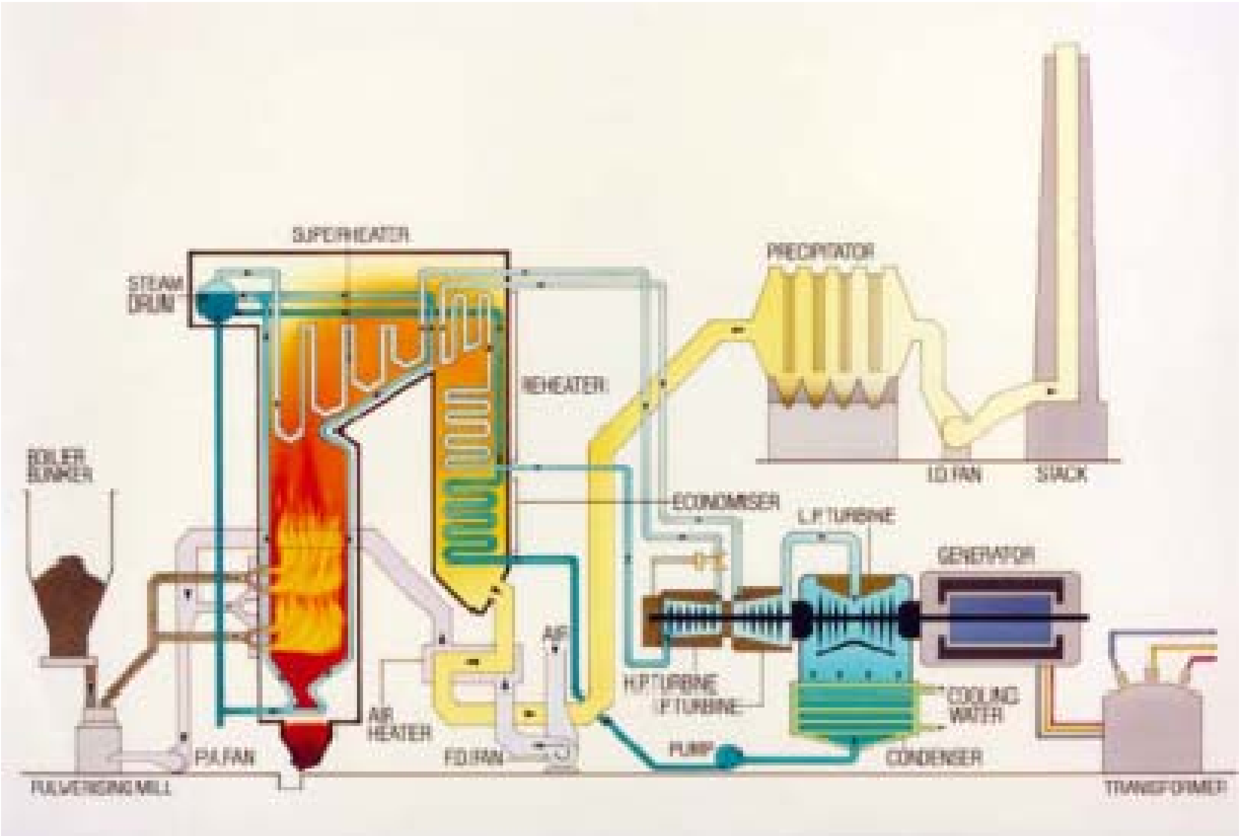
Barriers:

- The prices for energy should be adapted to a market level or, at least, to the level allowing expenses covering;

The lack of energy in the energy system. The re-equipment will take time and as a result of that TETS operation will be interrupted for several months (probably, 1-2 years) that will lead to power supply deficit.

The only drawback of the technology is a great need in investments, since enterprises that consume coal do not have sufficient amount of their own means to finance the above mentioned works.

The scheme of efficient coal combustion.



1.1.3. Small hydropower plants

Small and microHPPs are the objects of small hydroenergy. This section of power generation is focused on the use to water resources energy and hydraulic systems by means of hydropower installations of small capacity (from 1 to 3000 kWt). The small energy has been developed in the world for the last decades, since it allows securing power supply in hard-to-reach and isolated areas, as well as owing to small capital costs for construction of plants and a short period of cost recovery (within 5 years).

The most prospective areas for HPP development are the south areas of the Republic of Kazakhstan with a considerable potential and along with that importing great power volume from the north areas. About 65% hydropower resources are concentrated in mountain rivers in the south areas of the country.

In the period from 2007 to 2010 a number of small HPPs with the total installed capacity of 20.7 MWt were put into operation in the south areas of the republic.

Status

In Kazakhstan: widely used in the south of Kazakhstan.

In the world: widely used.

Social and economic benefits:

- The use of small HPPs does not make direct or indirect impact on environmental situation of the area and, consequently, on human health.
- The introduction of small HPPs allows hard-to-reach and remote areas being independent from central power supply.

- The following support is provided by state bodies to power generating organizations using renewable energy sources including small HPPs:
- The local executive bodies of the regions, cities of national importance and capitals reserve and provide plots of lands for construction of objects to use renewable energy sources in accordance with the land legislation of the Republic of Kazakhstan and a plan (a program) on their location.
- Agreements on purchase and sale of power and (or) heat energy generated by qualified energy generating organizations are concluded for a period of not less than a pay-back period for the project on construction an object using renewable energy sources determined in the feasibility study under the project on construction of an object using renewable energy sources.

Technology potential

In accordance with the Program on Forced Industrial-innovative Development for 2010-2014, increase of the share of renewable energy sources in the national energy system to 1%-5% till 2024 is expected.

Environmental benefits and GHG emission reduction:

Small HPPs are recognized as ecological safe power plants. Moreover, they allow complex using of water resources (power energy, water-supply, land reclamation, water protection and fish breeding).

