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Feasibility of Wind Energy Development in Kazakhstan
Technical-Economical Analysis of Wind Farm Construction in the Almaty Region

MSc Energy Systems and the Environment

Erik Danayev 2008

Copyright Declaration

Acknowledgement

First of all, I want to praise God for all His rewards and leading me to this research.

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In the name of God, the most beneficent, the most merciful

Abstract

The purpose of this work is to research the current potential for the development of wind energy in Kazakhstan. It examines whether it would be attractive for foreign investors to build a wind farm in the country and what state licenses and permits would be required for this.
As a background to this project, this document provides information about the country, its political and economical situation, and state mechanisms of investments support. For wind energy, it provides a comprehensive survey of the potential in the country. It reviews the electrical energy market of the country, providing electrical energy production and consumption data. It describes what is being done to develop the renewable energy sector in Kazakhstan, and what barriers to progress presently exist. It describes the features of the electrical grid infrastructure that might be relevant for potential wind farm developers, and also identifies the special territories that are under state protection where construction of wind farms is not allowed.

As a case study, a site was chosen for potential wind farm construction, selected on the basis of quality of wind resource and proximity to consumers. Calculations were made of its wind resource and potential annual energy yield. The predictions were adjusted for expected losses and uncertainties associated with the energy yield, and used as inputs to an economic analysis of the project. A detailed examination was also made of the site environmental assessment issues, and the state licensing and permitting requirements pertaining to the development of the wind farm. The conclusions were that the present low cost of energy in Kazakhstan would make it very difficult to justify a wind farm on purely economic grounds. But if financial incentives appear as part of a national policy to improve environmental performance, as seems likely, the picture will change.

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List of abbreviations

The RoK - The Republic of Kazakhstan

GDP - Gross domestic product

GHG - green house gasses

CO2 – carbon dioxide

USSR - Union of Soviet Socialist Republics

UNFCCC - United Nations Framework Convention on Climate Change

UNDP - United Nations Development Program

RoK ME&MR - RoK Ministry of Energy and Mineral Resources

GEF - Global Environmental Fund

KSSR - Kazakh Soviet Social Republic

CP - communist party

NPF - National Petroleum Fund

CPC - Caspian Pipeline Consortium

BTG – (Aktau)-Baku-Tbilisi-Geyhan

MPC - maximum permissible concentrations

UNDP - United Nations Development Program

WSp - Wind Speed

W Dir – Wind Direction

SCCCC - State Climate Change Coordination Center

The RoK ARNM – The RoK Agency on Regulation of Natural Monopolies

KEGOK – Kazakhstan Electrical Grid Operating Company

APC – Almaty Power Consolidated

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Introduction

The Republic of Kazakhstan (RoK) is one of the rapidly developing and youngest independent countries in the world. The formation of the modern Kazakhstan and its nationality has gone through a very long history.

Today, it is a country with multiethnic citizenship that values principles of democracy, equal rights and freedom of all its citizens, and aims to stable social-economical development and building of good intergovernmental relationships around the world.

The country used to play important role in the Union of Soviet Socialist Republics (USSR). Its economy was damaged when USSR collapsed and it has undergone significant changes to recover since obtaining independence.

Kazakhstan has got rich mineral resources and well developed mining and production industries.

Starting from relatively recent time, it has achieved stable economical development mainly due to intensifying of oil and gas capital inflows. Gross domestic product (GDP) has been constantly growing.

The RoK has introduced legislation to stimulate investments, both foreign and domestic. Large international companies invested billions into the Kazakhstan's mining and production sectors.

The country has got a lot of serious unresolved global and domestic environmental issues and they need to be addressed as soon as possible. One of the means of addressing the environmental issues could be developing renewable energy production such as wind power.

Kazakhstan has approved the United Nations Framework Convention on Climate Change (UNFCCC) and it is going to approve Kyoto Protocol. Therefore it needs to improve its energy efficiency to protect environment and provide sustainable economical development.

A number of international organizations including Global Environmental Fund (GEF) and United Nations Development Program (UNDP), together with the RoK Government (represented by the RoK Ministry of Energy and Mineral Resources (RoK ME&MR)), institute Kazselenrgoproject are currently involved into discovering of wind power opportunities in Kazakhstan.

The governmental support is very important point to facilitate the studies and allow soonest development of the first wind farms in Kazakhstan, which tells that the issue is being addressed seriously.

The international interest and support of soonest development of wind energy in Kazakhstan is not only due to the GHG emissions concern only but also because it could be prospectively a good opportunity of making business in the new sector based on the positive experience of partnership with Kazakhstan in other sectors.

It is known that Kazakhstan has got significant wind resources. More than half of its territory has average annual wind speeds of more than 4 m/s at 10 m height. The territory of the country is the ninth largest in the world and presents very good opportunities to install a lot of wind power generating capacities and utilize the wind resources properly.

According to approximate estimations the overall wind energy resources of Kazakhstan are 1820 TWh/year. The maximum total installed wind energy generating capacity could be about 3500 MW with annual production of 8-9 TWh [44].

However these numbers are not ultimate. Each site potentially suitable for construction of a wind farm in Kazakhstan needs to be studied in particular to make proper estimation of its wind resource and predicted energy production; to find out about available infrastructure, potential consumers and energy prices within the region, suitability to build the wind farm at the site in term of environmental impact. These are the main issues to be addressed.

This study has chosen Chilik Corridor area for analysis of its wind resource and feasibility of a wind farm construction here. The metering of wind speeds and other parameters at this place were performed under the currently acting wind monitoring program conducted by the UNDP and the RoK Government. This program is aimed to conduct metering of wind energy parameters around the country and will give better estimation of the overall wind energy potential upon completion.

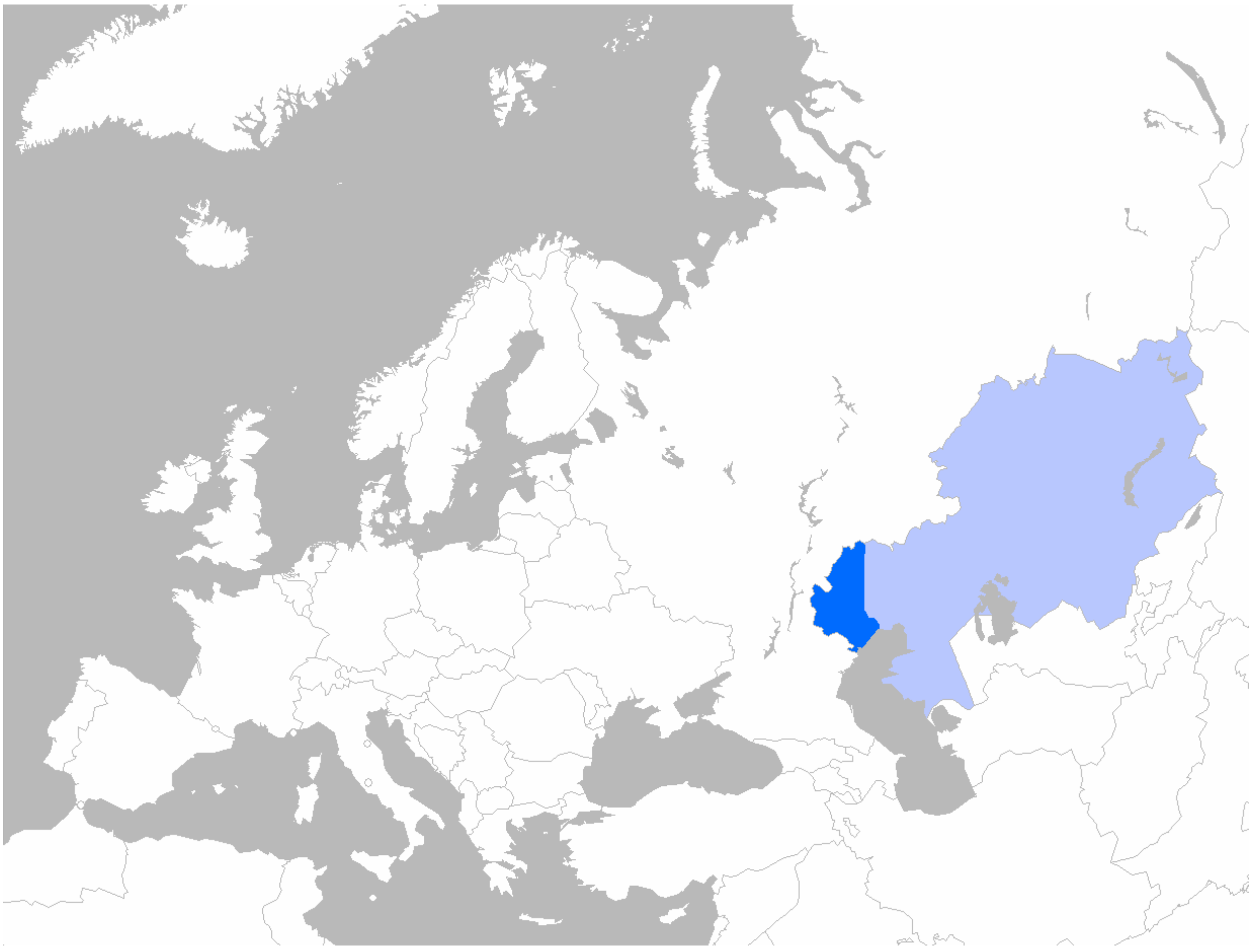
The primary purpose of this research is to provide technical-economical analysis for potentially interested wind energy companies in the UK. However since a professional technical-economical justification of wind farm construction in the Chilik Corridor had not previously been done, the author hopes that the work provides a good resource for people working on wind energy development matters in Kazakhstan as well.

1. About Kazakhstan

1.1 General Information about the Country and its Current Political Situation

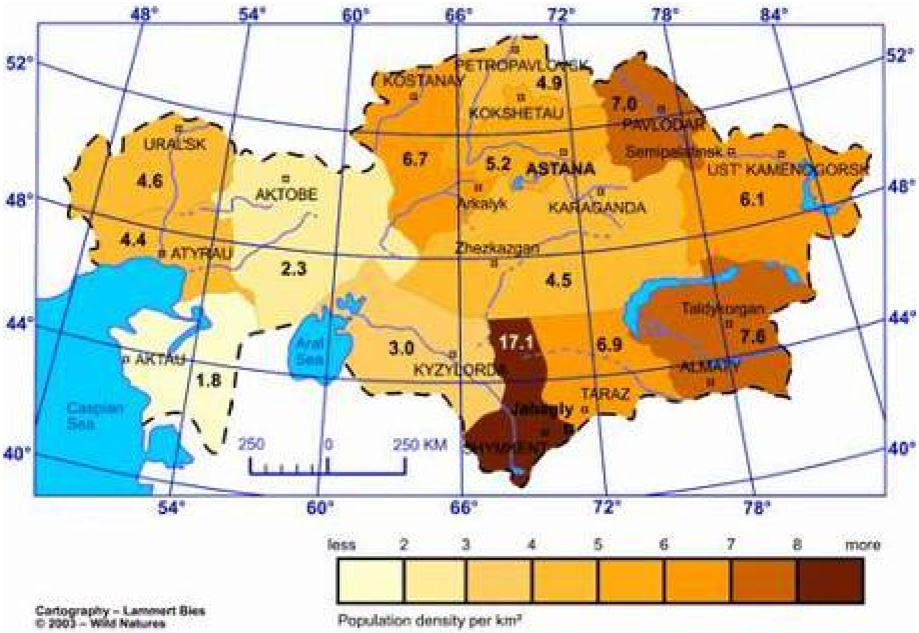
The RoK is a land locked country located in the middle of the Eurasian continent. Its geographical coordinates are in between 39059` -55049` of the northern latitudes and 46028`-87018` of the eastern longitudes. The country has the entire northern border common with Russia, common border with China at the east, the southern borders with Kyrgyzstan, Uzbekistan and Turkmenistan, and the Caspian seashore at the west.

The overall area of the RoK territory is 2,724.9 million square kilometers [1], which would take about 30-35% of the all Western European countries together. This makes Kazakhstan is the ninth largest country in the world and the largest country in Central Asia. Approximately 7-10% of the Kazakhstan area is located in the European part of the Eurasian continent (oil rich western part of the Atyrau province and the West Kazakhstan province) but the major territory is in Asia.



Picture 1.1 - Kazakhstan in the Eurasia [2]

However the population of the country is not high, with the latest estimation of 15.64 million people. Having the huge land territory, Kazakhstan has one of the lowest population densities in the world, with 5.5/km²[1]. The population distribution around the country is not even: the southern regions have highest population density, northern parts have rather fewer inhabitants, and the central parts are the least populated.



Picture 1.2 – Kazakhstan-Population Density[3]

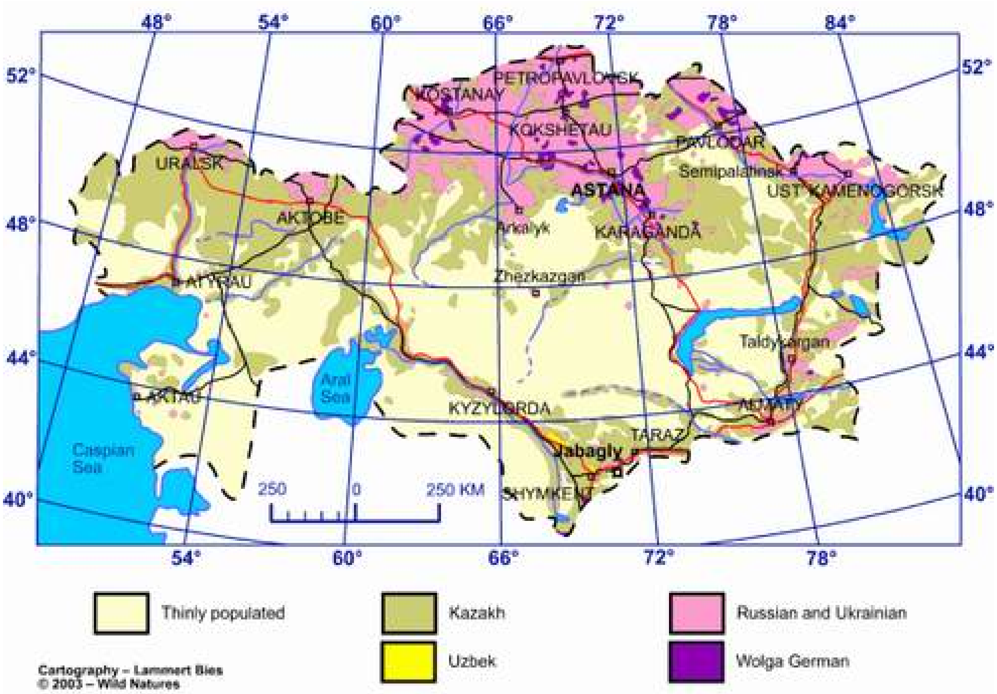
Kazakhstan has administrative divisions consisting of 14 provinces (oblasts) and 3 cities under local control – Astana, Almaty and Baikonur.

Picture 1.3 – Kazakhstan-Administrative Divisions [2]

The capital of RoK is Astana city established on the place of the former USSR workers` town called Celinograd, which was named Akmola after the Soviet collapse. This is a newly growing city with current population of 613.8 thousand people and planned future population growth up to 1.5 million people [1]. Astana received the official status of the RoK capital in 1997, when the capital was moved from Almaty.

Almaty is the largest city and the financial center in Kazakhstan with officially registered population of 1.324 million [5]. The next major regional cities and towns in Kazakhstan are Karaganda (600 thousand people), Shymkent (450 thousand people), Pavlodar (350 thousand people) and Semipalatinsk (350 thousand people).

Kazakhstan is a multinational country. The major ethnic composition of the Kazakhstan citizens is the following: Kazakhs - 57%, Russians – 30%, Ukrainians – 3.7%, Germans – 2.4%, Uzbeks – 2.5%, Tatars – 1.9% and about 2.5% are Turks, Kurds, Jewish, Koreans, Chechens, Greeks and others.



Picture 1.4 – Kazakhstan-Major Ethnic Groups in1990 [3]

All of the non-indigenous ethnic groups have equal rights to the Kazakhs and all of them are free to keep their traditions and historic culture. Normally each ethnic group has its official cultural centers or temples depending on their religion. Choice of belief is free in Kazakhstan, each citizen has right to choose his or her religion. In general, the majority faiths are the following: Sunni Muslims - about 50%, Christian Orthodox - around 40%, Christian Protestants - about 3%, Christian Catholics - about 3%, Judaism and Buddhism - approximately 4%.

1.2 Kazakhstan - History and Policies

1.2.1 Formation of the Kazakh Nationality

The roots of Kazakh nationality hail from the ancient alliances and conflicts between the Turkic and Mongols` tribes who lived in the territory of current Kazakhstan. The ethnic group has numerous tribal divisions and clans. Basically, the roots of Kazakh ethnos lie in the 8^{th} – 6^{th} centuries B.C., when there was a formation of tribal alliances of Sacks, Skifs and Hunnas on the territory of modern Kazakhstan.

The most ancient state in this area was established in the 6^{th} century, in the year 552y. It was an early feudal state called Turkic Kaganat. The written evidences on the first city of Taraz (southern Kazakhstan) are dated in 568.

In the 8^{th} and 9^{th} centuries, Arabs brought Islam to the region.

The states of Karluks and Karakhanids were established in the 9^{th} and 10^{th} centuries correspondingly.

At the beginning of the 13^{th} century, the whole Central Asian region was conquered by the Mongolian tribes controlled by the Khan Shyngys. Some time after the death of Khan Shyngys, his empire was split into hordes and khanates where his descendants took over.

In the 16^{th} century, the first Kazakh khanate was established by the sultans Dzhanibek and Kirey. However, the Kazakh nationality never had a consistent unity. The whole nationality would be divided by Zhuzes (Hordes) living in the different parts of current Kazakhstan. These are known as the Great horde tribes located in the southern territories, the Middle horde tribes in the northern territories, and the Lesser horde tribes who lived in the western areas.

1.2.2 Joining Russia

In 1573, the first Russian diplomatic representatives settled in the Kazakh khanate.

In 1594, Kazakh khanate diplomatic representatives settled in Moscow.

In the 17^{th} century, the first Russian towns Yaitsk (Uralsk) and Gurev (Atyrau) were established in Kazakhstan.

In 1726, khans of the Lesser and the Middle hordes applied for Russian citizenship. In 1731 and 1740, territories of the Lesser horde and a part of the Middle horde were included into Russia correspondingly. The Great horde remained separate until the early 19^{th} century. In 1860s, the whole territory of Kazakhstan was included into the Russian Empire.

In 1854, the fortress of Verny was established in south of the region (modern Almaty).

Up until 1916, there were national liberation movements organized by Kazakh intelligentsia in some hordes against policies of the Russian Tsar and for restoration of independence.

1.2.3 Kazakhstan in the Union of Soviet Socialist Republic

In 1917, the October Revolution in charge of Vladimir Lenin in Russia removed Tsar power.

The First World War and the following civil war completely destroyed the economy of the region. Almost half of the cattle stock died in the winter of 1920-1921. Summer crops in 1921 failed and severe famine struck the region. The economy recovered only by the end of the 1920s.

After the revolution and civil war in 1925, Kazakhstan obtained status of Autonomous Soviet Republic with the capital in Kyzylorda. However the capital was subsequently moved to Alma-Ata (Almaty) in 1929. In 1936, the borders and territory of the current Kazakhstan were defined and the country obtained the status of Soviet Social Republic (SSR). In 1937, the Kazakh SSR (KSSR) adopted its constitution.

The Soviet government approved a plan of accelerated development of the economy in the region and Kazakhstan became a strategic area of industrial and agricultural development in the USSR. Thousands of large industrial facilities were built. Thousands of kilometers of motor and railway roads were laid. The country became a large producer of non-ferrous metals, iron, coal, oil, grain and meat. In 1991, Kazakhstan produced 70% of lead, zinc, tin, titanium, magnesium; 90% of phosphorus and chromium; and more than 60% of silver in the whole USSR [6].

However the economical success of communism was not good at all for Kazakhstan. The collectivization campaign collected the possessions of every farmer, especially rich farmers. The collectivization led to famine in the 1930s. The famine and diseases caused death of 1.5 million people which was about 40 % of the whole nation. Some Kazakh families had to move to China and other Asian countries to avoid collectivization.

In the 1930s, the Soviet leader J. Stalin created prison-camps for involuntary servitude and also forcibly relocated hundreds of thousands of people disagreeable to the Soviet regime. About 120 thousands of Poles were deported from Ukraine SSR and Lithuania SSR from 1935 up until 1940. During the Second World War, Germans were forcibly relocated from the Volga river regions. Chechen, Ingush, Turkish and other ethnic groups were forced to move from the Caucasus during the Second World War.

The tough Soviet system would restrain development of the region therefore people in Kazakhstan supported publicity and openness policy of the Perestroika. On 17 December 1986 in the Republican Square in Almaty, thousands of Kazakh students went out to protest against the decision of the USSR central communist party (CP) to appoint a new leader for the CP of KSSR and remove its previous leader Dinmuhhamed Kunayev. The protest was brutally suppressed by the Soviets; many activists were killed and others strictly prosecuted.

In 1990, the KSSR government started radical reforms. The position of KSSR president was validated in law and Nursultan Nazarbayev was elected as the first president. The Supreme

Soviet of KSSR adopted a Declaration of the State Sovereignty which declared integrity and inviolability of the country borders, the country defined as the entity of international laws, introduced the institution of citizenship and equal rights of citizens; and the rights of a property ownership.

1.2.4 Obtaining Independence

In December 1991, the whole USSR collapsed. On December 16th 1991, the KSSR parliament declared total independence of the Republic of Kazakhstan.

The early 1990s was not an easy period for all people in Kazakhstan. Due to economical difficulties and production stops, many people left Kazakhstan and moved to their ethnical homelands, including millions of Russians.

The first RoK Constitution was adopted in 1993. However this document copied many aspects of the previous KSSR Constitution and was not good enough for a democratic society. Therefore a new RoK Constitution was adopted on 30 August 1995. The new constitution formed a model of the presidential republic, described issues of the republican power distribution and opened up a road for market and system reforms.