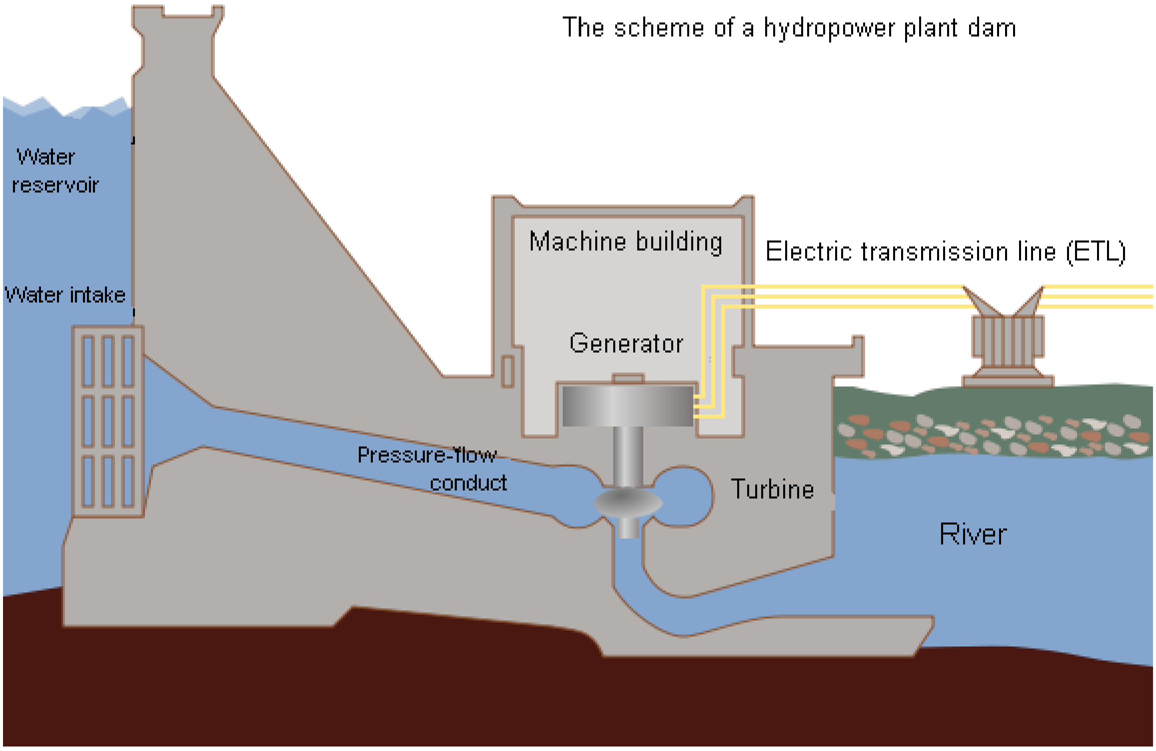
Considering the fact that power generation in Kazakhstan is based on the use of coal, the use of hydropower generators will lead to the reduction of air pollution and greenhouse gasses emissions. Considering that the small energy practically results in zero CO_2 emissions, it is expected that the situation concerning greenhouse gasses emissions polluting the air will be considerably improved compared to “business as usual” power generation scenario.

Unlike large hydropower constructions, the ecological impacts of them on ecosystems are limited. Small HPPs require little changes in the river current and, consequently, the existing ecosystem can continue functioning as before.

Barriers:

The shortcomings of the small hydropower that may make impact on its efficiency may include the instability of electric power generation due to hydrological regimes of small rivers, the probability of accidents at small hydro units in case of high water, seasonal operation of small HPPs and fast silting of water reservoirs at small HPPs dams. The general problem concerning small hydropower in C.I.S. countries are insufficient study of hydrological regime and small water courses flow, lack of equipment production in series and maintenance services and in many cases a comparatively high specific cost for installed capacity. The regulatory and normative documentation, as well as standard specifications on designing and construction of objects and assemblage of the equipment is not sufficiently developed.

The scheme of the small HPP technology



1.1.4 Wind power

The prospects of wind power use are predetermined by related available wind power resources. Kazakhstan is very rich in wind resources. About 50% of the Kazakhstan territory are characterized by the average wind speed of 4-5 m/s and over that predetermines very good prospects for wind power use. According to the experts' assessment Kazakhstan is one of the countries of the world with appropriate conditions for wind power development. The wind areas are located in Pre-Caspian region, in the centre and in the north of Kazakhstan, in the south and in the southeast of Kazakhstan. Considering the WPS capacity density on the level of 10 MWt/km^2 and considerable vast areas, the opportunities for installation of WPS capacity of several thousand MWt in Kazakhstan may be defined. According to some data the theoretical wind potential in Kazakhstan is about 1820 bln kWt.h per annum. To assess the wind potential of perspective areas properly, special meteostudies with use of meteo masts of 30-80m high should be conducted, at least, for one year.

Technology status

In Kazakhstan: not used. The construction of a number of "wind farms" of 300 MWt (2 projects 2x300 MWt) is expected

In the world: widely used.

Social and economic benefits:

- Social benefits are an available autonomous power source for domestic and economic needs, improvement of life-support quality in isolated areas.
- Economic benefits - the power supply from existing electric grids for several kilometers often turns out to be much more expensive. In many cases the reception capacity of electric transmission lines may be exhausted and the grids should be reconstructed.

- To realize the decisions made by the President of the country, "NAK "Kazatomprom" JC has established an affiliated enterprise - "Ecoenergomash" LTD and adopted the program on wind power development securing the opportunity for creation of new international alliances with larger technological companies of the world and expansion of the business through "NAK "Kazatomprom" JC operation regions in the world.
- The creation of a new branch - energy machine building to produce innovation products - wind turbines, power generators, power and auxiliary electric equipment for power systems of wide capacity range to supply power for autonomous users and to generate power for local and central power systems is envisaged in the Republic of Kazakhstan.

Environmental benefits:

Environmental benefits include emission reduction, reduction of impact on the climate, natural resources saving.

Technology potential

According to the Program on Forced-innovative Development for 2010-2014, the share of renewable energy sources in the national energy system should increase by 1%-5% by 2024. Kazakhstan should enlarge the use of renewable energy sources including "wind farms". In the opinion of the experts, the wind power potential in Kazakhstan may reach 1820 bln kilowatt-hours per annum.

In the Republic of Kazakhstan nearly in all areas there is great wind power potential and many areas may be considered to be gigantic "deposits" of wind power:

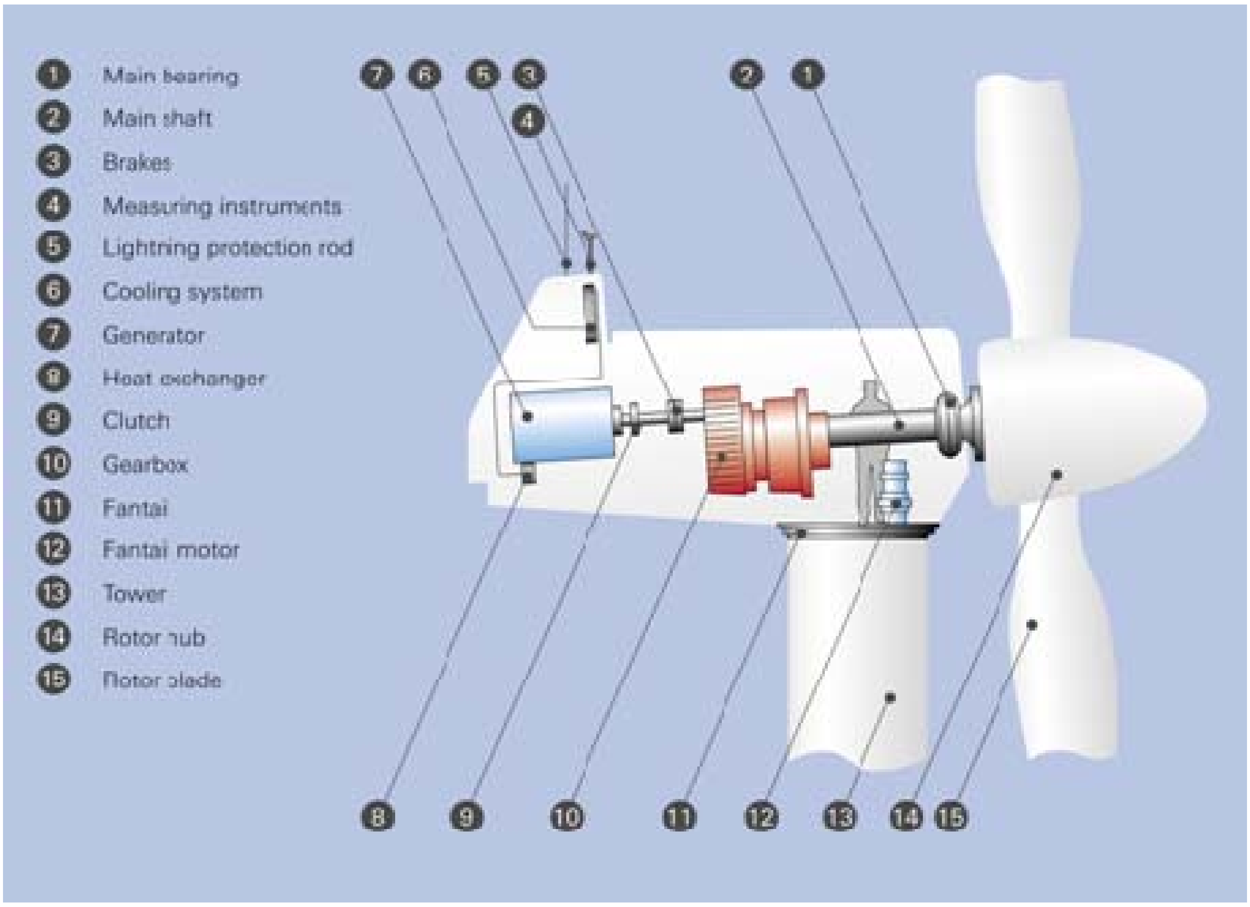
- Dzhungar gates (Almaty region)
- Shelek corridor (Almaty region)
- Yereymentau (Akmola region)
- Astana
- Shevchenko Fort (Mangistau region)
- Atyrau
- Arkalyk (Kostanay region)
- Korday (Zhambyl region)

Reduction of GHG emissions:

If to assume that the wind power potential has been defined correctly, we can calculate that Kazakhstan may reduce the emissions approximately by 1456 mln tons of CO_2 that is considerably more than it has ever been in Kazakhstan.

Barriers:

- The law is of indirect application and refers to bylaws;
- Additional bureaucratic obstacles in agreement process of WPS projects;
- Lack of incentives in the use of small WPS installations by the population for their own needs;
- The winds on the whole territory of Kazakhstan are characterized by high turbulence, frequent change of the direction and speed that leads to reduction of power generation efficiency.



1.1.5 Substitution of fuel: from coal to natural gas

Status

In Kazakhstan: Presently, natural gas is used instead of coal at one of the power plants in Almaty city. This is a pilot project.