The president Nursultan Nazarbayev presented the Development Strategy of "*Kazakhstan up to 2030*" in October 1997. This document contained long term priorities to be implemented to ensure further development of the RoK until the year of 2030. Its main ideas are:

- Public and political stability and consolidation;
- National security and preserving integrity of the country's territories;
- Economical development by means of creation of an open market economy with high level of international investments and domestic savings;
- Effective management and utilization of the country's natural resources;
- Achieving of high living standards by means of future increase of oil and gas production, establishment of good education and health care systems and the improvement of environmental situation in the country;
- Development of transport and communication infrastructure to support economical growth and industrial development;
- Establishment of effective and professional state and civil servants` corps to ensure they serve to the state priorities to achieve the development targets;
- For the long term priorities, the state needs to develop and implement short term action plans to perform specific action item of the strategy. The type of action are dependant on the budget at the particular period;

1.3 Economical Development and International Partnership

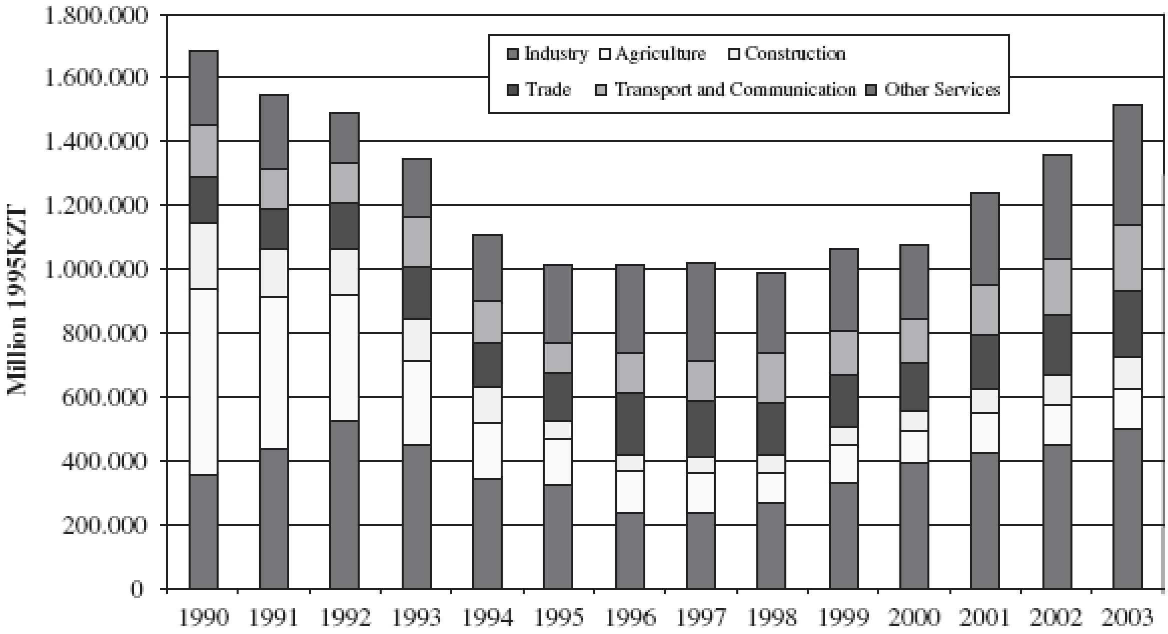
1.3.1 Post Soviet social-economical crisis and the recovery

As mentioned in the previous section, Kazakhstan used to be an important industrial and agricultural region in the USSR. The country produced a large number of metals such as beryllium, bismuth, cadmium, chromium, copper, ferroalloys, lead, magnesium, rhenium, titanium, uranium, and zinc. Its mining sector would provide significant amount of minerals such as arsenic, barite, coal, gold, molybdenum, natural gas, oil, phosphate rock, and tungsten. The region is rich with reserves of 3 ferrous metals, 29 nonferrous metals, 2 precious metals, 84 types of industrial minerals, and coal, natural gas, and petroleum [7].

It had relatively well developed industry and produced 70% of lead, zinc, tin, titanium, magnesium; 90% of phosphorus and chromium; and more than 60% of silver of their total USSR production by the 1991 [6]. Agricultural sector used to be traditionally well developed here though it significantly declined after USSR collapse. The main agricultural products exported used to be grain and meat.

The USSR collapse undermined political stability in all of the post soviet republics.
It damaged the economy of Kazakhstan, weakened the state system and brought a very difficult period for majority of its population in the early 1990s. Many people were not paid their salaries at work. Strikes were frequent but brought little response. Many industrial plants stopped completely. Some of the previously prosperous strategic industrial facilities of the former USSR were abandoned and robbed, which would make millions for some people but leave jobless many others. Commercial banks and private investment companies tended to go bankrupt in the early 1990s; taking away the money of the people who entrusted them their savings. Corruption and crime became the fastest way to get away from poor living for some. Highly experienced professionals – industry workers, engineers, doctors, university and school teachers, state officials, and others had to become small scale businessmen. In addition to the fact that many people did not see their salaries for a long time; the country had a very rapid inflation with almost empty grocery stores.

The gross domestic product (GDP) of Kazakhstan was steadily falling from 1990 to 1995. It decreased to less than 60% of its Soviet level of 1990 by 1998 (Pic 1.5) [8].
But from 2000 the DGP began to rise again and reached 90% of its level of 1990 by 2004 [8].



Picture 1.5 – Structure of GDP in Kazakhstan [8]

In 2003 the GDP was estimated at 36.41 billion USD and at 39.8 billion USD in 2004.

In 2005, the GDP value reached 47.4 billion USD, a rise of almost 20%. The GDP per capita was estimated at 3118 USD in 2005. Contribution of services was about 54.7%, contribution of products was about 38.6% and the rest (6.7%) was delivered by the agricultural sector [9].

According to the World Bank data, the GDP of 2006 was estimated at 81 billion USD and Kazakhstan currently should be classified as "a middle-income country with an estimated gross national income per person of 5010 USD" in 2007. The bank has also stated the country to be one of the world's 20 most attractive economies for investments. Economical development of Kazakhstan during the 2000s was impressive and was one of the best among the post soviet countries [10].

In 2007, the GDP reached 12,763,211 millions KZT [11]. This was about 104.15 billions 2007USD taking the average exchange rate in 2007 at 122.55 KZT/USD.

Economical redevelopment has been radical and dramatic, and the situation became significantly better and in social aspects as well.

This was mainly due to strengthening of state power, which removed political disorder and dismissed criminal organizations that would tend to be involved in businesses by providing "a safe cover" for their owners in the early 1990s. Having passed through the transitional period of economical recovery in 1990s, Kazakhstan is on the way of building a prosperous state of the art constitutional and democratic society.

Another very important factor of the economical and social recovery is growth of prices of hydrocarbons in the world market. This induced investments into the country's rich oil and gas sector. Even in the USSR period, oil and gas production in Kazakhstan had not been as rapidly developing as it is now. Not only the huge oil and gas reserves such as Tengiz, Karachaganak, Kumkol and Kashagan were attractive for investors. A lot of small and quite challenging hydrocarbon formations, found in the Soviet period but not reasonable to develop at that time, became attractive for the new investors.

With constant demand for hydrocarbons and their ever highest costs on the world market, the oil proceeds of Kazakhstan inhaled fresh air and ignited development of some other economy sectors. Significant movements have been observed in the food, construction, banking and the electricity sectors.

Beginning from the 1998, state and private savings have been constantly rising. Private savings in the commercial banks of Kazakhstan are growing, which tells about the enhancement of peoples` trust in the country's financial sector and its controlling state authorities. The country's debt is not significant and its major part is concerned with direct foreign investments into the oil and gas sector [12].

It is expected that oil production will reach 2 million barrels (bbl) a day by the end of this decade, and will be increasing up to 2020. Management of this kind of revenue inflow sets challenges for the RoK government [12].

In 2004, the RoK government created National Petroleum Fund (NPF) that accumulated 4 billions USD. By 2008, the NPF has increased up to 40 billions [13].This fund is to be audited by independent bodies, to be topped up in accordance with annual hydrocarbon revenues and no money has been spent therein yet. Creation of the fund is an important step towards transparency of the Kazakhstan's oil and gas revenues [12].

1.3.2 Oil and Gas Sector

The republic is the second largest oil producer among the former soviet countries after Russia. The value of total proven recoverable hydrocarbon reserves is estimated at 39.6 billion barrels of oil and 3 trillion cubic feet of natural gas (approximately 3.3% and 1.7% of the world's totals) [14].

The country is the second largest oil holder of reserves outside the OPEC membership countries and none of the Eurasian countries have this amount of proven recoverable oil and gas reserves, except Russia [15].

Oil production rose from 225.75 millions bbl to 264.75 millions bbl in Kazakhstan, during 1999-2000. About half of the production was taken from the three largest onshore fields – Tengiz, Karachaganak and Uzen [16].

Tengiz is one of the world`s largest oil fields. It has been estimated to have oil reserves of between 6-9 billions bbl [16].

However the biggest oil and gas production is expected from the Caspian offshore fields - Kashagan and Kurmangazy. The first production flow in Kashagan is expected by 2009. Kurmangazy promises totals of 5.5-7.7 Bbbl but it is still in the probing phase [17].

According to KazMunaiGas Company, Kazakhstan is planning to produce 3 millions bbl a day to get into the world's top 10 oil producers [14].

The major international enterprises in the oil and gas sector of Kazakhstan are Chevron, BP, BG, Conoco, Agip, Exxon Mobil, Shell and Total. In addition to this list, there are some other large petroleum companies such as Chinese CNPC - increasing its participation from year to year, Russian "Lukoil" and "Rosneft", Romanian Petrom, Turkish Petroleum, Japanese "Inpex", Denmark`s "Maersk", Korean KNOG[17].

Kazakhstan is committed to the development of multiple export routes in order to support its large forecasted production growth.

The Atyrau- Samara pipeline is used to deliver oil to Russian refineries. It is being expanded, and should enable Kazakhstan to increase oil exports via Russia up to 300,000 bpd [17].

The Caspian Pipeline Consortium (CPC) was formed to build a pipeline system to transport oil from Tengiz to the Black Sea at Novorossiysk, and to bring oil to world markets. The projected capacity of the CPC is 560,000 bpd [17].

The Atasu-Alashankol link is currently under construction. It is supposed to connect Kazakhstan with Western China. Its expected capacity is 10 million tons per year [17].

Kazakhstan -Turkmenistan-Iran - Libya. A proposed pipeline from Kazakhstan to Iran is being discussed. The pipeline would have a capacity twice as much as the CPC. Although this route is one of the shortest and cheapest, U.S. Iran and Libya Sanctions Act forbids US companies to conduct any business with these countries. Therefore this project is likely to be suspended.

Aktau-Baku-Tbilisi-Geyhan (BTG). Current discoveries in Kashagan and Kuramagazy fields prompted plans to connect the planned BTG pipeline with a route from the port of Aktau. Kazakhstan politically supports the BTG route, and proponents of the BTG pipeline believe that the likely absence of the route through Iran will probably make this the most commercially viable route for vast Kashagan oil flows. Its projected capacity is 1 million bpd.

1.3.3 Investments in the Kazakhstan economy

It has been estimated that in order to extract oil valued at 3.5 trillions USD, it will be necessary to invest around 700 billions USD in total [18].

According to the Cherednichenko A. and Dolanbayeva R., the total amounts invested in the Kazakhstan's economy were 9.1 billions USD in 2004 and 10 billions USD in 2005. Among the 9.1 billions USD invested in 2004, about 7 billions went to the petroleum and mining sectors [18].

The National oil and gas company KazMunaiGas is planning to invest a total amount of 1 billions USD into the project of new integrated petrochemical complex for raw hydrocarbon materials of the west Kazakhstan provinces by 2010 [18].

Kazakhstan is a leader in attracting foreign investments per capita among the other CIS countries. The amount of direct foreign investments totaled more than 21 billions USD within the period from 1996 to 2007. Around 8 billions USD were attracted during the last two years, in 2005 and 2006, showing the increasing interests of foreign investors [10, 11].

In the long term, Kazakhstan's development strategy is aimed to build a competitive open economy oriented to the export of product, services, capital and labor based on mutually beneficial cooperation with all partners from around the world [20].

At the same time, attraction of internal local investors is a very important aspect of future development strategy. There are already a number of large commercial organizations with funds sufficient for investment in projects active in the country. Some already invest in the economies of other CIS countries, e.g. Bank Turan-Alem has invested in some sectors of Georgia's economy.

The government of RoK hopes to attract investors into the processing and sustainable energy sectors that remain less attractive than the mining and production industries. This should be achieved by means of the government preferences for investments, in accordance with the RoK Law "Concerning Investments" of the 8^{th} January 2003.

The aerospace industry of Kazakhstan has high potential. In order to explore it better, it would be necessary for Kazakhstan to move away from the temporary benefits gained from letting the space center of Baikonur to joint space programs.

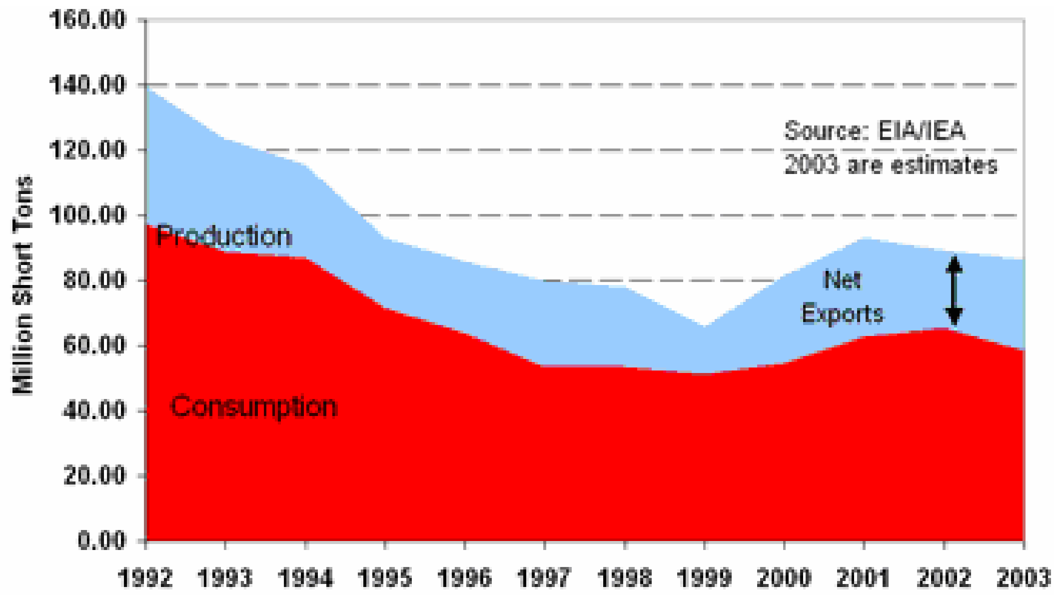
1.3.4 Coal Sector

Kazakhstan possesses the biggest coal reserves in Central Asia estimated at 37.5 billion short tons of mostly anthracitic and bituminous coal [19].

Coal basins of the Karaganda province has been developed since 1930^s and they are still the main coal supplier of Kazakhstan with annual productions of about 50 million short tons. The Ekibastuz coal reserves in the Pavlodar province on the Irtysh River, that are around two hundred kilometers northern direction from Karaganda city, are the second biggest supplier nowadays [19].

In 2003, the country produced 86 million short tons, consumed 58 and exported 28 million short tons. Russia and Ukraine are the main importers of Kazakh coal.

The main domestic consumers of the local coal are the country's largest power plants.



Picture 1.6 – Coal Production and Consumption in Kazakhstan [19]

1.3.5 Uranium Sector

Kazakhstan is called to have 25% of the world's uranium reserves and experts say it could power the entire world's nuclear energy for 50 years [22]. However the value of 25% might have been exaggerated since according to other sources. The world nuclear association gives the value of 15% [23].

The national nuclear company Kazatomprom controls all nuclear related activities in the country. The company is increasing uranium production and intends to supply 30% of the raw uranium, by means of joint ventures with Russian, Japanese and Chinese companies 12% of uranium conversion, 6% of enrichment and 30% of nuclear fuels fabrication on the world's market until 2015. According to the company general director, Kazatomprom does not experience lack of finances to increase production though the main problem is to find markets for the products [23].

It plans to focus on selling value-added nuclear fuel rather than just raw uranium material.
The only nuclear power reactor in Kazakhstan, 350MW plant in the Mangistau province, used to produce electricity and desalinize water from the Caspian Sea for some 27 years. It was closed in 1999 [23].

The RoK Government and Kazatomprom currently address prospective developing of new nuclear energy plants seriously and plan to achieve it by means of international co-operation and attracting foreign investments [23].

It is currently being proposed to build new nuclear plant near the Balkhash Loch.

In 2006 joint venture with Russia has been set that plans to develop manufacturing of small and medium size nuclear reactors in Kazakhstan [23].

In 2007, two joint venture agreements with Japan were concluded to provide assistance for Kazakhstan to build new nuclear energy plants [23].

The state institution National Nuclear Center suggests building twenty 50-100 MW plants to provide energy for remote and distributed towns [23].

1.4 Investment Support Mechanisms in Kazakhstan [21]

The RoK Law "On Investments" of 8 January 2003 defines the term of investments, state legal and economic mechanisms on how investments shall be stimulated and supported, sets guarantees and protection for investors who work in Kazakhstan, resolutions and procedures in case of a dispute.

The law stimulates and supports both domestic and foreign investors. The time for reviewing applications for investment preferences has been reduced to 30 working days. The law has not stipulated the minimum or maximum levels of investments so it must be applied for all sizes of companies. Though, the condition for the investment preferences is that they have to be addressed to the industry sectors of the state importance and current needs.

The law equalizes guaranties of both foreign and domestic investors in cases of requisition, inspections of state authorities, nationalization, resolution of disputes and reimbursement of a damage caused by incorrect actions of state authorities

Equality of domestic and foreign investors is fair while guaranteeing from requisitioning and nationalizing, control by the state bodies, resolving investment disputes, indemnifying wrong made by the state organs and officials.

The law states that an investor shall make a contract with the state institution authorized to represent interests of the RoK government. This contract may stipulate these types of preferences:

1. Taxation preferences as following:
   - of corporate income tax;
   - of land tax;
   - of property tax
2. Customs and imports exemptions;

3. State In-kind Grants (from the state property e.g. free land use for an investor)

In order to apply for the state preferences an investor shall submit the following scope of documentation to (*clause 19, RoK Law "On Investments"*):

1) a copy of the certificate of state registration of a legal entity, notarized;

2) a copy of the statistical card of a legal entity, notarized;

3) a copy of the charter of a legal entity, notarized;

4) the business plan of the investment project that is compiled in accordance with the requirements as established by the authorized body;

5) documents which support the estimated value of construction works and expenditures for purchasing of fixed assets applied for the implementation of the project;

6) documents which indicate sources and guarantees of the project financing.

7) documents which support the amount (value) of the state in-kind grant requested by the investor and the preliminary consent for conveyance thereof.

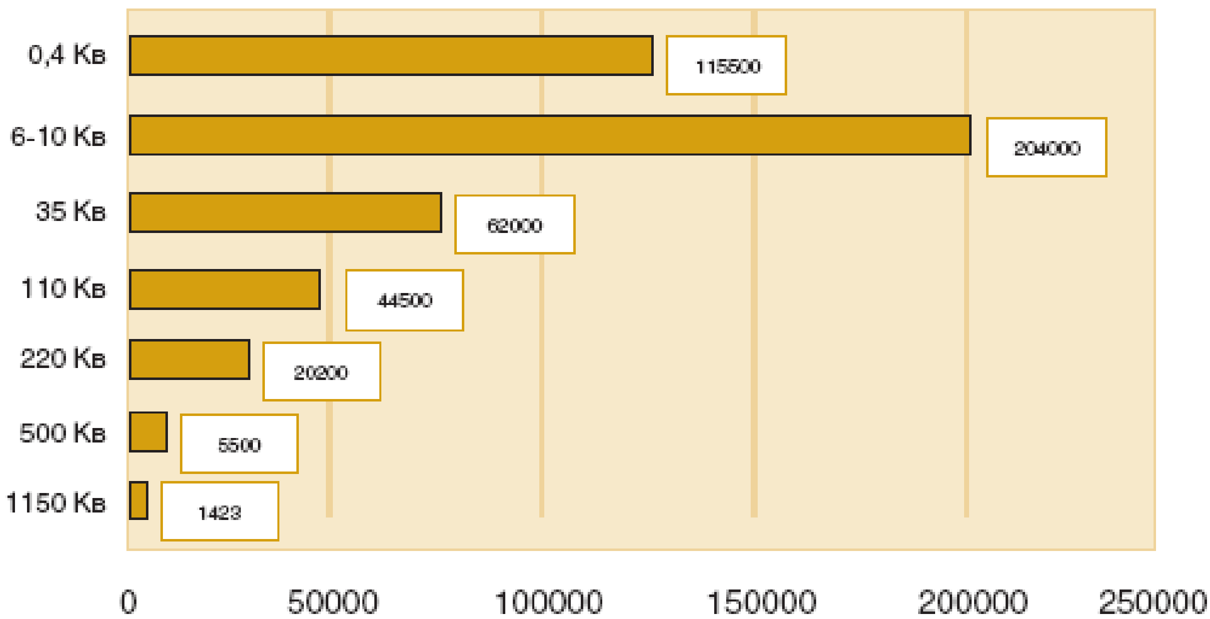
2 Electrical Energy Market in Kazakhstan

The electricity sector has played an important role in Kazakhstan since the soviet time. Analysis showed that the economical growth of Kazakhstan is highly dependant on electrical power and its GDP is highly energy consumptive, which requires improvement (see ANNEX III).

The country has relatively large electricity generating and transmission capacities. The main part was built in the Soviet time to support industrial and domestic demands. However, Kazakhstan has usually imported some amounts of electrical power. This is for economical and technical reasons: because the territory of the country is huge so it is sometimes more reasonable to purchase electricity from the neighboring countries (former USSR republics).

Since the area of Kazakhstan is large, it required the creation of corresponding electrical power networks. The total length of electrical power lines in Kazakhstan is about 453,223,000 km distributed as shown below:

(Кв – kV)



Picture 2.1 – Length of Electrical Power Networks in Kazakhstan (thousand km) [24]

Transmission through the huge territory incurs significant power losses that account for about 15%-20% depending on the destination [24]. This is one of the main factors behind inequality of electricity prices in different provinces throughout the country, as well as the inequality of maintenance and operation costs in different regions, according to the National System Operator - Kazakhstan Grid Operation Company (KEGOC) [27].

The main installed generation capacities of Kazakhstan are concentrated in the central part of the republic, in the Karaganda, East Kazakhstan and Pavlodar provinces. They are the main power suppliers. Therefore, some regions of the country still import electricity since it becomes more reasonable in terms of economical and technical factors. A surplus of generated electricity is exported to the neighboring countries throughout the interconnected grid systems.

The electricity grid system of northern Kazakhstan is connected with the Russian Federation's Unified Energy System and the southern Kazakhstan grid system is a part of the Central Asia United Energy System. The northern Kazakhstan networks normally use electricity from Siberian power stations and the southern Kazakhstan networks are normally supplied from the hydroplants of Tajikistan and Kyrgyzstan. The electrical network of south-eastern Kazakhstan is also interconnected with the electrical network of the Republic of China.

The majority of the electricity generated in Kazakhstan comes from thermal plants, which account for 87% of the total installed capacity, where coal is the main energy source accounting for 80% and hydrocarbons (oil and gas) account for 7%. The other 13% comes from hydro power plants. Total installed generating capacity of all power stations in Kazakhstan is 18.7 TW, which is comparable with countries such as Switzerland, Netherlands and Turkey [24].

However some of the existing generating plants have been operated for a long time (25 years and more) therefore the total available generating capacity is estimated at 14.6 TW [26].

№	**Power Plant**	**Installed Capacity MW**
Thermal		
1	LLC «AES Ekibastuz» (Ekibastuzskaya GRES-1)	4000
2	JSC «ЕЭК» (Aksuiskaya GRES)	2110
3	JSC «Zhambylskaya GRES»	1230
4	JSC «Station EGRES-2»	1000
5	LLC «MAEK-Kazatomprom» TEC-2	630
6	LLC «MAEK-Kazatomprom» TEC-3	625
7	«Kazakhmys Corporation», «Karagandinskaya GRES-2»	608
8	JSC «APK», «Almaty TEC-2»	510
9	«Pavlodar TEC-3», JSC «Pavlodarenergo»	440
10	LLC «Access Energo Petropavlovsk TEC-2»	380
11	LLC «Aluminum of Kazakhstan» (Pavlodar TEC-1)	350

Hydro		
1	LLC «AES Shylbinskaya HES»	720
2	JSC «Kazzinc», «Bukhtarminskaya HES»	675
3	JSC «APC» «Kapshagayskaya HES»	364
4	TOO «AES Ust-Kamenogorskaya HES»	331

Table 2.1 - The Largest Power Plants in Kazakhstan [26]

The nuclear power plant in the Mangistau province (350MW) has been closed since 1999 so does not produce any power at the moment [23].

In 1990, Kazakhstan produced its biggest electricity output of 85.3 TWh and consumed its largest demand of 104.7 TWh. The deficit was imported. Subsequently, production decreased significantly after the USSR collapse. The consumption decrease was however smaller [26]. By 1994, annual production of electricity fell to 77.44 TWh and annual demand was 89.15 TWh [26].

At this time, some southern regions of Kazakhstan experienced electricity shortages that made some towns completely without electricity.

During the period from 1993 to 1998, Kazakhstan introduced some new electrical energy units. A new 110 MW thermal power unit was installed in Karaganda, a 100 MW gas turbine was introduced in Aktobe province (rich with hydrocarbons) and the 117 MW Shulbinsakya hyrdro-power plant was completed in the Karaganda province.

The energy balance has slightly changed also. This is because of an increase in the oil price that was used as a fuel for some thermal plants. Oil was replaced by a worse quality heavier hydrocarbon derivative – mazut. Engineers started considering the utilization of associated petroleum gases as economically reasonable. A 144 MW gas turbine power plant on the Tengiz oil and gas field has been upgraded to create a reliable supply for hydrocarbons` production on this location and to deliver some amounts of energy for Atyrau province. However, associated petroleum gases still remain unmanaged in general throughout Kazakhstan.

Kazakhstan has made attempts to demonopolise by privatization of the domestic electrical energy production market. According to the RoK Laws "On Electrical Energy", "Investments" and "On Energy Savings", some guarantees have been offered to investors for modernization, maintenance and reconstruction of some old units and for implementation of national energy saving policy.

These policies resulted in the privatization of about 80% of the country's electrical power market. Only operations of the transmission and distribution lines remained as state responsibility according to the Law "On Electrical Energy". The aim of the privatization policy is to create and develop a competitive electrical energy market (Law "On Electrical Energy").

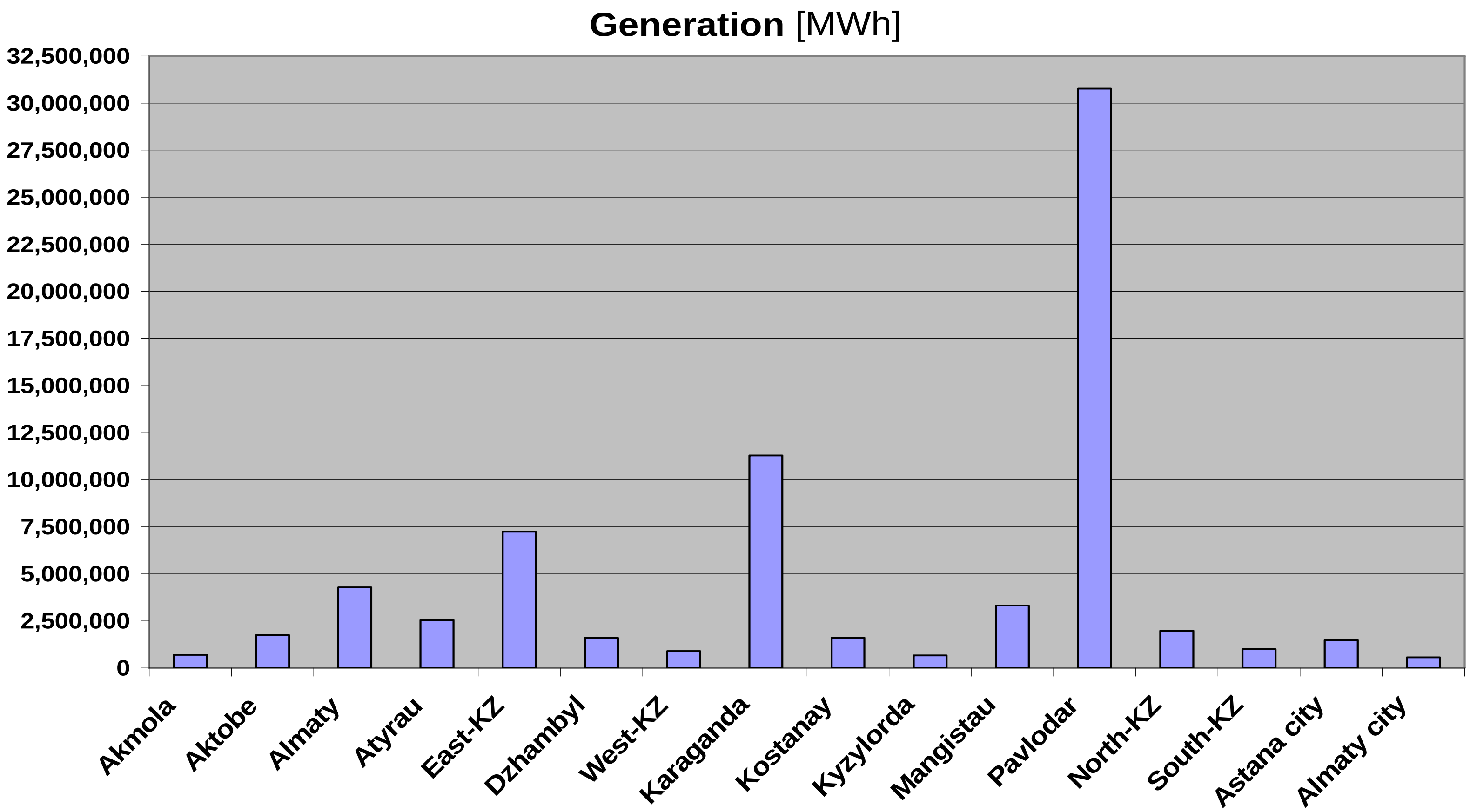
With a view to future production increases, the TCO Company is currently planning to install additional gas turbine units with total capacity of 480 MW to utilize abundantly available associated gases that are partially flared at present.

The US Corporation AES purchased the largest power plant in Kazakhstan Ekibastuzskiy GRES-1 fired by local coal in 1996. It also acquired Shulbinskaya and Ust-Kamenogorskaya hydro power plants for 20 years admission. After this, four large soviet thermal power plants in Leninogorsk, Ust-Kamenogorsk, Sogrinsk and Semipalatinsk were stopped. According to the RoK Ministry of Energy and Mineral Resources, investments of AES Corporation to the Ekibastuzskiy GRES-1 totaled in 45.37 millions USD in 1998.

JSC Kazakhmys acquired Karagandinskaya GRES-2 providing stability of electricity supply for the large metallurgical facilities and domestic demands in the Karaganda province. The Corporation invested 36.6 millions USD in the power plant by 2000 [26]. It has also purchased Zhezkazganskyaya and Balkhashskaya thermal electricity plants. In addition to that, it runs coal mines and copper plant in Karaganda province.

JSC Kazzink acquired Bukhtarminskaya and Karaterinskaya hydro power plants. At the same time the corporation has a number of mines, lead and zinc plants and metal melting plants.

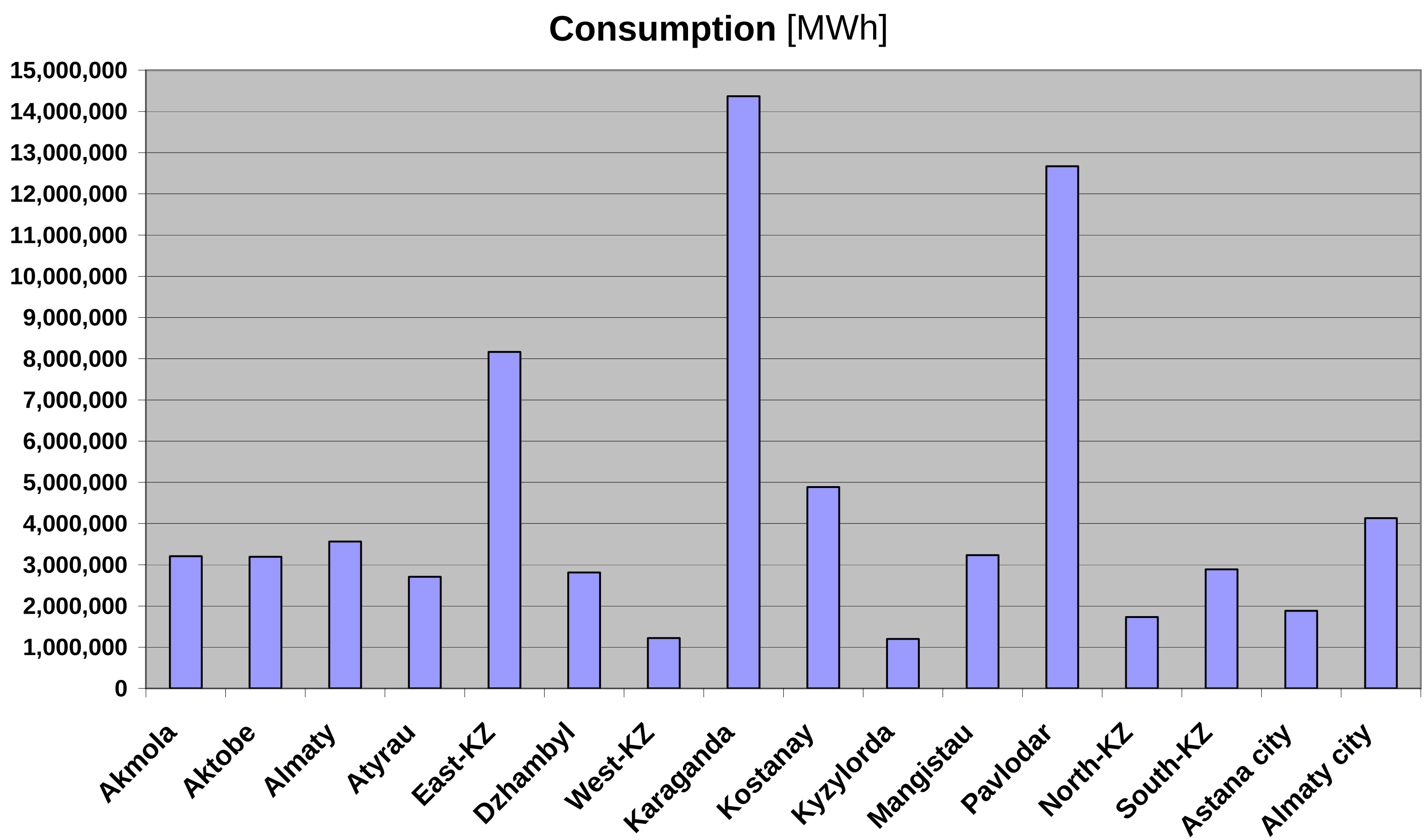
2.1 Domestic Electricity Generation [28]



Picture 2.2 - Electricity Generation in Kazakhstan during 2006 [28]

The largest energy outputs during 2006 were generated in the coal rich regions of Pavlodar and Karaganda, 30767409 and 11286426 MWh correspondingly. East Kazakhstan province produced 7236967 MWh. Almaty province output was 4278664 MWh whereas the city of Almaty produced 563948 MWh. The regions possessing richest oil and gas reserves, Atyrau and Mangistau, generated 2551960 and 3312425 correspondingly.

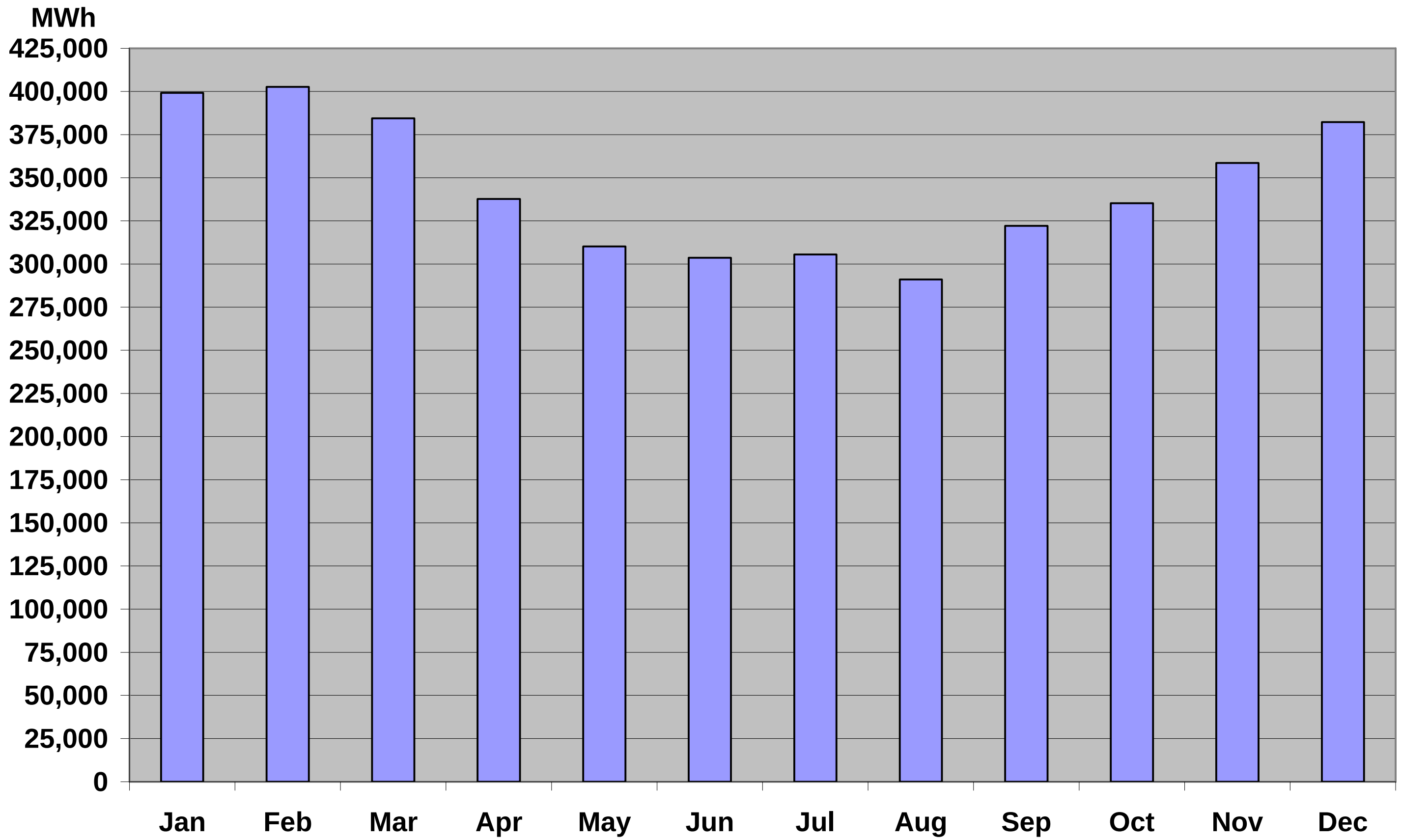
2.2 Electricity Consumption [28]



Picture 2.3 - Electricity Consumption in Kazakhstan during 2006 [28]

The largest consumption of electricity was in the industrial regions with the highest outputs (Karaganda – 14370526; Pavlodar -12672317; East KZ – 8165100). The Almaty city consumed 4132513 MWh alone, which was the 5th largest demand after the Kostanay province whose consumption was 4887500 MWh.

The largest electricity consumption in the Almaty city was during the coldest winter period from December to January and the lowest consumption was in summer. August is the normal period for people to leave the city or the country and the weather is usually very hot.

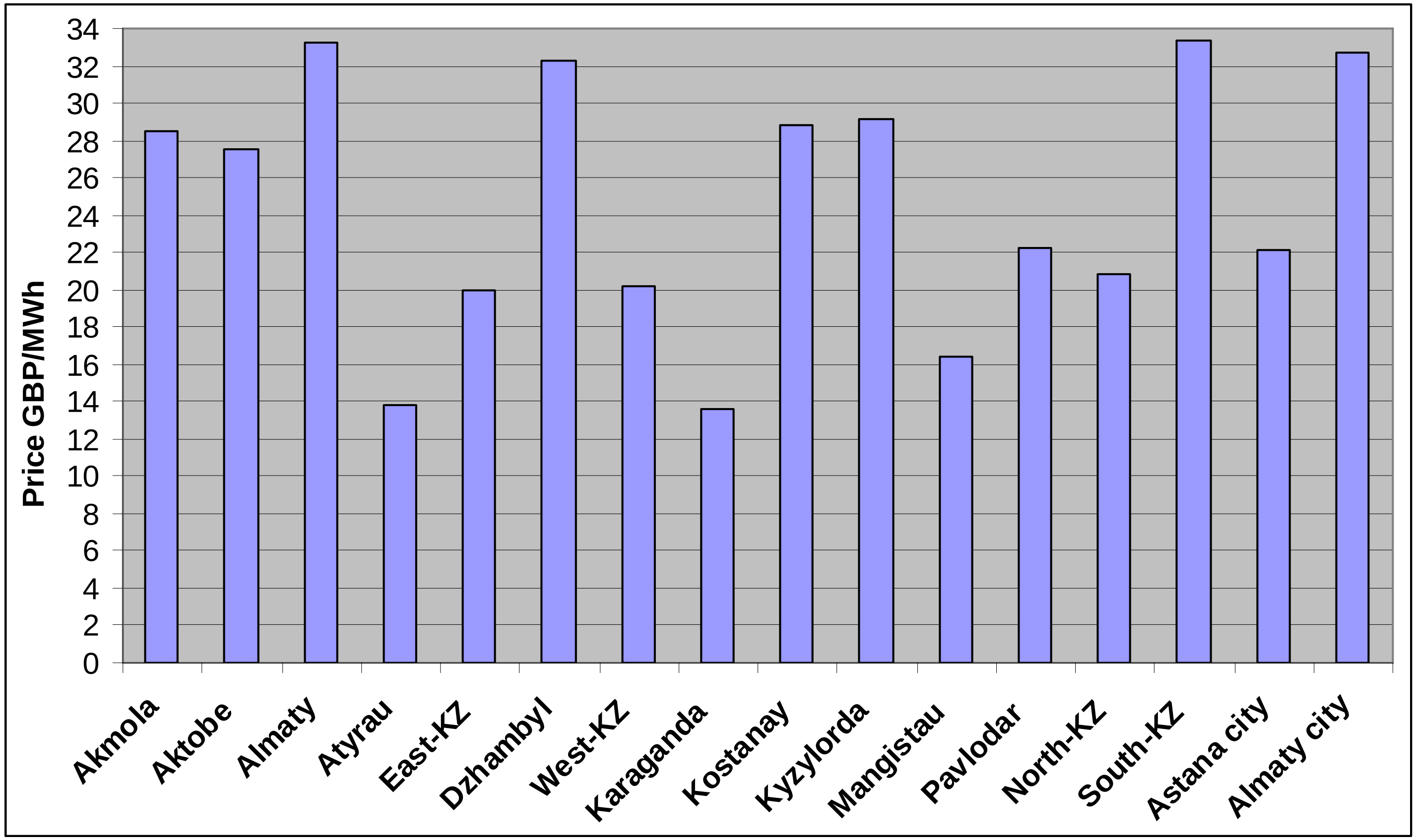


Picture 2.4 - Seasonal Electricity Consumption in Almaty during 2006 [28]

It should be noted that the province Karaganda consumed more electricity than it produced and it currently has the lowest electricity tariffs in the country. However it is also large and relatively well populated, having the biggest mining facilities on its territory.

In addition to the electricity tariffs, population density, the presence of large industrial facilities and climatic differences in different provinces of Kazakhstan affect electricity consumption.

2.3 Electricity Tariffs in Kazakhstan [29]



Picture 2.5 - Electricity Tariffs in Kazakhstan on 01.04.2008 [29]

Note: The prices were given by the RoK State Agency on Natural Monopolies in KZ tenge per kWh. The average exchange rate for calculating electricity tariffs was taken as 243 KZT/GBP [30].