In the world: widely used

Social and economic benefits:

- At transition of power plants from coal to gas not only a fuel prime power cost part (its share is over 50 %) decreases, but also nearly all elements of other expenses become less. So, at transition of a power plant to gas, the efficiency of boilers use increases owing to zero slag and reduction of a number of stops. The transition of power plants to gas allows avoiding the costs for fuel delivery and preparation, for filling in grinder balls, for coal grinders, for water for hydroashremoval and cleaning of smoke gasses. No costs for maintenance of the administrative-management personnel and workers of a fuel-transport shop and partly of a boiler shop are required. The costs for maintenance of the fixed assets and their repair are reduced. The power consumption for own needs becomes lower.
- At transition of a power plant to gas the fuel losses related to its storage at storage facilities are also reduced.
- The level of vibration and noise (68-70 dB) at gas power plants is the least that enables their optimum location in direct vicinity to a final energy consumer that, in turn, leads to zero losses in electric transmission lines and a heat network.

Environmental benefits:

The transition of power plants, boilers, industrial enterprises and stoves in apartment buildings to gas heating will lead to sharp reduction of air and environmental pollution in populated areas.

When using gaseous fuel, compared to coal, only four substances are emitted: nitrogen dioxide, nitrogen oxide, sulfur dioxide, benzpyrene.

In relation to the level of impact on the environment the gas power plants correspond to the strictest world standards including Russian standards, California CARB, German norms TA–Luft, ½TA–Luft.

Technology potential

The technology has a great market potential in the world. In Kazakhstan about 75% of energy is generated at coal power plants. The use of natural gas will have a good potential.

Barriers:

There is a problem on natural gas transporting. The particularity of electric power systems is territorial isolation of power sources from deposits.

1.1.6. ***Atomic energy***

The only atomic power plant in Kazakhstan was located in Aktau city with a reactor on fast neutrons of the capacity of 350 MWt. The APP was in operation in 1973-1999. At present the atomic energy is not used in Kazakhstan in spite of the fact that the estimated resources (according to the data of IAEA) of the uranium in the country reach 900 thousand tons. The main deposits are located in the south of Kazakhstan (SKR and Kyzylorda region), in the west in Mangystau and in the north of Kazakhstan (Semizbay deposit).

Presently, an issue on the construction of a new atomic power plant of 600 MWt in Aktau is being considered. About 5 exploratory nucleus reactors are operating in the country.

Status

In Kazakhstan: There is an atomic power plant in the west of Kazakhstan. The power was used for marine water desalination**.**

In the world: widely used.

Social and economic benefits:

- The own developed uranium mining and processing industry;
- The implementation of the "Kazatomprom" Holding strategy on the establishment of a company with a full nuclear fuel cycle will allow securing the Kazakhstan atomic energy with nuclear fuel produced in the country. This will enable to impose a low tariff for electric power;
- The national system of nuclear and radiation safety integrated in IAEA;
- The most significant advantage of the nuclear energy is economic attractiveness of the tariff and stability of prices for electric power for a long period;
- The development of atomic energy will contribute to energy security of the country, which in prospect may not be achieved without diversification of energy generation. This will allow considerably reducing or completely eliminating the dependency from electric power import that in the conditions of expected fluctuations of prices for raw material and forecasted frequentative growth of demand for electric power is considered to be a great advantage;
- The development of atomic energy will objectively lead to increase of the technological level of domestic machine-building and strengthening of the research potential of the country
- The construction of APP will allow creating a great number of new jobs
- The ensuring of energy resources will allow securing sustainable social-economic development in the region of Kazakhstan.

- The industrial enterprises will be integrated into international cooperation on production of the equipment for APPs.
- In Kazakhstan there are skilled personnel, which maintained steady operation of the experimental-industrial reactor on fast neutrons BN-350, the first one in the world, for a quarter of a century. Since 1999 the reactor has been being removed from operation;
- The opportunities of the Customs Union will allow expanding the foreign market for consumers of Kazakhstan's atomic industry products.
- The entering of Kazakhstan in a number of 50 competitive countries of the world that develop atomic energy;
- Location near China and RF - the most dynamically developing markets on civil atomic energy;

Environmental benefits:

The atomic energy does not make impact on the climate;
Currently, the APP is one of the most environmentally safe power producers. The nuclear energy will allow increasing the volume of generated power without impact on the ecological balance. This will lead to zero additional hazardous emissions into the atmosphere and will allow implementing the international obligations on the solution of global environmental problems;

Technology potential

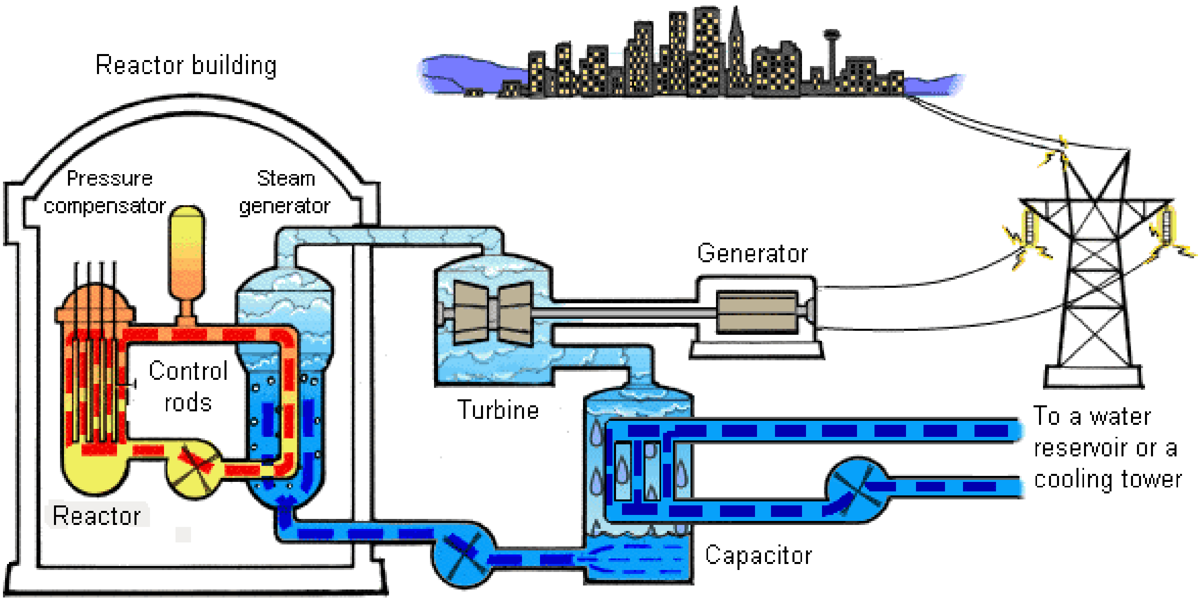
- Strengthening the export potential of Kazakhstan (the electric power, uranium and metallurgical products, organic fuel);
- Securing of industrial-innovative development of the economy of the country through the development and introduction of scientifically based nuclear energy technologies;
- Improvement of ecological safety of the energy sector through the reduction of hazardous substances emissions into the environment at APP operation;