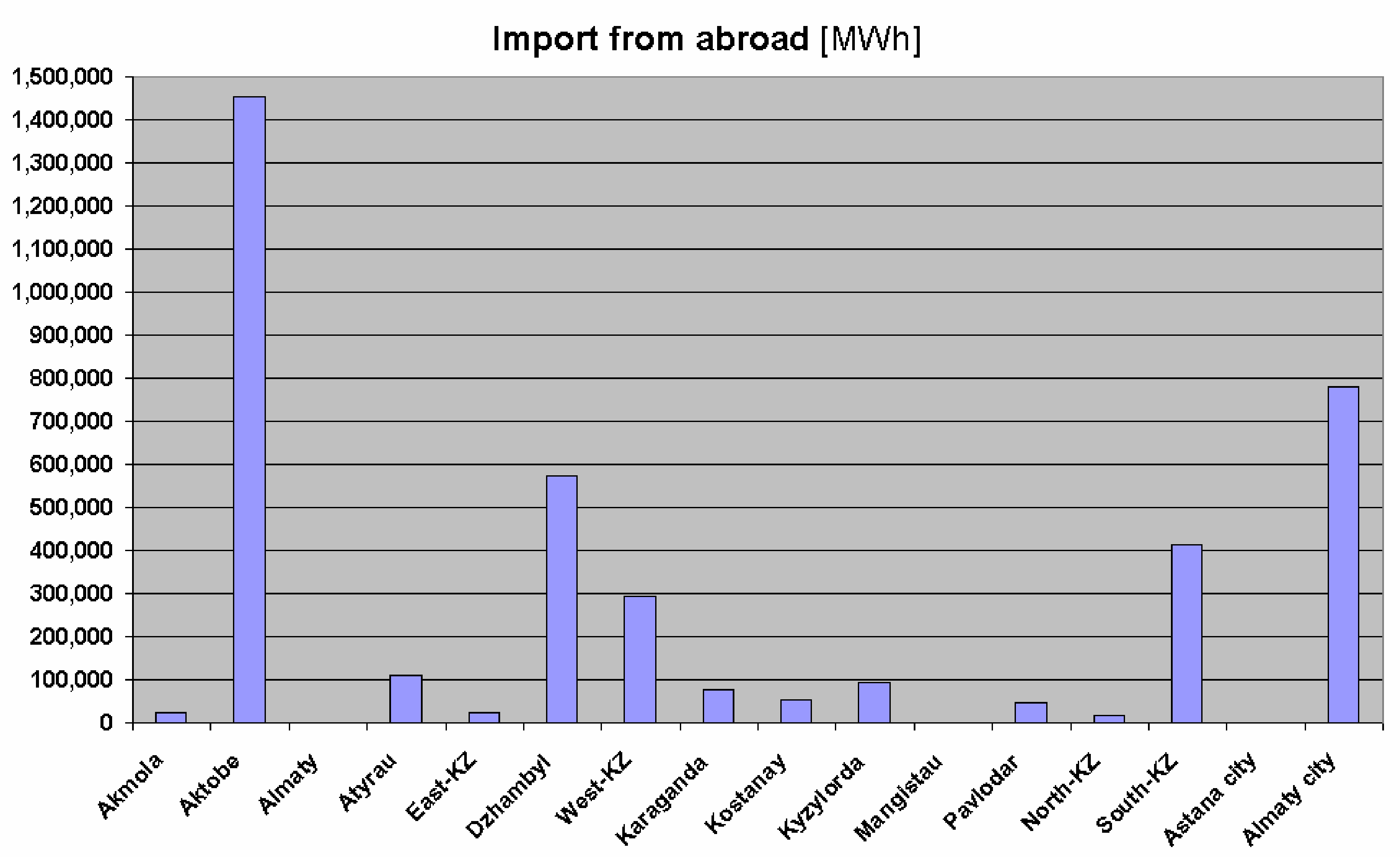
The lowest electricity prices are in the Karaganda province (1.3 pp/kWh) and the hydrocarbon producing regions Atyrau (1.4 pp/kWh) and Mangistau (1.7 pp/kWh).

The price in the Almaty city is in order of 3.3 pp/kWh.

The average cost of electricity in Kazakhstan is 2.5 pp/kWh.

The tariff differences in the country are justified by the different transmission distances and losses, operation and maintenance costs of power lines in every province. All local energy companies have to obtain approvals on their tariffs from the state committee on natural monopolies. Reasonable justifications must be submitted to the committee if a local energy company needs to change previously approved tariffs.

2.4 Electricity Imported from Abroad [28]



Picture 2.6 – Electricity Imported from abroad [28]

The picture of importing electricity from abroad is important in terms of the issue of energy independence.

The Aktobe province imported foreign electricity most of all (1,454,107 MWh). The imported energy was from Russia.

Almaty city is the second largest importer of foreign electricity (779,200 MWh).

The full data on the electricity balance in Kazakhstan during 2006 is given in ANNEX I

2.5 Current and Forecasted Electrical Energy Balance in Kazakhstan

Year	2006	2007	2010	2015
Consumption billion kWh	71,8	76,6	91,5	113
Production billion kWh	71,5	75,5	85,0	94,5
Deficit billion kWh	**0,3**	**1,1**	**6,5**	**18,5**

Table 2.2 - Current and forecasted electricity balance in Kazakhstan [26]

It is forecasted that at the current annual average demand growth of 6% and taking into account upgrading of some generation capacities, Kazakhstan is expected to get significant electricity shortages, mainly due to deterioration of the currently operating equipment if no measures are taken [31].

3 Environmental Problems of Kazakhstan

3.1 Introduction

During industrial operations in Kazakhstan, beginning from the USSR period until nowadays, the country has got extremely negative impacts from its key economical sectors on the environment. The agricultural, military and energy sectors have caused the present environmental situation in Kazakhstan and there are a number of international studies showing that the situation is critical.

The Semipalatinsk nuclear testing area and the Aral Sea are the most famous and significant environmental disasters of Kazakhstan that are under the continuous attention of different international scientific and financial institutions.

In addition to that, electrical power plants, production and mining of coal, oil, gas and uranium continue to create significant air pollution, and contaminate soil and water.

3.2 The Major Environmental Disasters

Unsustainable agricultural revolution and its rapid consumption of water from the Syr Darya River in the soviet period caused an environmental disaster in the Aral Sea, which dried and split into 3 separate basins.

There were 14 large nuclear weapon testing polygons in Kazakhstan in the USSR period. They created catastrophically situation and high radiation backgrounds on their places in the East Kazakhstan province. This issue still remains to be open.

3.3 Nuclear Industry Impacts

These military sites are not the only source of nuclear pollution in the country. The uranium, oil and gas industries produce radioactive discharges and wastes.

The Aktau nuclear power station was closed in 1999. However "Kazatompromm" is planning to build a new nuclear power plant at the Balkhash Loch.

The idea is opposed by ecological movements and some deputies in the RoK Parliament as the country has been suffering from unsustainable nuclear activities in the past.

Generally, nuclear energy is not regarded as a green energy source by the people in Kazakhstan based on past experience and associations of the Chernobyl disaster that shocked all of the former USSR republics.

Generally the Semipalatinsk weapon testing site, the military nuclear rocket site of Sary-Shagan and the space lunching base of Baikonur are the main sources of negative public opinion about nuclear applications.

3.4 Oil and gas industry impacts

The planned giant hydrocarbon production from Caspian deposits in the near future is a potential big environmental threat in a long term prospective and the risk has not been well assessed yet.

The optimum oil production has to be assessed and must not be exceeded to make sure the marine ecosystem is not damaged by the operations. For instance, the Atyrau province is located in a flat low land area and is not a seismically active zone by nature, though it occasionally experiences some slight earthquakes due to ground movements caused by intensive production of oil and gas in this region.

The drilling operations on the Caspian shelf cause serious water pollution of the sea in spite of using new technologies. There have been a number of accidents when fish died with chemical contamination of the sea as the most possible cause of it. Analysis of the Caspian Sea habitants has shown the presence of chemical substances in their bodies due to hydrocarbon industry exposure [47].

Some ecologists have even hypothesised that preserving the Caspian ecosystem and breeding sturgeon species could compete somehow with the oil and gas business and bring huge benefits for Kazakhstan as well.

The Caspian oil fields` operating consortium was meant to complete drilling in 2008. However this has been delayed and the company is now urged by the RoK government to start the first production as soon as possible according to the initial plan [48]. Under such urgency, it is questionable how much the company could take care about the environment. In addition to that, traditional on-shore oil and gas production in Kazakhstan causes very serious soil pollutions.

Proper management of associated natural gas in the petroleum industry is a serious problem. For instance, in the oil field "Prorva" exploited from the soviet time, there were 6 billions cubic meters of associated gas fired since 1965 [48]. There are many oil fields that continue to flare big volumes of natural gas in Kazakhstan without proper management due to different economical-technological reasons.

3.5 Impacts of mining and electrical power production sectors

Air pollution is a serious and growing environmental problem. The largest cities and industrial regions of the country are of course the worst affected. Most of the current mining and power generation facilities do not comply with the best modern ecological standards. The RoK Government has already been planned to install new state of the art equipment, modernize some of the old and close those facilities can not be upgraded [32].

Air pollution in Kazakhstan is caused by mining industries and by the widespread usage of fossil fuels. There were 19 million tons of harmful substances discharged into the atmosphere in 1998 by Kazakhstan. Among this, Karaganda province discharged around 1 million tons, Pavlodar province released 440 thousands tons, East Kazakhstan produced 164 thousands tons and the Atyrau province made 135 tons of harmful releases [48].

However the amount of emissions decreased with the general industrial and economical decline in the country down to 3.1 million tons in 1995 and down to 2.3 million tons in 1998.

The Karaganda province is rich with coal and steel facilities, metallurgy complexes and large thermal power plants on its territory. According to international observers it should be considered as an environmental disaster area and it accounts for the major part of emissions in Kazakhstan.

The international observers Dahl C. and Kuralbayeva K. made the following statements:

"*The region is an environmental disaster area. The metallurgy enterprises, Ispatkarmet and Zhezkazhansvetmet, are major emitters contributing the most to air pollution in the region and together emit about 30 percent of the country's total. Concentrations of dust, phenol, nitric oxide, ammonia, and carbon monoxide exceed maximum permissible concentrations (MPC) in the Karaganda region. The air condition in the city of Zhezkazgan depends on emissions from Zhezkazhansvetmet (60 percent) and the thermal power station (40 percent). Concentrations of nitric dioxide (1.2 times MPC), phenol (1.7 times MPC), and lead (1.2 times MPC) all exceed permissible levels"*[48]

"Harmful emissions are caused mainly by low-quality coal used in power plants. In particular, the largest polluter in this region is the Ekibastus power plant, which had the dubious distinction of being the most highly polluting power plant in the former USSR." [48]

"The extraction of coal, lignite, oil and gas created 9529 thousand metric tonnes by the end of 1998. The production and transformation of electrical energy created another 7334 thousand metric tonnes of which about 97 percent were contributed by thermal power stations. In addition to soil contamination by heavy and non-ferrous metals (lead, copper, zinc), oil and oil products, soil is also polluted by radioactive elements" [48]

Pavlodar has oil refinery, chemical plants, metallurgy complexes, coal mining facilities and large thermal power plants on its territory. These industrial sites account for 97.7% of total air pollution in the region [48].

According to the Pavlodar Province Akimat (governance) the total harmful emissions in the region were 551.9 thousands tons in 2004 and 575.5 thousands tons in 2005. By locations, the emissions were 148.4 thousands tons in Pavlodar, 148.3 thousands tons in Aksu and 278.8 thousands tons in Ekibastus in 2005. The major producers of contaminants in the Pavlodar

Province are thermal power plants and mining enterprises which is around 94,4% of the total emissions [51].

Water pollution is another serious environmental concern. The Nyra and Irtysh rivers are the most contaminated water basins. There have been a number of international studies concerning chemical composition and contamination sources of these rivers. The rivers are being contaminated by the power, mining, metallurgical and chemical facilities. Most of these facilities have been in operation since the Soviet time when the environmental operational standards were worse than now.

Among the pollutants are heavy metals, nitrates, petroleum products and phenols. The Sary-Su River in Karaganda province is polluted by petroleum products at more than their 18 maximum permissible concentrations (MPC) and by phenols at more than their 6 MPC [48].

The Irtysh River flowing through the Pavlodar provinces is polluted by copper at about 20 MPCs and zinc at about 25.7 MPCs [51].

Coal mining facilities use water from the rivers for operational needs. For instance, in Karaganda province, around 30 million cubic meters of water are taken from the river in a year with nearly 50% discharged back to the environment causing land and water contaminations [48].

In addition to releases of harmful gases and water discharges, accumulation of production wastes is an environmental impact of coal mining facilities. For instance, there were 130 million tons of harmful solid wastes in 2004 and 136 million tons in 2006, accumulated in the Pavlodar province only. 92.2% of these are waste rocks, 4.4% are ashes, 3% are slags and 0.1 are domestic wastes [51].

3.6 Mitigation-Recovery Measures

Reactive response to mitigate the dramatic environmental situation is slow and not consistent in all enterprises.

For instance, substitution of highly contaminated coal used at *JV "PavlodarEnergo"* by coal with 0.5% less sulfur content is estimated to allow reduction of sulfur dioxide emissions by 3898 tons/year. The company is also planning restoration of tubes inside boilers that is expected to allow reduction of discharges of ashes by 1993 tons/year. Also, the sequential introduction of a system of intensive tube irrigation should reduce discharges of coal ashes by an additional 4356 tons/year by 2009 [51].

Another example is the installation of new electrostatic cleaners of enhanced separation efficiency on the *Aksu Thermal Power Plant* that is estimated to reduce discharges of ashes by

5000 tons/year and discharges of sulfur dioxide by 200 tons/year. In general, this measure should reduce all harmful discharges by 12.3 thousands tons/year by 2009 [51].

Thus, the effectiveness of upgrading old power generating units seems to be significant and calls for continuous improvement of RoK environmental legislation and technological standards. The previously lax RoK environmental legislation made it unreasonable for power plant owners to introduce new technologies. Future enforcement of environmental legislation and upgrading of all old power plants throughout the country will demand higher electricity tariffs.

However taking only reactive actions is not sufficient since the air, water and soil contaminations have been accumulated since the soviet period for several decades. This will require effective recovery measures of the contaminated areas also.

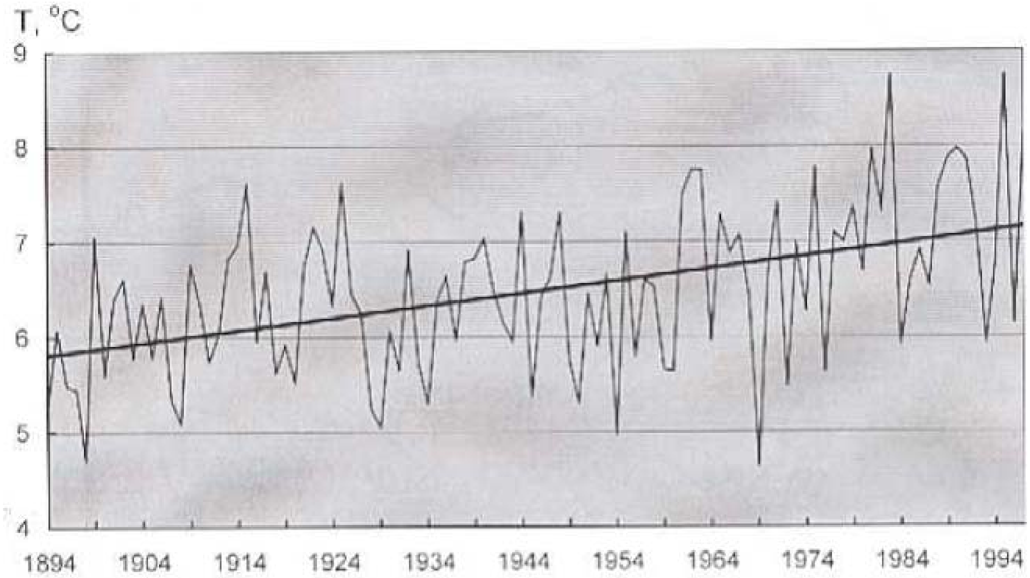
As an example of late reactive measures taken during the independence period is the river of Nura that flows through the industrial Karaganda province entering Ishym River, which flows through the new RoK capital Astana and further to Russia. A number of international studies have shown extreme concentrations of mercury in the river. There was a chemical plant operating for more than 40 years in the Temirtau town. This plant used mercury sulphate as a catalyst for production of acetaldehyde discharging wastewaters to the river [52].

There was more than 150 tons of mercury discharged to the Nura since commissioning of the plant in 1950. The fish were revealed to be exposed to mercury for more than 125 km downstream from the source [52].

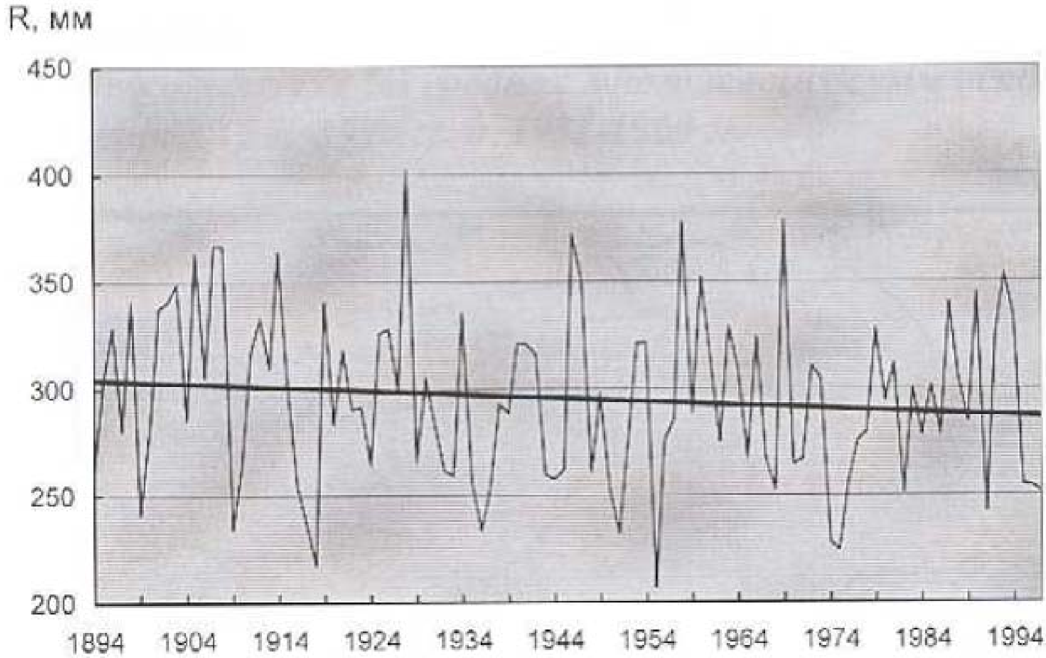
According to the State Climate Change Coordination Center (SCCCC), works on recovery of Nura basin have started. This action will require additional investments and further monitoring of the water compositions. This is an example of the real cost of industrial development and production that was not counted by the previous environmental legislation [50].

3.7 Global warming

Climate change is also a very important issue for Kazakhstan. According the state weather agency "KazHydroMet" the mean temperature has grown by 1.3 DegC and annual precipitations reduced to 17 mm during the 1894-1997 (please see pictures 3.1 and 3.2) [39].



Picture 3.1 – Air temperature fluctuations in Kazakhstan [39]



Picture 3.2 – Precipitation changes in Kazakhstan [39]

Desertification is a serious problem as the existing arable lands; horse, cattle and sheep breeding farms are under the threat of global warming. The agricultural sector has had declined since the Soviet period and has not recovered so far.

Kazakhstan is very dependant on supplies of water from its neighbors. At the same time, glaciers in the Northern Tien-Shan retreat due to the mean air temperature rise [39]. All of these glaciers feed numerous small and large rivers. In addition, the mean temperature rise process may increase the risk of mudflows, particularly in the largest city of Almaty.

3.8 Conclusion

Cancer, allergic diseases and anemia are the health risks of people living close to or in the areas of the military and industrial facilities.

Kazakhstan is one of the richest countries in natural resources however its people have experienced and realized what unsustainable industrial development could potentially lead to.

Therefore it is time for wise management of the vast natural resources to make sure they are used for the benefit of current and future generations.

Getting rid of the so called historic accumulation of contamination is a serious scientific and financial challenge. Therefore Kazakhstan is actively cooperates with UN to address the issues and cope with them.

The RoK President has expressed concern over the issues and wished to investigate environmental problems in Kazakhstan and develop specific recommendations to attract necessary investments on respective remedial and mitigation actions [13].

According to the World Bank, Kazakhstan has values of life expectancy of 60 years for males and 72 years for females. The RoK President N. Nazarbayev has emphasized that the country has to set about revival of acceptable environmental conditions along with the actions to improve the health of people in Kazakhstan and general life quality indicators.

Environmental legislation was not strict at the soviet time. This is why the country has to develop its own effective legislative base. The RoK environmental requirements and penalties for their violations have become stronger, which has already forced some oil and gas companies to replace old equipment. There is plenty yet to be done in this area.

It is planned to build the RoK environmental legislation based on the experience and existing standards of the countries of EU as it is one of the most significant investment and trade partners for Kazakhstan. In this way, introduction and implementation of the ISO standards and certification of companies has already begun.

Environmental audits of dangerous facilities and obligatory insurance of ecological liability are being smoothly introduced and implemented in practice.

The country is an active participant of different international ecological programs. For instance, program of the Environment for Europe where it takes part since 1995. It has signed nineteen international environmental conventions concerning climate change, ozone destruction, saving of biodiversity and desertification issues.

4 Need for Renewable Energy in Kazakhstan

4.1 Energy Independence of the Independent Country

The RoK president Nazarbayev Nursultan Abishevich set a goal for the republic's rapid economical development and for becoming one of the 50 most competitive economics in the world [32]. One of the most important tasks to be solved in achieving of this goal is the problem of energy security and stability. Many times has the president emphasized the need that Kazakhstan's economy has to maintain the same development speed in future as during the recent years without dependency on mineral resources.

Therefore, it becomes very important to discover and harness the renewable energy potential available in the country and to use it efficiently in order to provide national energy security and independence in the future. The social and economical, scientific and technological, and environmental consequences of the growing energy consumption and the need for energy industry development have to be taken into account all together to define the right path for the country's economical growth and improvement of quality of life of all citizens.

The president has approved conception of the country's transition to sustainable development for 2007-2024 [33]. According to the plan, Kazakhstan will need to achieve the following targets:

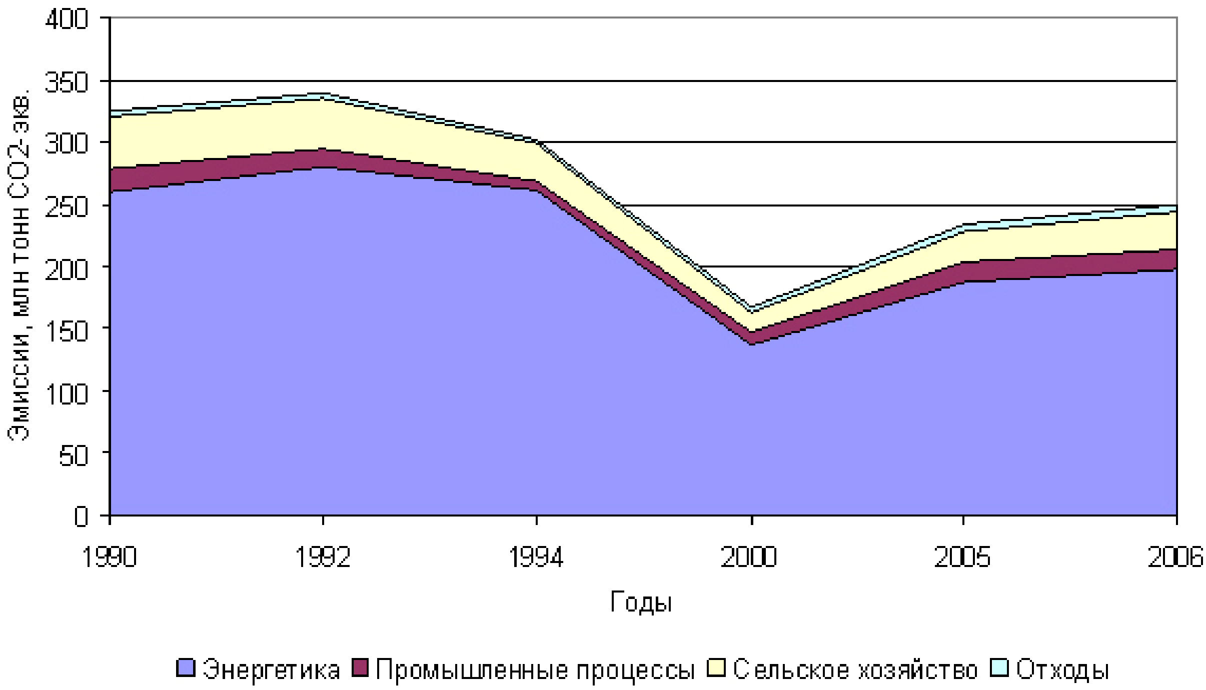
- Stage #1 (2010 – 2012 years) – provide measures for entrance into the world's 50 most competitive economics;
- Stage #2 (2013-2018 years) – achieve and strengthen a position of one of the world's best developing countries in terms of life quality indicators, significant reduction of losses caused by irrational usage of natural resources, providing high levels of environmental sustainability in the country;
- Stage #3 (2019-2024 years) – achieving the best international criteria in terms of sustainability.

4.2 GHG Emissions and International Concerns

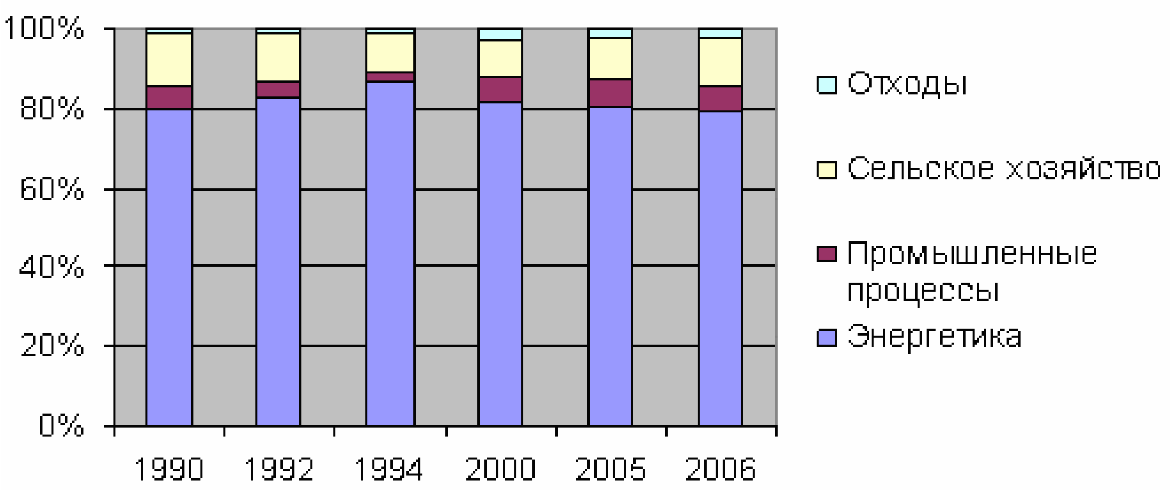
According to the inventory of the SCCCC, the country annually emits large amounts of GHG, where about 80% comes from the energy sector and 80% of the GHGs is CO2. There was reduction of emissions along with the production decline during the period of economical destabilization though emissions are rapidly growing now [34].

Years/ Sources	1990	1992	1994	2000	2005	2006
Energy Sector	259,9	280	261,3	136,6	187,7	198,2
Industrial Processes	18,3	14,9	7,2	10,7	16,1	15,3
Agriculture	42,3	40,1	29,7	15,8	25	30,8
Wastes	4,5	4,2	3,5	4,6	5,1	5,2
Total (excluding	325,0	339,2	301,7	167,7	233,9	249,4

Table 4.1 – Total GHG Emissions by the Source Categories [million t-CO2 equivalent] [34]



Picture 4.1 – Trends of GHG Emissions in Kazakhstan from 1990 to 2006 [34]



Picture 4.2 – Shares of GHG Emissions by the Source Categories [34]

Notations:

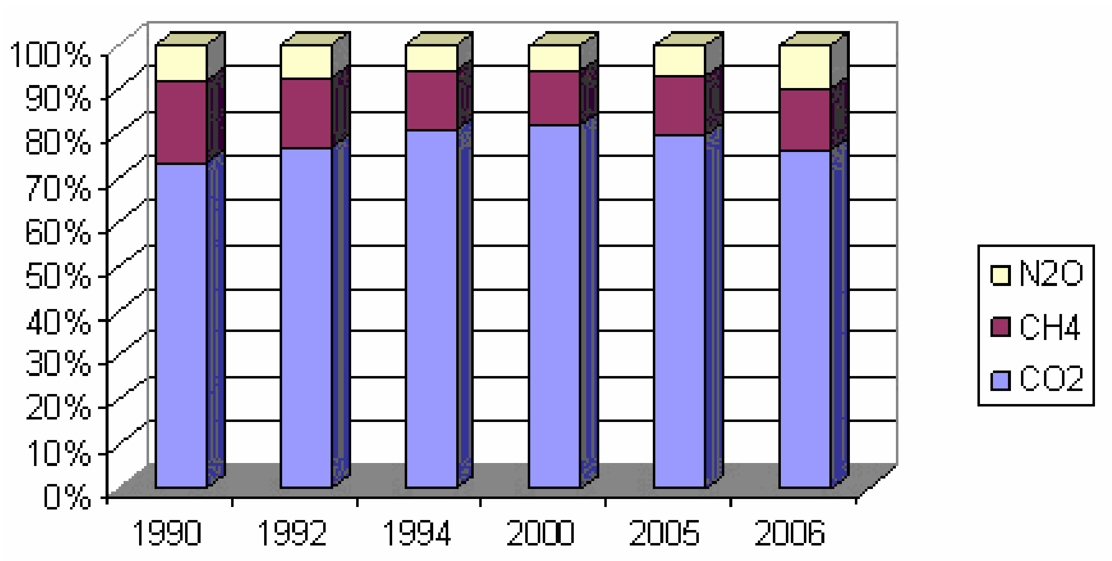
Эмиссии млн тонн CO2 экв – Emissions million tones CO2 equiv;

Энергетика - Energy Sector; ;

Промышленные процессы - Industrial Processes;

Сельское хозяйство – Agriculture;

Отходы – Wastes



Picture 4.3 – Contribution into the total GHG [34]

These figures tell that Kazakhstan should be referred as a significant emitter of GHG into the atmosphere by international governments. Since Kazakhstan considers strengthening international partnerships as an important aspect for future development, the fact of large carbon dioxide emissions means that the international society will negotiate the problem with the RoK government. As an example of international concerns over the problem, the United Nations Development Program (UNDP) that has opened its residence in Almaty and has actively participated in different social and ecological programs of Kazakhstan including the wind energy development issue.

4.3 Opinions about Climate Change

The global warming problem and international efforts to mitigate climate change are important for this study. This is not only because the Kazakhstan produces significant carbon dioxide emissions and the global warming, but also because changes in the international energy market are in the forefront of RoK Government interest.

International scientific society and governments of many countries in the world have come to a mutually agreed opinion that the main cause of global warming is the rapidly growing concentration of green house gases, particularly carbon dioxide, in the atmosphere. Green house gases such as carbon dioxide (CO2), water vapor, tropospheric ozone, methane, chlorofluorocarbons and nitrogen oxides (NOx) are known to be responsible for keeping our planet warm by trapping solar heat.

It has been investigated that trends of the global mean temperature increase have had correlation with trends of increasing concentration of green house gases in the atmosphere, particularly with the carbon dioxide concentration increase. Many international scientists consider carbon dioxide as not just a contributing but the main factor of the global warming [39].

Although it could be presumed there might be still some disagreements on whether climate change is caused by the process of rapid increases in GHG concentration due to anthropogenic activities or it is re-occurrence of natural cycles of glacial and interglacial periods in the oil and gas producing countries. During the revision of the official publications in Kazakhstan, there was not noted any disagreement concerning this issue.

According to some local and international opinions, the main worry about consequences from global warming in Kazakhstan is that the agriculture and vegetation may be under a serious threat. Climate change may cause a drop in crop yield and is likely to increase desertification of lands [39, 40].

4.4 Renewables vs. Hydrocarbons in Kazakhstan

Oil and gas deposits that were known but were not feasible in previous years have become profitable today. Even old oil formations that had been shut off in the past are now being developed. This is mainly due to the energy demand growth and the steady increase in oil and gas prices. Kazakhstan is one of the world's leading oil and gas exporters and is expecting significant increases in production in the near future. The country produces about 87% of its electrical power from fossil fuels including oil and gas. In order to judge the opportunities for renewable energy development in this country it is necessary to consider global oil and gas concerns that affect the energy market in Kazakhstan.

There are some existing opinions that the oil and gas resources should be over in about 40 years. But experts in the field are confident that both oil and gas and coal reserves will last much longer. Oil and gas demand in the world is expected to be growing in the next few decades, as well as in Kazakhstan. In addition to this, the world's oil and gas prices will rise significantly as it becomes more and more difficult to recover oil and gas [38].

Recovery of the oil that resides in deep deposits and has high concentrations of mercaptans, hydrogen sulphide and sulphuric gases, particularly in Kazakhstan, requires solutions for numerous problems concerned with the separation, processing, preparation and the environmental protection challenges. All of these cause additional production costs. More and more, the world oil industry will have to bring into development heavy and highly viscous oil reserves that require new, more expensive technologies and significantly higher amounts of energy for recovery, transportation and processing of these types of oil.

In the1950s, the energy contained in 1 barrel of oil would be approximately enough to produce 50 barrels, i.e. burning 1 kg of oil would bring 50kg. In the middle of the 1980s, the efficiency ratio decreased to 1 to 8, or 1 to 5 taking into account transportation and delivery to the consumers. It has been supposed that the efficiency ratio may reach 1 to 1 in the middle of the century. Then, oil becomes unsustainable in energy terms [36].

As far back as in the year of 1956, Dr. King Hubert published his oil production forecasting graph that is well known to all oil industry workers as the "Hubert Law" stating that oil is used as an energy source until it is reasonable to produce, and when it becomes very expensive to produce it spending unreasonable amount of energy, production will stop independently on a monetary and credit value of oil at that time [37].

Kazakhstan's economy can not afford to rely on oil and gas production alone to realize the economical development targets set by the RoK President to enter the world's 50 most competitive economies.

4.5 Renewable Energy Needs and Public Opinion in Kazakhstan

The history of energy has not yet shown a case when resources of an energy source would run out before the demand on it would drop. The firewood age finished earlier rather than wood resources were depleted, the age of coal is finishing earlier than its reserves are empty. The age of oil and gas demand should finish before all their resources get absolutely depleted on the earth. There are other main energy sources that will have to be developed and harnessed to serve for peoples` needs. These new energy sources must be solar and its derivatives such as wind. However the transfer must be smooth, painless, sequential and thoroughly prepared. Oil and gas should be used more as unique raw materials, Professor Nadirov says [37].

According to the Professor Nadirov, Kazakhstan has already got some patented technologies that use single solar or combined solar-wind energy devices for oil production, processing and transportation in spite of the current weakness of its renewable energy sector [38].

One of the following chapters will describe current laws, regulations, energy policies and changes planned in the near future in Kazakhstan aimed to support renewable energy development.

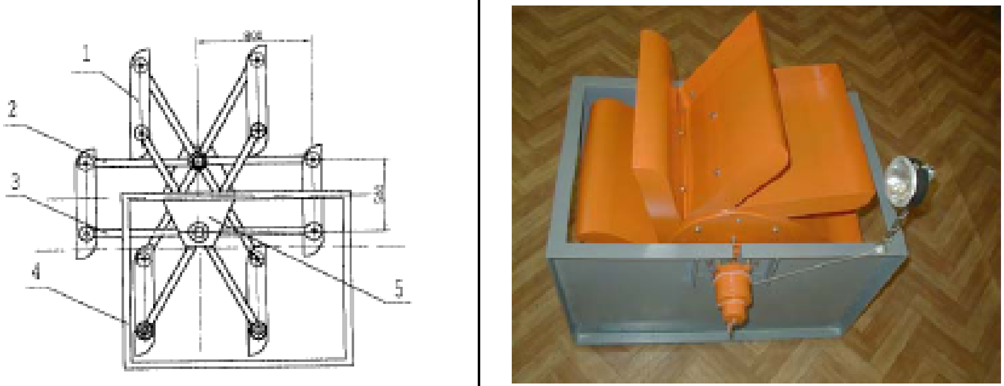
The renewable energy sources could be a good reserve for purification of the contaminated air and the environment in Kazakhstan, especially in the cities, providing electrical energy and heating. There are already some pioneering practical cases of the renewable energy usage involving small wind and solar installations.

The sunshine duration in Kazakhstan varies from 2200 to 3000 hours a year [37]. This prompts good potential for expansion of solar energy applications. Some of the local companies have already started sales of solar units.

There are good perspectives for hydropower in Almaty. The former Akim (mayor) of the city Imangaly Tasmagambetov, speaking about prospects for renewable energy, emphasized: "None of the cities in the world is able to boast of 22 rivers running through their territory". All of the rivers in Almaty run from mountains and they could be potentially good for creation of a hydropower system in the city.

There is a good potential for many small hydro plants in Kazakhstan. Some of the local engineers are working on the designs of small unmanned hydro plants. There are some prototypes that have already been designed and tested. These prototypes have been described at scientific seminars and exhibitions.

The following pictures are examples of small hydro and wind turbines from local inventors.



Picture 4.4 - Micro Hydro Turbine [41]

Picture 4.5 – Wind energy unit with diffuser [43]

As mentioned in the introduction, Kazakhstan should have very good wind resources. The wind metering and studies of the sites potentially suitable for wind farms marked by the institute "Kazselenergoproject" are being conducted by European scientific groups and will need to be completed to know more accurate values. This is because not all of the meteorological stations of the state weather agency "Kazhydromet" are located close to the relevant sites. The section 5.4 will describe wind resources on the territory of Kazakhstan.

A better idea on renewable energy perspectives today, is given by a quotation from Mr. Y.A. Kubaichuk who is a deputy of the RoK Parliament: "*The search of clean and environmental friendly energy is very important under the current conditions of widely spread environmental contaminations caused by the products of anthropogenic activities. Inexhaustible and renewable power sources should be considered as an important additional contribution to the energy balance of the country. The republic catastrophically lags in terms of usage of solar, wind and other alternative energy. This should be explained by the existing industrial and economical* *conditions. Renewable energy does not have an alternative at solving existing environmental problems in the country* ".

Generally, public opinion about renewable energy, particularly wind power, in the country is currently positive and optimistic. There are some hopes that it may be possible not just to cover domestic electrical power and heating needs but also to export some extra amounts of energy abroad.

Mainly, the reasons for not using renewable energy resources so far are their relatively high price compared to cheaper oil, gas and coal, and the absence of adequate scientific base, which have restrained technological progress in this area.

However the neighboring Republic of Kyrgyzstan has made efforts to find a substitution for the natural gas by producing bio gas. The main motivation for the country to seek for alternative energy is the absence of oil and gas reserves on its territory. Kyrgyzstan imports natural gas from Uzbekistan. Kazakhstan has had different motivations and all its efforts have been petroleum industry orientated.

Picture 4.6 - Biogas unit in Kyrgyzstan [42]

However as prices of conventional fuels grow, renewable energy around the world becomes less expensive due to technological progress and new developments in this relatively young sector.

4.6 Renewable Energy Events Organized in Kazakhstan

There also have been a number of international research and development seminars concerning renewable energy in Kazakhstan.

The first international "Renewable Energy" conference took place in the miner's city of Karaganda, 14 – 16 November 2005. Participants of this seminar were directors and specialists of universities, research institutions and companies from Georgia, Kyrgyzstan, Ukraine, Denmark, Kazakhstan and representatives of UNDP.

In September of 2006, there was an international conference "*Role of Renewable Energy in the Central Asia Development Strategy*" in Almaty under the aegis of UNESCO. The purpose of this conference was to help the Central Asia countries to use their renewable energy sources.

4.7 Why renewable energy in Kazakhstan?

In spite of the large share of electrical power generation from conventional fossil fuels and their wide usage in Kazakhstan, it is necessary to pay special attention to the following factors:

- Currently, Kazakhstan is the largest emitter of GHG in Central Asia and the third in the world in emissions per GDP unit (6.11kg CO_2/$)[44]. The country's economy consumes significantly more energy per GDP than developed countries do (see ANNEX III). In addition to the need of increasing energy consumption efficiency, application of emission free technologies can reduce general emissions;
- According to the RoK Ministry of Agriculture, there are 255 of villages and settlements in the country that do not have access to this to meet their energy needs since it is not economically profitable to direct a power line to these places. There are 35 of such settlements with total population of 28 thousand in the Mangystau province only. In addition to this, there is the issue of unresolved water supplies for some rural demands [44];
- There are also 180 thousand of newly settled farms, winter horse and cattle breeding camps in Kazakhstan. Some of them do not have electricity access as well being placed far away from power lines [44];
- Numerous geological expeditions make do with lack or deficiency of electrical power;
- Numerous relatively small formations of oil, gas, natural bitumen and other valuable mineral resources are not at present economically viable to develop due to their remoteness from the existing electrical power lines and other infrastructure [36];
- Huge territories and concentration of the main generation capacities in the central area of the country, in Pavlodar and Karagandy provinces, create the situation where electricity has to be transmitted over very long distances, which causes significant power losses. A significant amount of electrical power is imported from neighboring countries, e.g. from Russia whose territory is even bigger;
- Chapter 2 described that power consumption is growing far more rapidly than power production in the country. Most of the thermal power plants are old and should not be able to

work on their maximum allowed load as in the USSR period, even if their developers invest to their good maintenance. If consider a mean life time of a power plant as 20-30 years, major generation capacities currently working in the country are nearing the end;

- Environmental pollution and contamination keeps on growing due to the coal power plants. These plants have equipment that has been mainly inherited from the USSR industrial period, which sometimes may not correspond to the best modern environmental standards. Since environmental legislation has been quite lax until the new environmental code was issued last year, it would not be reasonably practicable for energy companies to follow the best environmental practices and invest into costly technologies to reduce pollution and contamination. Clean fresh air, soil and water of rivers are exhaustible natural resources, therefore many ecological unions in Kazakhstan struggle for adequate measures to prevent exhaustion of these vital resources;
- Today, the cheap electricity supplied from local thermal power plants using conventional energy resources is due to the way in which the cost is calculated. The point is that it does not take into account adverse ecological and social-economical consequences of burning organic fuels on these power plants in the immediate regions where these power plants concentrated.

All of the factors given above prompt a need for immediate actions including renewable energy development in Kazakhstan. Today or tomorrow, renewable energy aims to take a stable place in the energy balance of the Republic, before the time when all of its vast mineral resources will run out. In order for this to happen, the country firstly needs to have viable governmental supporting mechanisms.

As a petroleum engineer, the author would like to dispute the opinion that oil and gas will be absolutely over in 30, 50 or 70 years. Of course, there will be less of oil and gas so they might not be enough to meet all of the peoples` energy needs. They will become more and more difficult to reach and extract. They are not going to be absolutely over, neither in the whole world nor in Kazakhstan. There will be residual hydrocarbons in the currently developed productive formations, where some additional volumes could be extracted depending on required investments and market situation at that time. There are also areas and depths in the Earth interior that have not been studied yet because it was not financially reasonable before. The right question is how much oil and gas will cost if it gets too challenging to extract or reach them when all easy resources will run out.

4.8 View on the Renewable Energy in Kazakhstan. Investigation of the RoK Legislation and Government Policies

There has been a series of laws, governmental regulations and state programs concerning electrical power generation since the Republic of Kazakhstan obtained its independence in 1991. This section will describe the current RoK laws and regulations pertaining to the needs of renewable energy in the country.

The first step towards sustainable development and the first act of commitment to support international efforts to mitigate climate change impact was taken by Kazakhstan on the 15^{th} of May 1995 when the RoK President Nursultan Abishevich Nazarbayev signed the UN Framework Convention on Climate Change [45].

The first legislative act in this way was the *RoK Governmental Regulation # 474 of 19 April 1996* "*Concerning Energy Savings Measures in the RoK*". This document emphasized that one of the primary tasks towards achievement of the energy savings program is

> "*to develop mechanisms to provide necessary support to the businessmen implementing measures for energy savings and introducing unconventional power sources for the purpose of creation of the state energy fund-in-trust and embedding alternative energy sources* " (clause 3).

The RoK Ministry of Energy and Mineral Resources, Ministry of Finances, Ministry of Economy and Budgeting, Ministry of Justice were designated as responsible for this policy to develop necessary mechanisms. In order to realize these goals, Ministry of Energy and Mineral Resources issued two orders:

- # 6 of 18 March 1997 "*Concerning embedding renewable energy sources into the energy balance*";
- # 14 of 12 January 2000 "*Concerning creating of working group for development of the domestic wind power sector*";

The second document aimed to regulate social relationships in the energy savings area, for the purpose of effective usage of fuel-energy resources and environmental safety, is the *RoK* "*Energy Savings*" *Law # 210-1 of 25 December 1997*. This document gives the legal definition to renewable energy resources in the country as the

> "*Constantly existing or periodically arising in the environment fluxes of solar, earth heat, wind, rivers and the biomass*".

The necessity of the renewable energy development was mentioned as one of the primary directions of the state energy savings policy. The stimulation of their usage was mentioned as principal of the state policy. A designated state agency in the energy savings sector was given responsibility for the accomplishment of economical-regulative methods and mechanisms to involve renewable energy resources into the Republican power balance.

The next legislative act has been issued by the RoK ME&MR based on the *RoK "Energy Savings" law*. It is the order of 21 October 1998 "*Concerning Organization of the RoK "Energy Savings" law Realization"* and delegated duties of the state agency for the purposes of harnessing renewable energy resources and practical realization of the law. According to the order duties to realize the governmental policy were delegated down to the institute "Kazselenergoproject".

Another statutory act about effective energy usage was the *RoK Governmental Regulation # 384 of 09 April 1999* "*Concerning the Program of Electrical Energy Sector Development by the year of 2030*". According to the development program, improvement of environmental conditions in the country will be germane to involvement of the renewable power sources (i.e. "*hydro, wind and solar resources*") into the energy balance. There shall be total installed capacities of wind power estimated at 500 MW by the 2030.