Barriers:

Financial barriers include very high initial investments required for APP construction;
Storage facilities for nuclear wastes are required.
A problem on nuclear waste utilization.

There is a danger of possible disastrous accidents at the reactor, as well as of a really not solved problem of nuclear waste utilization and release of small radioactive amount into the environment.

The scheme of an APP



1.2. Priority subsector: Cement industry

1.2.1 Energy saving and improvement of energy efficicency in the cement production process.

The methods on energy saving are being intensively searched for at cement plants, the main of them is reduction of fuel consumption for clinker kilning. At the average consumption of fuel for clinker kilning in Europe is 102 kg c.f./t cl., but technological coefficient of efficiency at cement production process is about 67%, moreover the main losses are related to clinker heat and gasses at transition from a heat-technological device and the heat lost in the kiln. In Kazakhstan the wet process of cement production is the main widely used process, so the fuel consumption is two times exceeds the amount consumed in Europe.

The following activities on energy saving are currently implemented at the production process in European countries:

- the use of alternative fuel types (various production and human life activity wastes), which at the average are 5% of the total fuel consumption in Europe, and in some countries reach 15-20%;
- heat energy and electric power generation at enterprises using gas turbine installations, transition from electric motors of grinding and draught equipment to gas engines;
- use of natural gas for electricity generation from the energy released at gas distribution stations at its throttling (reduction of pressure);
- increasing of compaction hermetic properties on hot and cold edges of kilns;
- rational combustion of fuel in a kiln, reduction of excessive air rate at its intensive mixing with fuel;

modernization of burner equipping of cement kilns to regulate the form and intensity of gas flame, along with that the specific fuel consumption 3-7% decreases, and the capacity increases by 10%.

Status
In Kazakhstan: on the stage of feasibility study
In the world: widely used

Social and economic benefits:

Ensuring annual reduction of costs for acquisition of raw materials, energy resources consumption and enterprise's payments for public utilities and securing incentives and support from the state.

Technology implies business development, training in energy saving methods, undertaking activities on energy saving and improvement of energy efficiency and re-equipment of the production facilities. All this will allow creating additional jobs.

Enabling the environment for the development of an energy services market on the territory of the country.

- Development of research and innovative activity focused on the development and introduction of energy efficient technologies;
- Awareness raising and formation of energy saving behavior at production enterprises;

Training and development of the staff potential in the field of energy saving and improvement of energy efficiency

Environmental benefits:

- Improvement of ecological indicators for the habitat through creation of new generating facilities using renewable energy sources and development of alternative fuel types.

- Energy resources saving through introduction of energy saving activities.
- Conservation of water resources.

Technology potential

- The national legislation focused on the reduction of energy consumption and improvement of energy efficiency has been adopted In Kazakhstan.
- In Kazakhstan there are 5 major cement plants and a number of small ones.
- According to the UNDP estimates the potential on energy saving in Kazakhstan is 25-30% of currently used energy resources.

Barriers:

- **Political and legislative barriers** include: separation of powers between agencies, outdated requirements, inefficient realization of regulatory-legal documents in the field of power supply and construction and insufficient financial support of the activities on the improvement of energy efficiency;
- **Technical and market related barriers**: insufficient availability on the market and low competitiveness of goods allowing improving the energy efficiency in a production process;

The informational barriers include lack of the knowledge about the best practices and advanced technologies among specialists in the construction sector and inability of the broad public to define the energy efficiency of buildings and goods.

1.2.2. Transition from a “wet” to “dry’ process of cement production.

The cement production process consists mainly of the following main operations: mining of raw material; preparation of raw material mixture including crushing, grinding and averaging of its composition; kilning of raw materials mixture (clinker creation); clinker grinding to have fine powder.

Depending on the type of raw material preparation to kilning there are wet, dry and combined process of cement clinker production. When using the wet production process the raw materials are crushed, mixed and averaged and the raw material mixture is corrected using certain amount of water, at the dry process dry materials are used at all mentioned operations.

At present the majority of cement producers in Kazakhstan apply the "wet" process, the prime cost of which is 25% exceeds the production cost of the "dry" process.

Status

In Kazakhstan: on the stage of feasibility study
In the world: widely used.

Social and economic benefits:

The volume of kiln gasses at the dry process is 35-40% less than at the wet process under the same kiln capacity. Because of that the costs for dedusting of kiln gasses are lower.

The kilns of the dry process need less metal and material, in contrast with the kilns of the wet process of the same capacity. Short kilns with cyclone heat exchangers (Ø 5x75 m; Ø 6,4 ; 7,0x95 m) are used at the dry process, and at the wet process long kilns (Ø 5x185 m ; Ø 7x230 m) are used.