In order to provide electrical energy independence of the republic, the RoK Government issued *the Regulation # 1700 of 13 November 2000* "*Concerning Approval on the Action Plan for Achievement of Electrical Energy Independence by the year of 2005*". However, this important document did not mention anything about usage of renewable energy resources to achieve energy independence as would be expected. This was a relatively short term action plan during the period of rapid and intensive development in the oil production and social sectors of the republic.

Having ratified the UNFCCC, to comply with the international liabilities taken by Kazakhstan in the May of 1995, the RoK Government issued the *Regulation # 857 of 25 August 2003* "*Concerning Development of the Wind Energy Sector*". In this document, Kazakhstan approves the suggestion of the UNDP to build a 5 MW pilot wind farm in the Drungar Gates area (Almaty province) with financial participation of the UNDP and GEF [46]. The RoK ME&MR, as the organ designated to work with the GEF on behalf of the RoK Government concerning the wind power development affairs and construction of the pilot wind farm, was authorized to make decisions concerning realization of the wind project, promote issues of grid connection, attract additional private investments for the project, arrange with the Akim (governor) of Almaty province matters of sharing land for the wind farm and give other necessary technical-organizational support for the wind farm.

An important legislative act relevant to wind power in Kazakhstan was the *RoK Governmental Regulation # 190 of 18 February 2004* "*About measures of further Development of Marketing Relations in the RoK Electrical Energy Sector*". This document described the main principles of the wholesale and retail electricity markets, market structure, development models of marketing mechanisms, and stages of transferring to an open model of competitive electricity market and mentioned the need for future development of renewable energy.

With regards to hydro power, the RoK Government issued *Regulation # 161 of 22 February 2004* "*About additional measures of the Hydro Power Development in the RoK*". This document directed to establish the joint stock company "Kaz Kuat" with 100% state ownership and specified its activities. The RoK Ministry of Finance was directed to share 149 244 000 KZT to pay the authorized capital of the company.

Finally, it can be concluded that there is no adequate legislative base and specific mechanisms promoting usage of renewable energy in Kazakhstan at present.

However the RoK Ministry of Environmental Protection and UNDP have prepared draft of the new RoK "Law on Renewable Energy" that is meant to provide necessary supporting mechanisms, expectedly thought the introduction of the Renewable Obligation Certificates system. This law shall pass through the state approval process and is expected to be accepted either by the end of 2008 or at the beginning of 2009.

5. Climate, Terrain, Nature and Wind Resource in Kazakhstan

5.1 Climate in Kazakhstan

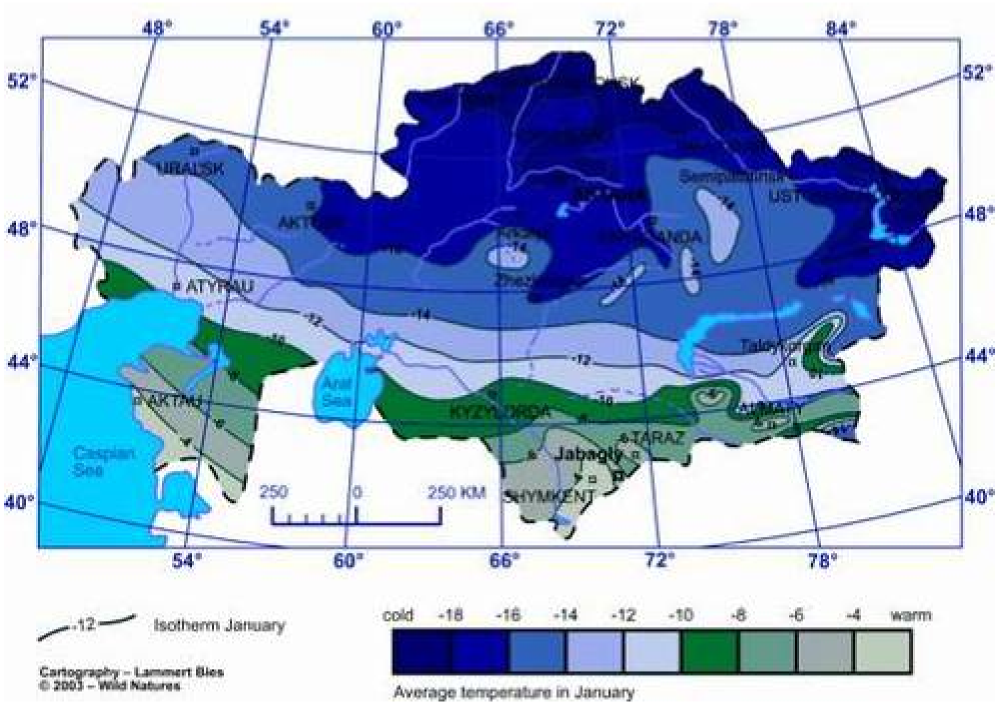
The territory of Kazakhstan is far from oceans and open for winds from the west and north. Therefore Kazakhstan's climate is sharp continental with uneven distribution of precipitations throughout its territory.

The most northern point of Kazakhstan is on the latitude of Moscow and Kazan.

The most southern point is on the latitude of Madrid, Stambul and Baku.

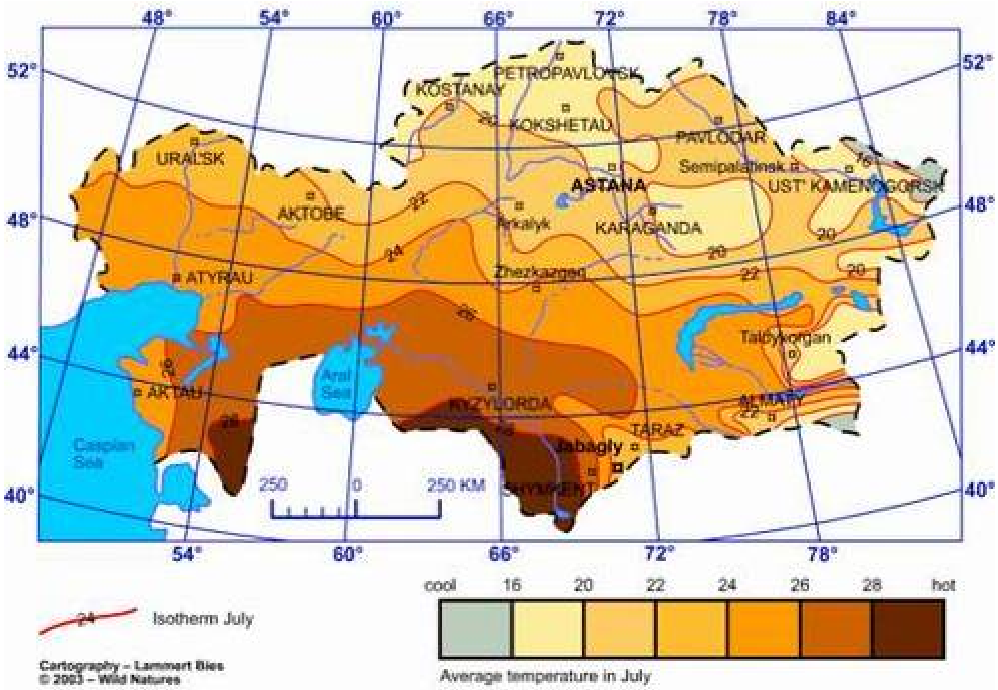
Therefore the climate of Kazakhstan is not even. When trees have started blossoming in south, the northern parts have got snow melting.

Winters are very cold and long in the northern parts, and more temperate in the southern parts.



Picture 5.1 - Average Temperatures around Kazakhstan in January [3]

Summers are dry, warm in the north, hot in central parts and very hot in the south.



Picture 5.2 - Average Temperatures around Kazakhstan in July [3]

Precipitations are not significant with the exception of mountainous regions.
Almost all territory is known to be windy. Some places may have very gusty winds.

5.2 Relief and Terrain in Kazakhstan

About 10% of Kazakhstan is high mountains territories. The highest mountain ridges are mainly in the southern and south-eastern parts of Kazakhstan. These mountains have glaciers and snows that stay even during the hottest months.

Deserts and semi-deserts take approximately 50% of the territory.

The other part is steppes and forest-steppes that are mainly in the northern Kazakhstan.
About 60% of Kazakhstan is flat lands.

Western Kazakhstan has PreCaspian Lowland and Mangyshlak Peninsula.

The Mugadzhar Mountains are to the north-east from the PreCaspian Lowland.

The Kyzylkum and PreAral Kazakum deserts are in the area of Aral Sea.

The Balkhash Cavity is in the south-east. The Ili Cavity is in the southern part.
The lowest point in Kazakhstan is 132 m below sea level, the Karagie Cavity, located in the Mangyshlak Peninsula.

The highest point is Khan-Tengry peak is about 7010 m above sea level.

5.3 National Parks and State Nature Reserves in the Republic of Kazakhstan

Picture 5.3 – RoK National Parks and State Nature Reserves [56]

Notations:

West Altayskiy in the East Kazakhstan province;

Устюртский - Ustyurtskiy (Mangistau Province);

Барса-Кельмес - Barsa-Kelmes (Kyzylorda province);

Каратауский –

Аксу-Жабаглинский – Aksu Dzgabagly (South Kazakhstan-Dzhambul Provinces);

Алматинский – Almatinskiy (Almaty province);

Алакольский –

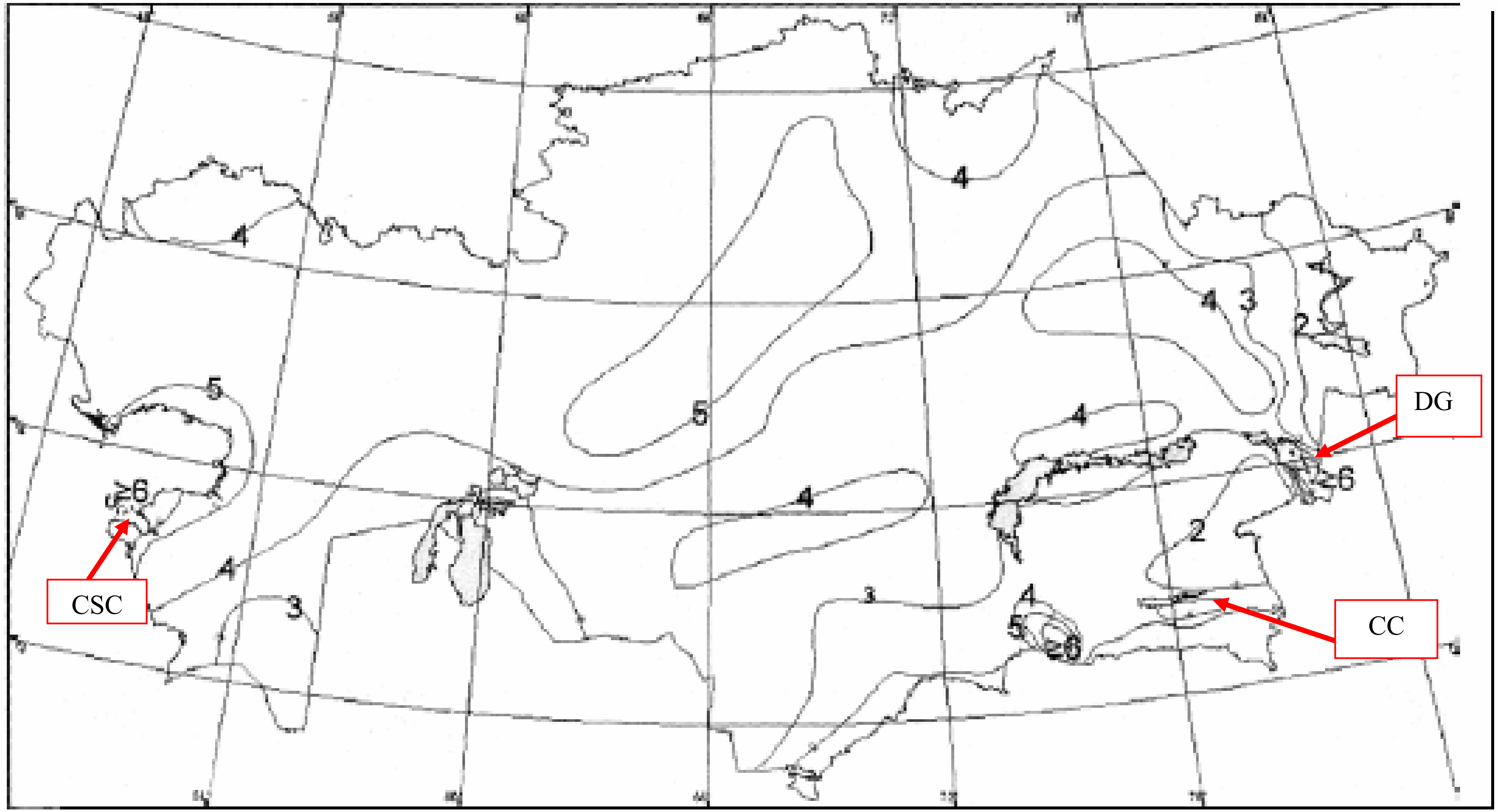
Маркакольский – Markakolskiy (East Kazakhstan province);

Коргальджинский – Kurgaldzhinskiy (Akmola province);

Наурзумский – Naurzumskiy (Kostanay province)

Territories of the national parks and their inhabitants are protected by law and will not be allowed for construction of a wind farm. All of the nature reserves have wide diversities of plants, birds and animals. Some of them are rare and protected by international regulations. More detailed information about each national park and nature reserve is given in ANNEX III. The Chilik Corridor site chosen for the study is about 70-100 km away from the closest national part Almatinskiy. The territories of Almatinskiy Nature Reserve are mainly located at very high levels in the mountain area. They are considered to be far enough away for construction of the wind farm in Chilik Corridor. However migration routes of birds nesting in the Almatinskiy nature reserve have to be additionally studied to make a more precise judgement on whether there may be an adverse impact or not.

5.4 Wind Resources in Kazakhstan. Prerequisites for Selection of the Potential Wind Farm Site [57]



Picture 5.4 - Wind Resource Map of Kazakhstan [57]

Notations: CSC – Caspian Sea Coast; DD – Dzhungar Gates; CC – Chilik Corridor.

Note: All average wind speeds on the map are given at 10 m height. The Chilik Corridor site has been chosen for construction of the potential wind farm and analysis of wind energy feasibility in Kazakhstan.

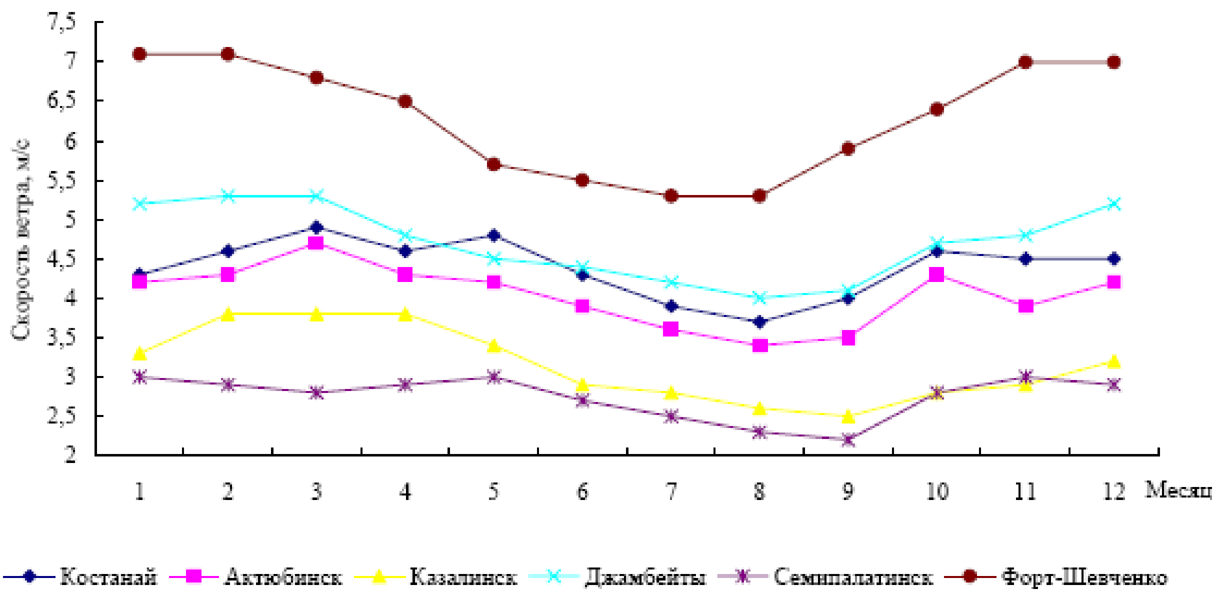
Wind speeds` regime is variable throughout Kazakhstan. On the flat territories, mean annual wind speed tends to increase from south to north.

Small wind speeds (1-2m/s) are observed in the submountainous areas of southern and south-eastern Kazakhstan. Wind regimes are very unsteady under conditions of complex topography features. For instance places sheltered from wind by their relief (hollows, lee and low parts of hill flanks, etc) have low wind speeds (up to 1 m/s) though wind speeds of mountain passes, corridors and peaks may exceed 5 m/s.

The windiest sites of Kazakhstan are considered to be wind corridor Dzhungar Gates, Chu-Ili Mountain Ridge and the eastern coast of the Caspian Sea. The average wind speeds of the sites are equal to or more than 6 m/s (see wind resource map).

There are seasonal variations of wind speeds. The flat parts of Kazakhstan have maximum wind speeds in spring and autumn, and minimum wind speeds in summer and beginning of autumn.

On the Caspian coast, the winter months are the windiest and summer months have minimum wind speeds.



Picture 5.5 - Annual Average Wind Speed Distribution on the Flat Territories [57]

Notations:

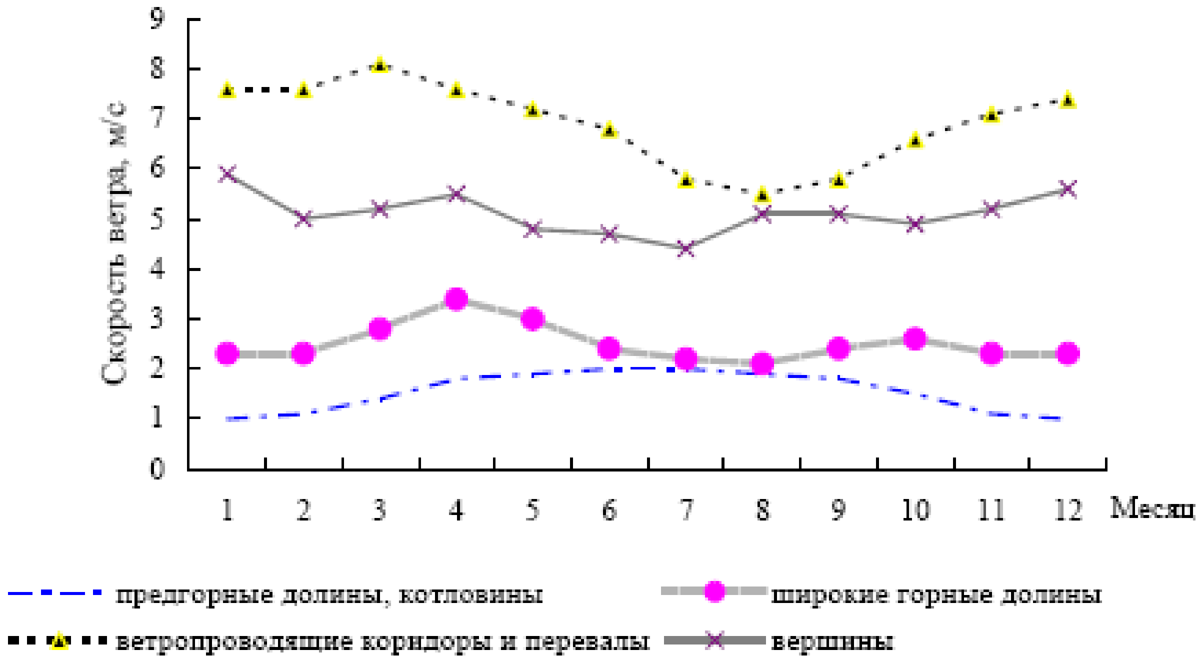
Axes - **Скорость ветра м/с** – Wind speed m/s; **Месяц** – Month;

Legend - **Костанай** - Kostanay; **Актюбинск** - Aktobe; **Казалинск** - Kazalinsk;

Джамбеты - Dzhambety; **Семипалатинск** - Semey;

Форт – Шевченко - Fort-Shevchenko

The mountainous and submountainous areas have different distributions of their average annual wind speeds depending on the location and topography.



Picture 5.6 - Annual Average Wind Speed Distribution on the Mountainous and Submountainous Territories [57]

Notations:

Axes - **Скорость ветра м/с** – Wind speed m/s; **Месяц** – Month;

Legend - **Предгорные долины, котловины** - Submountainous valleys, hollows;

Широкие горные долины - Wide mountain valleys;

Ветропроводящие коридоры и перевалы - Wind passes and corridors;

Вершины - Peaks

As could be expected, the low lands have the smallest wind speeds not exceeding 2 m/s. In terms of annual distribution, the winter months are observed to have the minimum wind speed values 0.4 -0.7 m/s due to stagnation of cold air masses in these areas. The period of the maximum air mass circulations is in summer. Then the wind speeds can reach 1.2 – 1.7 m/s.

The wide mountain valleys at the south-east and east of Kazakhstan have two maximums and two minimums during a year.

Enhancements of wind speeds are observed at the places of narrowing of wide valleys. The met station at the Chilik village, which is to the west of the place of the biggest narrowing of the

Ili river's wide valley, has observed wind speeds exceeding 4 m/s during winter months.

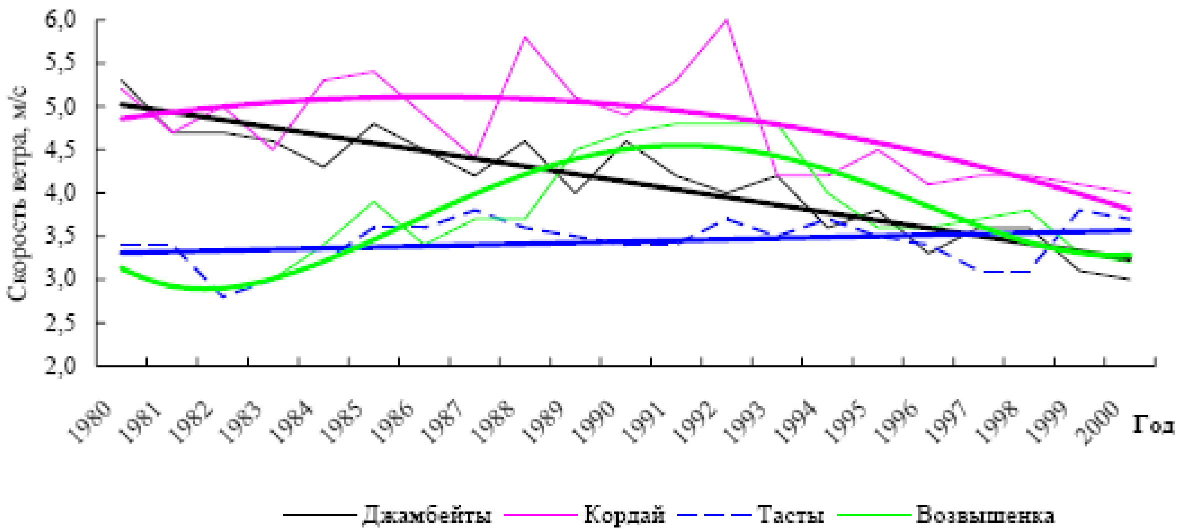
This wind has been known by locals as "Chilikskiy" wind for many years. However placement of the met station does not allow adequate information about the wind resource. It is located at the edge of the village and this might affect the wind regimes. The met station was built in the Soviet period and the Chilik village has expanded since then.

Wind speed enhancements are also observed at the peaks. For instance, the flat area on the Karatau ridge peak (Aksuran met station) has 5 m/s average annual wind speed, where the annual mean does not exceed 1.5 m/s.

Very high wind speeds have been observed in the mountain passes and wind corridors. The maximum wind on the passes of Chu-Ili Mountains is normally in the middle of spring (5.6 - 6.7 m/s) and the average annual wind speeds are in order of 5-7 m/s.

The wind corridors Dzhungar Gates and Zhangiz Tobe have maximum wind speeds in winter (7.4 -13.8 m/s). It weakens to 5 m/s in summer because of reduced cyclonic intensity. Generally the average annual wind speed in the Dzhungar gates is 7-8 m/s. The site is known to have the strongest wind since ancient times. There was an accident in the Soviet period when a number of cargo railway carriages were tipped over by the wind.

It is also important to note that the wind regime in Kazakhstan changes due to climate change, which requires additional observations. According to investigations from 34 met station around Kazakhstan carried out by Dr Kozhakhmetov, there is a common relationship of patterns of annual average wind speeds` decreasing since 1993. For some met stations such as Dzhambety, decreasing trends are very significant.



Picture 5.7 - Interseasonal Variations of Annual Average Wind Speed [57]

Notations:

Axes - **Скорость ветра м/с** – Wind speed m/s; **Год** – Year;

Legend - **Джамбеты** - Dzhanbety; **Кордай** - Korday; **Тасты** - Tasty;
Возвышенка – Vozvyshenka (Lofty site)

6. Electrical Grid Infrastructure of Kazakhstan

As mentioned in the electrical energy market section, the biggest electricity output and consumption in Kazakhstan, 85.3 TWh and 104.7 TWh correspondingly, was in 1990. In 2007, Kazakhstan produced 75.5 TWh and consumed 76.6 TWh. The facts show that the electrical networks in Kazakhstan have potential for additional generating capacities.

The main system backbone, interregional and international transmission lines are regulated at 220, 500 and 1150V [24].

The regional electricity transmission lines are regulated at 35, 110 and 220 kV [24].
The local distribution networks are regulated at 0.4, 6, 10 and 35 kV [24].

6.1 Electrical Lines of the National Grid Operator

KEGOC operates the main National electrical networks of Kazakhstan. It controls international and interregional transmission and also some of the local regional transmission and distribution electricity lines.

The table below presents information about the main electrical power networks controlled by the KEGOC branches around Kazakhstan.

#	Branch	Total Length, km	Transmission Voltage	Number of Substations	Voltage of substations	Total Grid Power, MVA
1	Almaty intersystem	2412.82	35-500	9	35-500	2559.35
2	Akmola intersystem	4225.519	220-1150	10	220-1150	7606.6
3	Aktobe intersystem	1200.02	220-500	6	220-500	875
4	East KZ intersystem	1039.2	110-500	5	220-500	3026.5
5	West KZ intersystem	1679.5	220	5	220	950
6	Sarbayskie intersystem	2416.481	110-1150	8	220-1150	6569.9
7	North KZ intersystem	3216.389	110-1150	8	110-1150	3518.1

8	Central KZ intersystem	2918.58	220-500	10	220-500	3851
9	Shymkent intersystem (South KZ)	4313.458	220-500	13	220-500	3252.6

Table 6.1- Electrical Lines of the National Grid Operator [27]

In general, the power lines controlled by the National Grid Operator are:

- 1150 kV lines, 1,421 km;
- 500 kV lines, 5,323 km;
- 220 kV lines, 15,976 km;
- 110 kV lines, 559 km;
- 35 kV lines, 43 km

Total carrying capacity of the existing international electricity networks in Kazakhstan is about 30 TWh per year including 12-14 TWh per year capacity of the lines integrated with Russian electricity system [24].

In addition to the National grid operator, there are some other private and joint venture companies operating local electrical networks and controlling energy sales within regions and provinces.

The Almaty region, including both city and province, is relevant for further investigation.

6.2 Electrical Lines of Almaty Power Consolidated

Almaty Power Consolidated (APC) was established in 1996 during the privatization of the RoK electrical energy sector. The main share holder of the company is the JSC "Kaztransgas"[58].

APC collaborates with the National Grid Operator KEGOC and some other energy companies of Kazakhstan, Uzbekistan, Tajikistan and Turkmenistan in the framework of Central Asia United Energy System. The APC supplies electricity to about 2.2 million people [58].

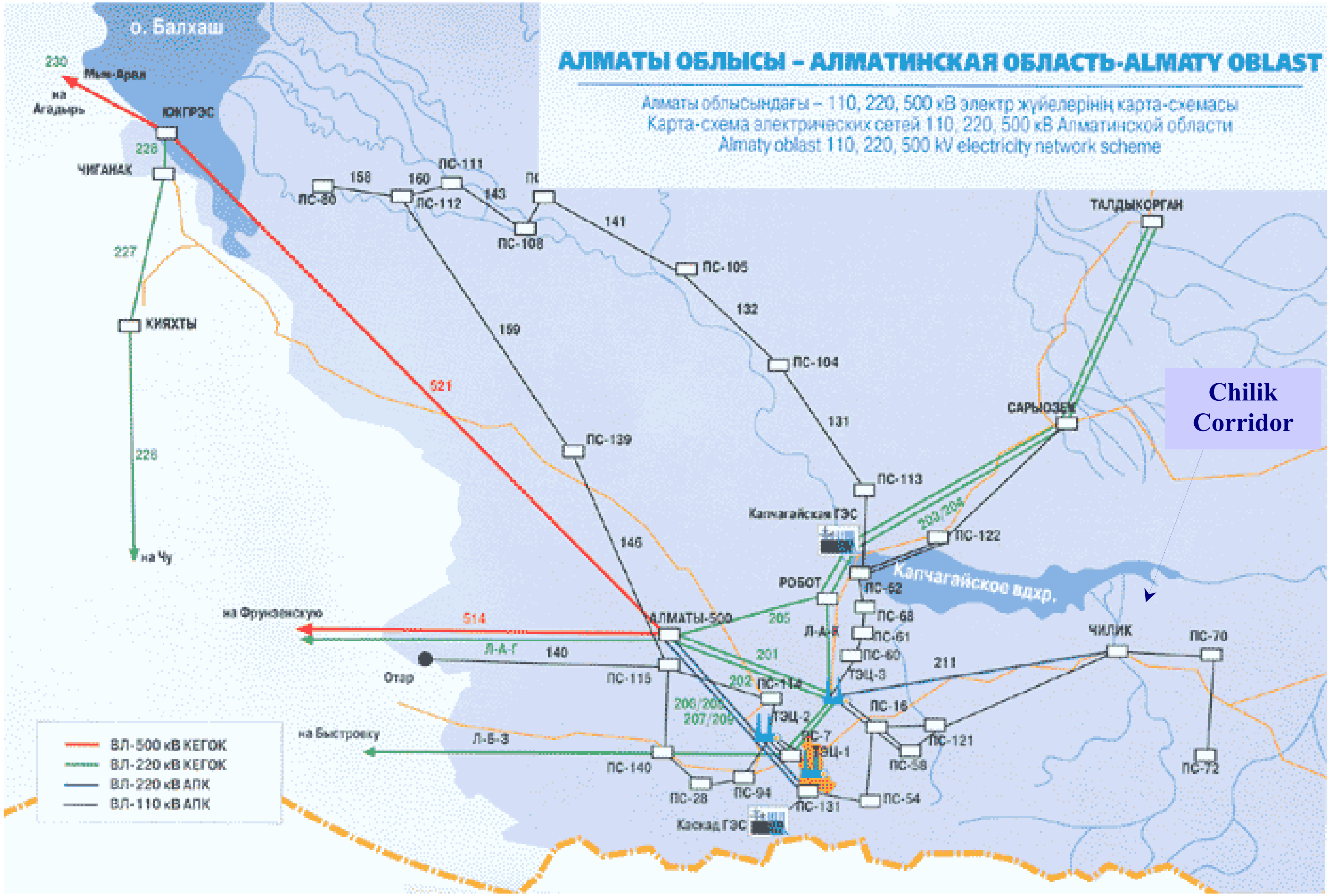
The table below represents information about the electrical power networks controlled by the ACP

Length of lines for electric power transmission: 34 084,0 km	
Including Overhead lines:	
by 220 kV voltage	305,3 кm
by 110 kV voltage	2 649 кm
by 35 kV voltage	2 565,3 кm
by 0,4-6-10 kV voltage	24 957 кm
Cable lines:	
by 0,4-6-10-35-110 kV voltage	3 607,4 кm
Electric power substations in total: 221 units	
Including:	
220кV	6 substations
110кV	88 substations
35кV	117 substations
Installed capacity of Transformer substations: 4 320,7 M VA	

Table 6.2 - Electrical Lines of the APC [58].

In addition to the electrical networks, ACP operates the «Kapshagayskaya HES» and «Cascade HES» Coordinated Hydroelectric System (see picture 6.1).

6.3 Electrical Grid Infrastructure in the Almaty Region



Picture 6.1 - General Map of electrical grid in Almaty region 110 – 500 kV [58]

Main notations from the map:

- **АЛМАТЫ** - Almaty
- **ЧИЛИК** - Chilik (village)
- **Капчагайское вдхр**. - Kapchagay Water Reserve
- **Карчашайская ГЭС** - «Kapshagayskaya HES» Hydro Electric Station 364 MW
- **Каскад ГЭС** – «Cascade HES» Coordinated Hydroelectric System 47MW
- **ВЛ-500 кВ КЕГОК** - HV 500 kV KEGOK power lines
- **ВЛ-220 кВ КЕГОК** - HV 220 kV KEGOK power lines
- **ВЛ-220 кВ АПК** - HV 220 kV APC (Almaty Power Consulidated) company power lines
- **ВЛ-110 кВ АПК** - HV 110 kV APC power lines
- **ПС** - Substation

The site chosen for the analysis of potential wind farm construction, Chilik Corridor, is located in the Almaty region approximately 35-40 km from Chilik village, which is 110 km from the city of Almaty by road. The area has a 110 kV transmission line operated by APC with the substations #70 and "Chilik" shown in the map above.

However there is another power line with substation that is approximately 15 km from the Chilik Corridor site which could be used to connect the wind farm. This is APC operated 35 kV substation #42, which is not included in the Almaty electrical grid map [59].

According to the Kazselenergoproject, the Dzhungar Gates and Chilik Corrodor areas could potentially have 50 MW wind farms. The estimations are based on their knowledge of the power grid infrastructure and electricity balance in the Almaty region [60].

The APC advised that if a 50 MW wind farm with annual production of roughly 150-200 GWh would need to be connected to the grid in that area, it would be necessary to consider the 110kV line for this amount of energy rather than the one with 35kV [59].

The capital cost of overhead power line from the wind farm to the available grid would be in order of $20000 per km per 20 MW of installed capacity [60]. This expense is not significant compared to the cost of wind turbines and will make around 2.2 % of total capital cost of the wind farm.

Wind farms have never been integrated into the electrical grid so far. Additional technical information would need to be obtained from the grid operating companies, KEGOK and APC, and the issues of matching demand supply and power quality should be further investigated. For this study, it has been advised by SgurrEnergy and Kazselenergoproject that an installed capacity of 50 MW for the potential wind farm is reasonable.

7. Technical Analysis of the Project

7.1 The Reasons for Choosing the Chilik Corridor for the Project

The Chilik Corridor area has been chosen for construction of the potential wind farm and analysis of wind energy feasibility in Kazakhstan.

However there are 45 areas that are considered good for construction of wind farms around Kazakhstan [60]. These places are known to have good wind resources but most of them have been designated for additional monitoring to obtain data sets good enough for adequate predictions of possible energy yields.

The Dzhungar Gates area is said to have the best wind resource in the country. It is located in the Almaty province near the border with China. It has not been chosen for this study due to the fact that it is already being planned for the first 5 MW pilot wind farm.

The Caspian Sea Coastal area has probably the second highest average wind speed in the country. As a note for possible next research topics, it would be reasonable to choose sites for potential wind farms here with a view to future oil and gas industry growth. The reason for not choosing this area was the issue of obtaining necessary data and information from the Mangistau province, which could be problematic for the author in Glasgow.

With relatively limited time, the choice of site for the analysis was mainly stipulated by the possibility to obtain information on electrical power grid infrastructure and consumption in the Almaty province and the availability of relatively recent 10 min wind records measured at the Chilik Corridor and Dzhungar Gates sites. Another important factor is that the author is from the city of Almaty. That made it possible to enquire about some specific issues arising during the project directly from the APC power grid operator.

The Chilik Corrodor area is one of the windiest places in Kazakhstan and the second windiest in the Almaty region.

Even though the Chilik Corridor does not have the best wind resource in Kazakhstan, it is very good for wind farm construction and relevant for wind energy feasibility analysis for the following reasons:

- It is known that the city of Almaty lacks domestic electrical energy and imports significant amounts of electricity mainly from the neighboring Kyrgyzstan. The deficiency is forecast to increase significantly if no measures are taken in the near future.
- During recent times there have been some disagreements between the governments of Kazakhstan and Kyrgyzstan concerning water resources of rivers flowing thought territories of the countries. Returning to the previously mentioned energy independence issue, emphasized by the RoK president Nursultan Nazarbayev, the installation of additional power

generating capacities to meet demands of the city of Almaty and whole province becomes important today.

- Good wind resource [57]
- Availability of power lines and substations to import generated wind energy into the grid.
- Large territory that should allow choice of places for the wind farm construction.
- Remoteness from populated places.
- Possibilities for increasing installed capacity in future (up to 100 MW) [44].
- Availability of transport communications and sufficient remoteness from the district's busy (main) motor road. However existing transport communications leading to the area would need to be checked on whether they would be enough for transportation of large wind turbines.
- Proximity to the consumers and small electricity transmission losses.
- Possibility of cost reduction using energy located close to the end user should be noted by the grid operators if any new transmission lines are planned to be built in future.
- And the reduction of environmental impact of existing thermal power plants.

7.2 Wind Resource and Energy Yield Prediction

7.2.1 Description of Raw Data Measured at the Site

The data files have been obtained from the RoK ME&MR in the EXE format. Original files provided were composed of 10 minute step records measured within the period from 13April 1998 (12:50) until 07 May 2000 (06:50) at the Chilik Corridor.

The metering was performed by Danish scientific group from the RISO laboratory. Unfortunately retrieval of additional information about the mast and type of metering instrumentation used was not successful.

The geographical coordinates of the site are 43º 43' 13" northern latitude and 78 44' 65" eastern longitudes.

The data was split into three files. Each file contained records of a calendar year. Each year data set consisted of a different number of 10 min step record rows and 12 data columns. The 1998 year file had 37,796 rows; the full 1999 year file had 52,560 rows and the 2000 file had only 18,329 rows.

In total: 37,796 + 52,560+18,329 = 108,685 rows.

This is an example of the records from the 2000 year data file.

0	5.72	7.49	0.7	9.35	56	60	0.1	0	-0.09	961	200001010010
1	6.12	7.49	0.6	9.04	44	49	0.1	-0.1	-0.18	961.2	200001010020
2	5.82	7.33	0.56	8.89	49	52	0.1	0	-0.09	961	200001010030
3	6.65	8.19	0.54	9.66	45	50	0.1	0	-0.09	961	200001010040
4	6.58	8.11	0.62	9.51	47	50	0.1	0	-0.09	960.6	200001010050
5	6.75	8.42	0.74	10.13	53	56	0.2	0	-0.18	960.6	200001010100
6	6.95	8.65	0.66	10.28	56	59	0.2	0	-0.18	960.6	200001010110
7	7.31	8.89	0.74	10.91	54	57	0.1	0	-0.09	960.5	200001010120
8	8.24	9.58	0.95	11.37	53	55	0.1	-0.1	-0.18	960.3	200001010130
9	7.84	9.51	0.7	11.06	47	51	0.1	-0.1	-0.18	960.5	200001010140
10	7.74	9.27	0.76	11.37	51	53	0.2	0	-0.18	960.6	200001010150
11	7.64	9.2	0.78	11.22	52	55	0.2	0	-0.18	960.8	200001010200
12	7.48	8.89	0.8	11.22	61	62	0.2	0	-0.18	960.6	200001010210
13	7.94	9.2	0.7	11.06	63	65	0.3	0	-0.27	960.6	200001010220
14	7.91	9.04	0.7	11.22	60	62	0.2	0	-0.18	960.6	200001010230
15	7.71	9.2	0.7	10.91	66	67	0.3	0	-0.27	960.5	200001010240
16	7.78	9.2	0.68	11.06	61	62	0.3	0	-0.27	960.8	200001010250
17	7.68	8.89	0.72	10.59	46	51	0.3	0.1	-0.18	961.2	200001010300
18	7.91	9.43	0.62	10.75	41	46	0.4	0.1	-0.27	960.8	200001010310
19	8.07	9.66	0.78	11.84	60	62	0.5	0.3	-0.18	961.2	200001010320
20	7.44	9.2	0.89	11.68	67	69	0.5	0.4	-0.18	960.8	200001010330
21	7.51	9.27	0.68	11.06	56	60	0.5	0.3	-0.27	960.8	200001010340
22	7.24	9.12	0.76	10.91	56	59	0.6	0.5	-0.18	960.6	200001010350
23	6.88	8.57	0.78	10.28	62	65	1	0.8	-0.18	960.8	200001010400
24	7.01	8.57	0.82	10.44	52	57	1.2	1	-0.18	960.8	200001010410
25	6.88	8.57	0.82	10.59	43	48	1.4	1.1	-0.27	961	200001010420
26	6.35	8.11	0.78	9.82	44	48	1.4	1.2	-0.18	961.2	200001010430
27	6.85	8.34	0.8	10.28	41	46	1.4	1.1	-0.27	961.3	200001010440
28	6.95	8.57	0.78	10.75	48	51	1.4	1.3	-0.18	961.3	200001010450
29	7.41	8.96	0.95	11.68	50	54	1.6	1.3	-0.36	961.5	200001010500
30	6.91	8.42	0.87	10.28	50	53	1.7	1.4	-0.36	961.3	200001010510
31	9.37	10.52	0.68	12.15	62	64	1.8	1.4	-0.36	961.2	200001010520
32	8.21	9.43	0.97	11.68	63	64	1.8	1.4	-0.45	961.3	200001010530
33	7.01	8.11	0.82	9.66	64	65	1.8	1.4	-0.45	961.2	200001010540
34	7.21	8.11	0.76	9.66	60	60	1.9	1.3	-0.63	961	200001010550
35	6.81	7.56	0.95	9.51	63	64	1.6	1.2	-0.45	961	200001010600
36	7.11	7.88	0.6	9.35	68	68	1.7	1.1	-0.63	960.8	200001010610
37	6.71	7.56	0.74	9.2	68	67	1.7	1.2	-0.54	960.8	200001010620

Picture 7.1 - Example of the original records

7.2.2 Compiling Site Data Together for Analysis

The original site data files were converted into MS Excel format, in order to undertake preliminary analysis of the raw data. MS Excel has been also used for further calculations and wind resource assessment.

The original site record files did not include a clear notation of what kind of data each of the records` columns contains. Therefore, to specify what each of the data columns stands for, it had to be further investigated by discussing with industry specialists, detailed study of the data columns and matching the dataset with the similar records from Dzhungar Gates, which is planned for the 5 MW pilot wind farm. This was possible because the measurements for Dzhungar gates were carried out by the same scientific group presumably using the same type of equipment and the data included clear notation of each column, however in a different order.