Implementation of the technology envisages creation of new jobs on the labor market.

Qualified staff is required to construct a new cement line and to operate and maintain the installed equipment. This will lead to direct and indirect employment of the population.

Along with economy the dry process will allow considerably improving labor conditions and ecological condition of the industrial zone.

Environmental benefits:

The reduction of water consumption. In the conditions of water defect (particularly in south regions) there is no need in its consumption to prepare raw material slag.

The reduction of energy consumption. At the dry process the heat consumption for kilning is 2900-3750 kJ/kg clinker, at the wet process - 5400-6700 kJ/kg.

The reduction of CO_2 emissions in the atmosphere. When applying the dry process there is an opportunity for usage of hot waste gasses for raw material drying at its grinding in ball grinders.

Technology potential

- Kazakhstan will introduce the system for the trading of emission quotas in the beginning of 2013, and will urgently call to companies, which construct new cement plants, to calculate the emissions and use the best available technologies;
- The national legislation focused on the reduction of energy consumption and improvement of energy efficiency has been adopted In Kazakhstan;
- In Kazakhstan there are 5 major cement plants and a number of small ones.

Barriers:

- **A technological barrier**. The opportunities of the dry process are considerably limited by raw material source moisture, since the material can be crushed in the existing grinders at the moisture of no more than 1%. So, crushing of the source material with moisture of 20 - 25% require considerable heat consumption for drying.
- **An ecological barrier**. At the dry process, it is more difficult to secure sanitary conditions and environmental protection as a result of dusting the material.
- **Seasonal nature of demand**. In the summer season the cement plants are operating in a frantic rush and cannot recoup the lost volume of cement production in the winter season. As a result of that the demand in the warm period is extremely high, and accordingly the prices for cement are too high at that time.
- **The need in state regulation**. The main part of the laws regulating the relations on the construction market is focused on the incentives for demand, but practically it does not solve the problems concerning the offer on the real estate market at all, particular there are no incentives for investments in the production of construction materials.
- **A financial barrier**. Investments are required.

1.2.3. Substitution of fossil fuel for wastes or biomass in the cement production process

The wastes are the energy raw material, which are becoming more and more important in the world. The generation of energy from wastes is of great importance, since the amount of wastes to be taken to a landfill decreases.

Approximately one third of wastes consist of organic materials that may be incinerated both from the point of view of energy and from the point of view of ecology.

The biomass. When the prices for fossil fuel are growing, the wastes of biomass are becoming an alternative fuel allowing reducing the costs for energy. Moreover, this is a renewable energy source the production of which results in the least emission amount in the atmosphere.

The biomass may be used in landfills, where the products are decomposed. When decomposing, the wastes emit the methane. The pipes put inside a landfill can collect the gas received from the biomass. Then it is used for power generation. This type of biomass is called the landfill gas.

Status

In Kazakhstan: not used

In the world: The plants in Belgium, France, Germany, Netherlands and Switzerland have reached the average substitution indicators from 35% to 70%.

Social and economic benefits:

The use of wastes and biomass as a fuel may allow solving the problem of overfilled solid and domestic wastes sites and reducing the load on the ecosystem of large cities.

The economic development of agricultural areas both in developed and developing countries is one of the advantages of biomass use. New financial revenues may lead to further development of the local economy. Finally, this leads to a lower rate of migration to cities that is very important for many regions.

The use of wastes may allow solving the problem of large cities, where the issue on solid and domestic wastes site is urgent.

Increase of the number of jobs and industrial growth may be enormous.

Construction of plants using wastes as a fuel may allow solving the problem of landfills in densely populated areas.

This will allow considerably improving the health and the life quality of the population. The modernization of cement kilns will also allow avoiding a serious danger for human health related to the work at the existing installation operating with use of coal and a high level of emissions of hazardous substances, smoke, dust and noise.

Environmental benefits:

The use of biomass will lead to the reduction of methane emissions from anaerobic decomposition of wood at dumps and zero impact of such wood dumps on the environment, in particular, on ground waters.

The use of kilns for wood biomass will considerably reduce sulfuric and phosphoric emissions, the major pollutants emitted from usual kilns in the cement production process.

Technology potential

• There are urgent problems with wastes in the cities of Kazakhstan. The use of them for cement preparation will allow improving the environmental conditions and the situation in the social sphere.

• The national laws focused on the reduction of power consumption and improvement of energy saving and energy efficiency have been adopted. The companies have to reduce the power consumption.

Barriers:

The changeable quality of fuel based on wastes destabilizes the combustion process. Besides, the restrictions related to wastes incineration are much stricter compared to coal combustion. So, there are new tasks for automated systems focused on securing stable cement quality and ensuring the observance of legislative restrictions for operation conditions.

The cement kilns are designed, first of all, for production of clinker and not all operation conditions corresponding to the production of an appropriate clinker product are ideal for waste disposal; for instance, in cement kilns the levels of waste oxygen are usually lower and the levels of carbon monoxide are higher compared to duly operated installations for incineration.

One of the main barriers is the legislative base. It is difficult for businessmen to get a license for the use of wastes. The state policy in the field of recycling and utilization of wastes is poorly developed. One more barrier is the habit of cement producers to use outdated technologies and the lack of their awareness about new production processes.

1.2.4 Carbon capture and storage (CCS) in cement industry.

The large-scale reduction of greenhouse gasses requires introduction of the whole number of latest technologies focused on the improvement of energy efficiency of fossil fuel combustion and CO_2 capture and storage everywhere. Since in the nearest future the coal will remain to be one of the most important energy resources in the world, the technologies on CO_2 capture and storage is one of the most important ones for the reduction of hazardous emissions.

The capture and storage of carbon dioxide (CO_2) - CCS – is a process including CO_2 separation from industrial and energy sources, transportation to a storage site and long-term isolation from the atmosphere.

Status
In Kazakhstan: *not used*
In the world: *a small number of plants.*

Social and economic benefits:
The reduction of payments for carbon oxide emissions in the atmosphere.

The application of the technology, assemblage and maintenance of CCS installations as well as construction and operation of pipe lines envisages attraction of a great number of specialists.

Environmental benefits:
The available technology allows capturing 85-95 % CO_2 moved through a separator.

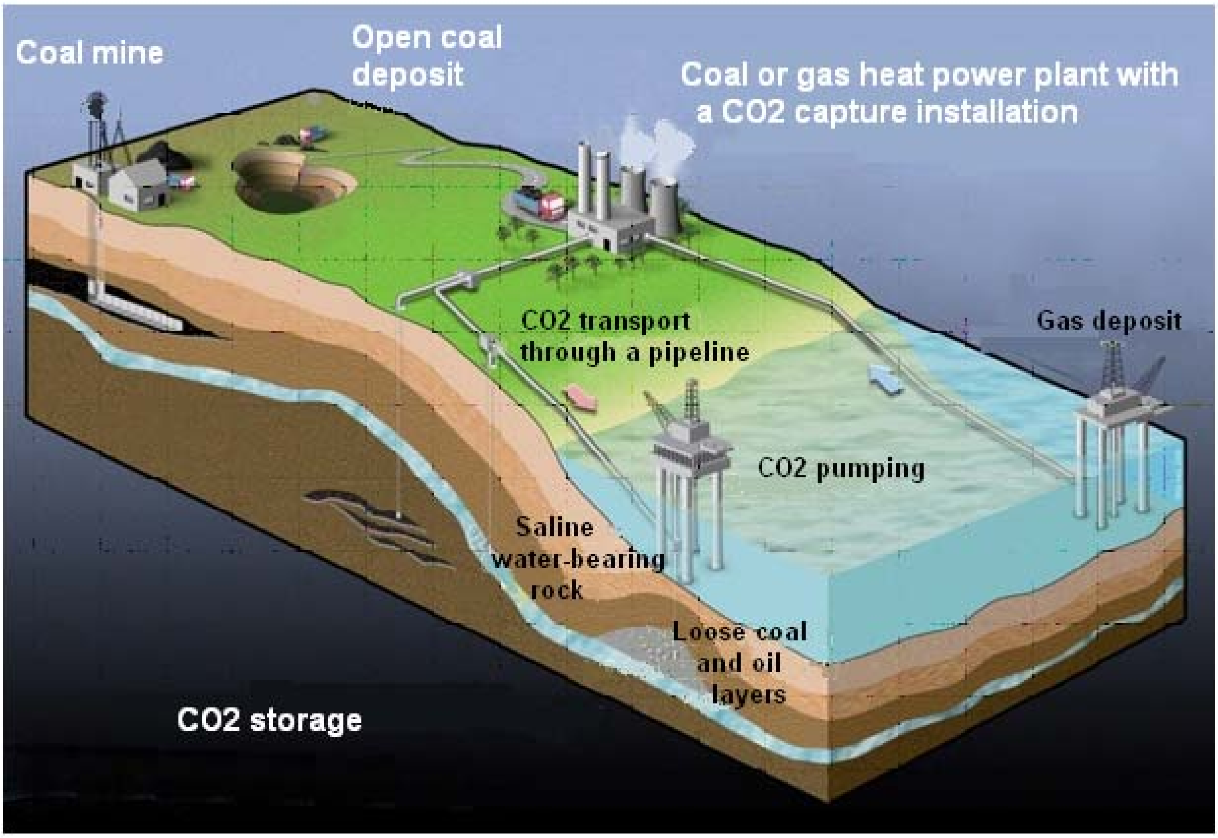
A cement kiln equipped with an CCS system (with an outlet to a geological storage site or storage in an ocean) will require the energy of approximately over 10-40 % in contrast with the installation of the same capacity without CCS, along with that the major volume of energy is used for capture and compression. In relation to safe storage the net result means that a cement kiln with CCS may lead to the reduction of CO_2 emissions in the atmosphere approximately by 80-90 % compared to the installation without CCS.

In the following 100 years CCS may precondition the reduction of costs for mitigation of climate change impacts by 30% and over.

Technology potential
There is an opportunity for the use of the technology in the west of the country with an available gasmain network suitable for transportation of captured CO_2 and oil wells to store CO_2.

Barriers:
- The cost of capture technology. At present it exceeds the costs for carbon dioxide emissions payment.
- Lack of public awareness.
- Unsolved issues concerning the CCS infrastructure.
- Lack of clarity in legal and regulatory issues.

The scheme of carbon capture and storage on the example of a heat PP.



1.2.5. Blast-furnace slag in the cement production process

The value of the blast-furnace slag as the raw material is recognized in practice. At present, it is processed to receive a useful product: granulated slag (granslag), cement, macadam, pumice, mineral cotton, casting, paving stones and other products as well as high alumina macadam at all metallurgical enterprises.

Status

In Kazakhstan: not used

In the world: In many countries the slag is used for cement production, for instance, at present in China the slag is considered to be a useful resource.

Social and economic benefits:

The costs for cement production are considerably reduced through energy saving and plenty of cheap blast-furnace slag.

When blast-furnace slag is used considerable energy saving is achieved owing to low temperature of blast-furnace slag melting and because crushing or spraying of the blast-furnace slag is not required.

The transition of cement production to new technologies will allow creating new jobs.

The application of the blast-furnace slag in the cement production process may lead to the reduction of prices for products and improvement of environmental situation in the areas, where slag dumps are located.

The cement production will be growing; it will be used as construction material for infrastructure development. The new roads and superhighways will allow increasing the employment level. This will also enable the environment for commercial activity for local businessmen, bankers/consultants, suppliers/producers, contractor and etc.

Environmental benefits:

- Improvement of environmental conditions as a result of low content of volatile substances in the blast-furnace slag.
- The blast-furnace slag utilization will contribute to the improvement of environmental conditions, since it allows securing the important sphere of application of a great amount of available blast-furnace slag and avoiding any so called problems of blast-furnace slag disposal.
- The application of slag in the cement industry leads to the reduction of the volume of raw material mining.
- The reduction of technological dump areas.

The emissions of volatile materials from a revolving furnace are decreasing, since the blast-furnace slag is subjected to preliminary thermal processing, when the major amount of volatile materials i.e. carbon dioxide, carbon, volatile organic compounds and etc. are removed.

Technology potential

The slag dumps are usually very distributed in energy generating areas and in industrial cities. All this may be used for cement production.

The cement production is a rapidly growing sector with good potential. This will lead to the problem of raw material for cement production and the use of the technology will allow solving the problem.

Barriers:

- Lack of technical skill and scientific approach;
- No opportunity for observing the practice and technologies applied in a real situation.

Annex II. Lists of stakeholders

Project Steering Committee

	Name/Surname	Field of expertise / position	Contact information
1.			
2.	**Tolebay Adilov**	Director of Department of Kyoto Protocol, Ministry of Environment protection RK	+7 7172 740258
3.	**Bekbergen Kerey**	Head of Strategic Planning, Department of Environmental Policy and Sustainable Development of MEP RK	+7 7172 740077
4.	**Albert Askarov**	Head of the Health Surveillance, Committee of the State Sanitary and Epidemiological Surveillance of Ministry of public health of RK	+7 7172 743446
5.	**Kairat Baimukhametov**	Head of the Chemical and Pharmaceutical Industries, Industry Committee, MINT RK	+7 7172 244908
6.	**Bolat Aldabergenov**	Chief expert of strategic planning and development of transport and communication complex of Ministry of Transport and communications of RK	+7 7172 243294
7.	**Bota Adilova**	Expert of fisheries of water biological resources, Fishery Committee of the Ministry of Agriculture of RK	+7 7172 555995
8.	**Asel Yntymakova**	Expert of the waste management of production and consumption, MEP RK	+7 7172 741253
9.	**Almas Shyntemirov**	Senior Manager of the Directorate of Science Project, Nazarbayev University	+7 7172 70(6154)
10.	**Valentina Kryukova**	Director of PF“Climate Change Coordination Centre”	+7 7172 717170
11.	**Egorov Sergey**	Head of management of technogenic character Emergency Prevention Department, Ministry of emergency situations of RK	+7 7172 602105
12.	**Gulden Okatayeva**	Expert of management of technogenic character Emergency Prevention Department, Ministry of emergency situations of RK	+7 7172 602105

List of stakeholders
involved in interview in selection of technologies

	Name/Surname	Field of expertise / position	Contact information
1.	Kanat Baigarin	Nazarbayev University, National Focal Point, Advisor of Minister of MEP RK	+7 7172 70 60 07
2.	Gulmira Sergazina	Ministry of Environment protection, Director of Department	+7 7172 74 02 58
3.	Ainur Sospanova	Ministry of Environment protection, Director of Department	+7 7172 74 02 59
4.	Aiymgul Ismagulova	Nazarbayev Uneversity, spesilist	+7 7172 70 60 07
5.	Ludmila Shabanova	Information Analitical Center	+7 7172 79 96 41
6.	Irina Yesserkepova	Kazakh scientific institute on ecology and climate	+7 7272 55 84 24
7.	Aleksyi Cherednichenko	Kazakh scientific institute on ecology and climate	+7 7272 55 84 48
8.	Aida Makazhanova	Ministry of Environment protection	+7 7172 74 08 74
9.	Dinara Dauletova	Ministry of Environment protection	+7 7172 74 08 74
10.	Saulet Sakenov	Manager of Third National Communication of the RK under UNFCCC	+ 7 7172 90 16 69
11.	Syrym Nurgaliev	Manager of UNDP project on energy efficiency	+7 7172 58 09 39

Annex III: Applying MCDA

Applying MCDA: Detailed steps
1. Establish the decision context. 1.1 Establish aims of the MCDA, and identify decision makers and other key players. 1.2 Design the socio-technical system for conducting the MCDA. 1.3 Consider the context of the appraisal. 2. Identify the options to be appraised. 3. Identify objectives and criteria. 3.1 Identify criteria for assessing the consequences of each option. 3.2 Organise the criteria by clustering them under high-level and lower-level objectives in a hierarchy. 4. 'Scoring'. Assess the expected performance of each option against the criteria. Then assess the value associated with the consequences of each option for each criterion. 4.1 Describe the consequences of the options. 4.2 Score the options on the criteria. 4.3 Check the consistency of the scores on each criterion. 5. 'Weighting'. Assign weights for each of the criterion to reflect their relative importance to the decision. 6. Combine the weights and scores for each option to derive an overall value. 6.1 Calculate overall weighted scores at each level in the hierarchy. 6.2 Calculate overall weighted scores. 7. Examine the results. 8. Sensitivity analysis. 8.1 Conduct a sensitivity analysis: do other preferences or weights affect the overall ordering of the options? 8.2 Look at the advantage and disadvantages of selected options, and compare pairs of options. 8.3 Create possible new options that might be better than those iriginally considered. 8.4 Repeat the above steps until a 'requisite' model is obtained.

Source: Chapter 6, Multi Criteria Handbook