After detailed reviewing of the raw data, matching it with the similar records from the Dzhungar Gates site it has been found out that the columns in the original data files contain the following records:

Column N	Data Measured	Measurement Units
1	Number of the record row	____
2	Wind Speed 10.6 m	m/s
3	Wind Speed 32.4 m	m/s
4	Wind Speed Standard Deviation 32.4 m	m/s
5	Wind Sp. Gust 2 sec. 32.4 m	m/s
6	Wind Direction 10.6 m	Deg
7	Wind Direction 32.4 m	Deg
8	Temperature at 4.7m	Deg C
9	Temperature at 32.4m	Deg C
10	Temp. diff. 32.4-4.7 m.	Deg C
11	Pressure 4.7 m	hPa
12	Year, Month, Day, Hour, Minute	____

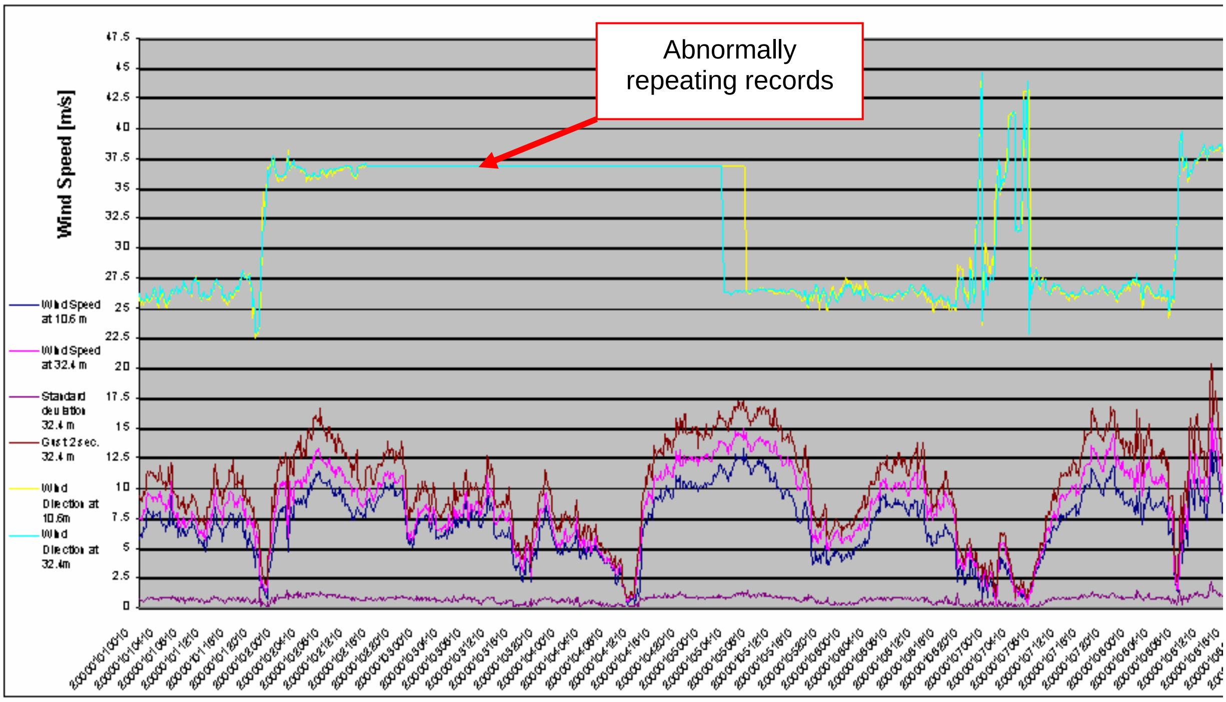
Table 7.1 – Notations for original data files

7.2.3 Screening of the raw data

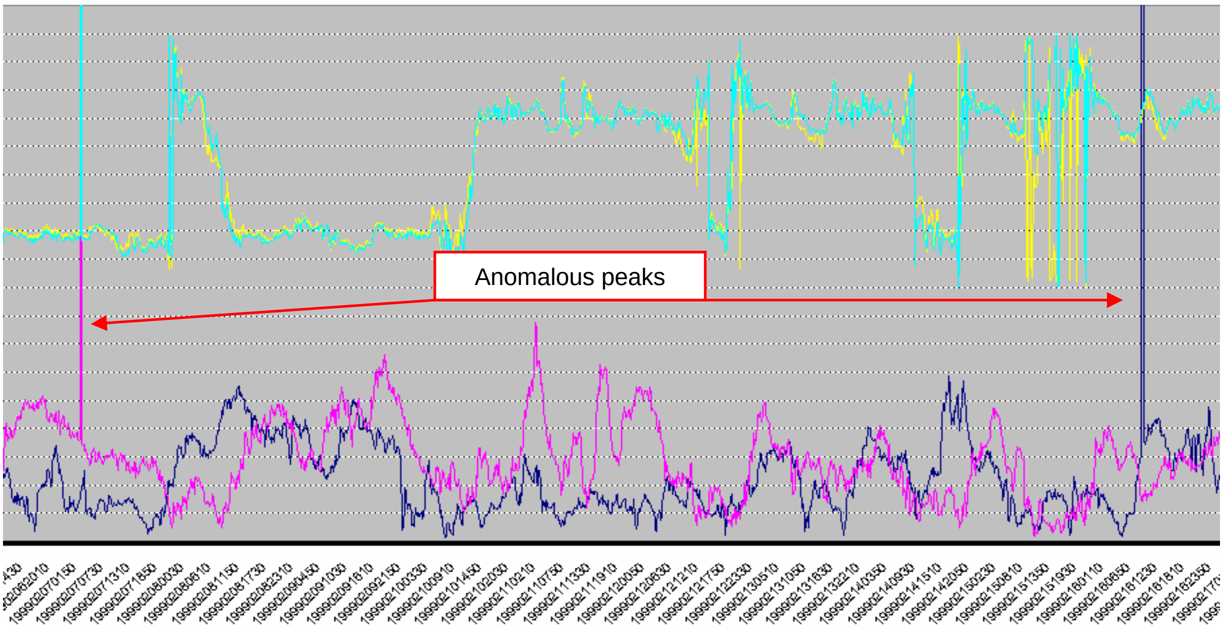
During the detailed revision and study of the raw data it was noted that some records are abnormal. Awareness about the climate in Almaty region and reference to the study of general wind resource from the met stations throughout Kazakhstan's territory performed by Dr. Kozhakhmetov et.al (in 2005) [57] were useful to check for any abnormal records in the data files.

Nine data columns (WSp 10.6 & 32.4 m ; W Dir 10.6 & 32.4 m; WSp st. dev. & WSp gust; Temp 4.7 & 32.4 m; Pressure) were screened.

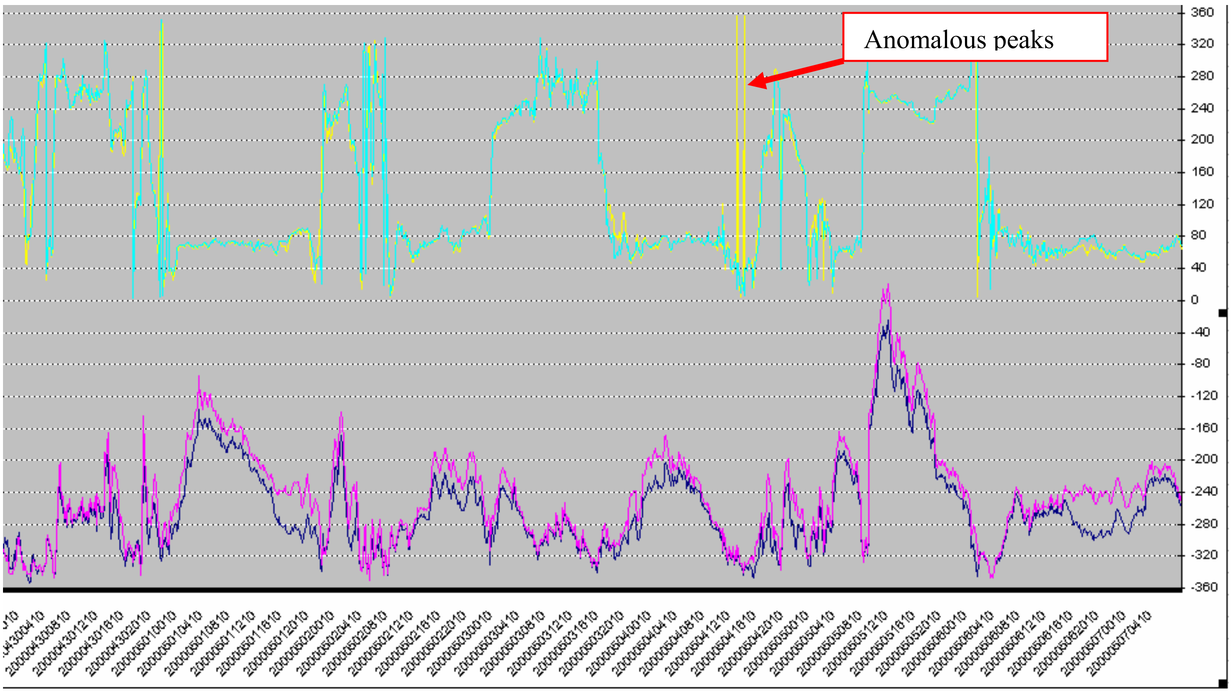
All of the anomalous records revealed during the screening were removed. After the removal, clear gaps were left to keep continuous 10 min time steps with the missing data.



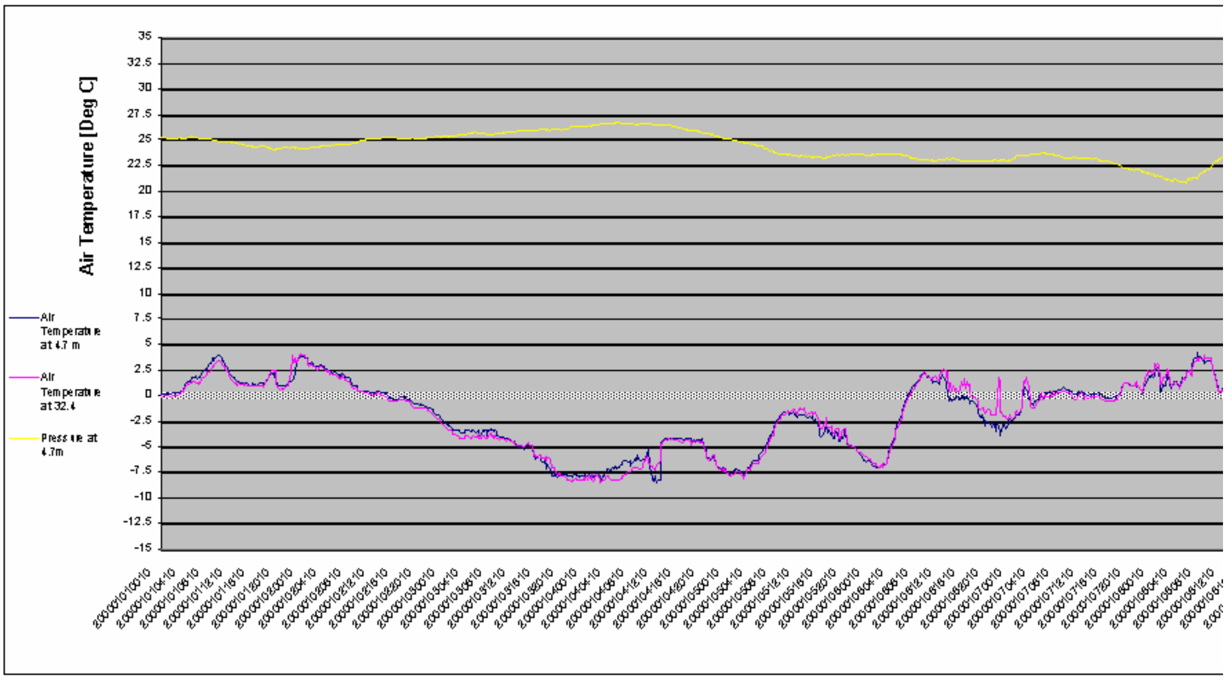
Picture 7.2 - Example of abnormal wind direction records



Picture 7.3 - Example of anomalous wind speed records



Picture 7.4 - Example of screened wind direction records



Picture 7.5 - Example of air temperature and pressure screening

The records of wind speed, wind direction, air temperature were plotted in two axis charts and were stretched as wide as possible in MS Excel to go over the data series and check if there were any abnormal data points.

Note: both 1998 and 1999 years` records were split in two parts and plotted for each data set since MS Excel limits the number of data entries in a series to 32000.

It is also important to note that all the screened off anomalous data were saved in separate sheets to keep records and to allow easy reference when needed. Clear blanks were left in the removed data gaps to allow continuous and unbroken 10 min time step series.

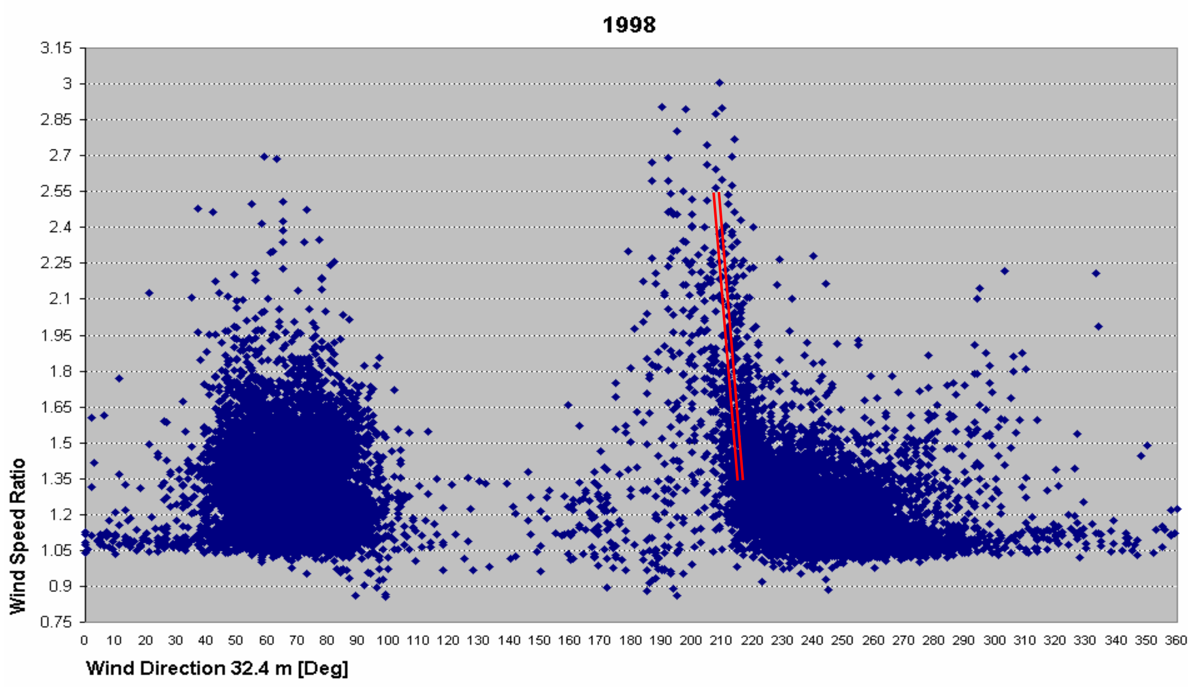
This is the outline of the screening results: the 1998 file had 76509 error records, 1999 had 81333 error records and 2000 had 784 error records.

The data errors could be due to physical damage to the equipment or its improper installation. The physical damage could be caused by lighting, birds, etc. The removed data errors from cold periods could be caused by icing of equipment in the cases when temperatures were low.

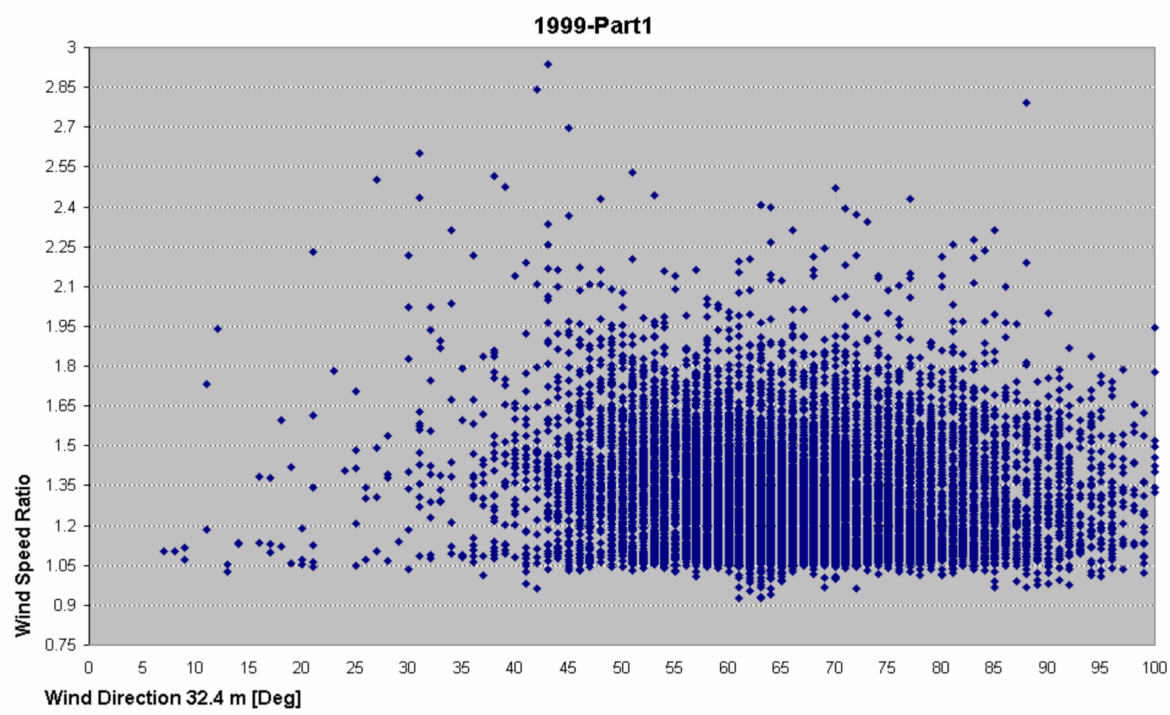
7.2.4 Mast Shadow Effect

Mast shadow check is to see if there are any abnormal trends in the records that could affect the accuracy of wind speed data analysis.

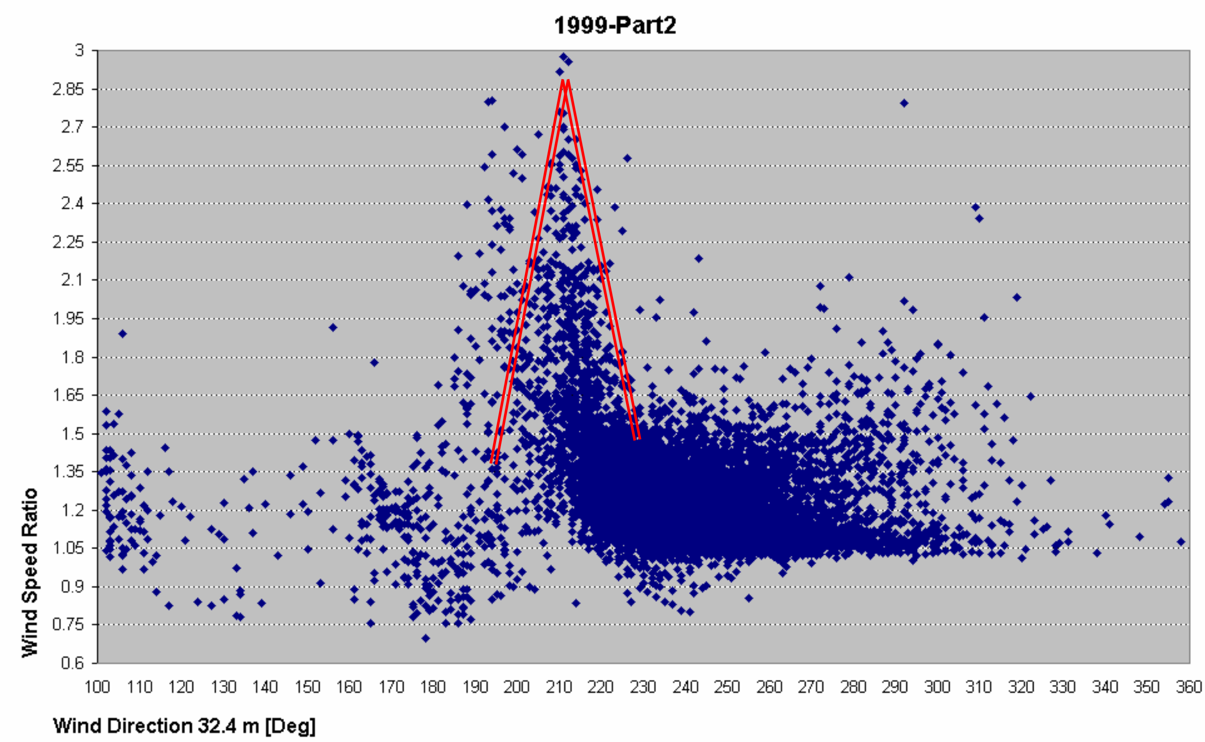
The ratio of wind speed records measured at the 10.6 and 32.4 m heights has been plotted against the wind direction. Before plotting the mast shadow check charts for each year, all rows with missing wind speed and direction gaps that were removed during screening were sorted out. Wind speed records of less than 4 m/s were eliminated to make clearer pictures on the charts.



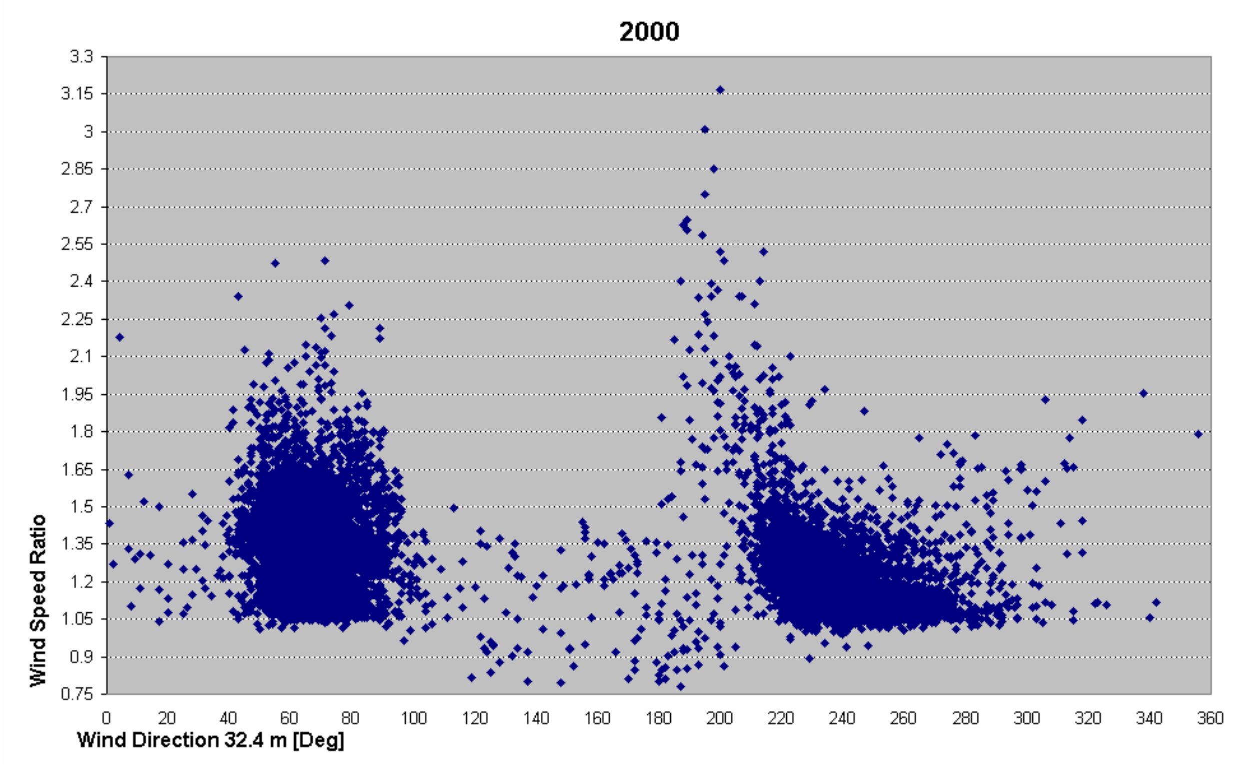
Picture 7.6 – Mast shadow check of the records from 1998



Picture 7.7 – Mast shadow check of the records from 1999, 1st part



Picture 7.8 – Mast shadow check of the records from 1999, 2nd part



Picture 7.9 – Mast shadow check of the records from 2000

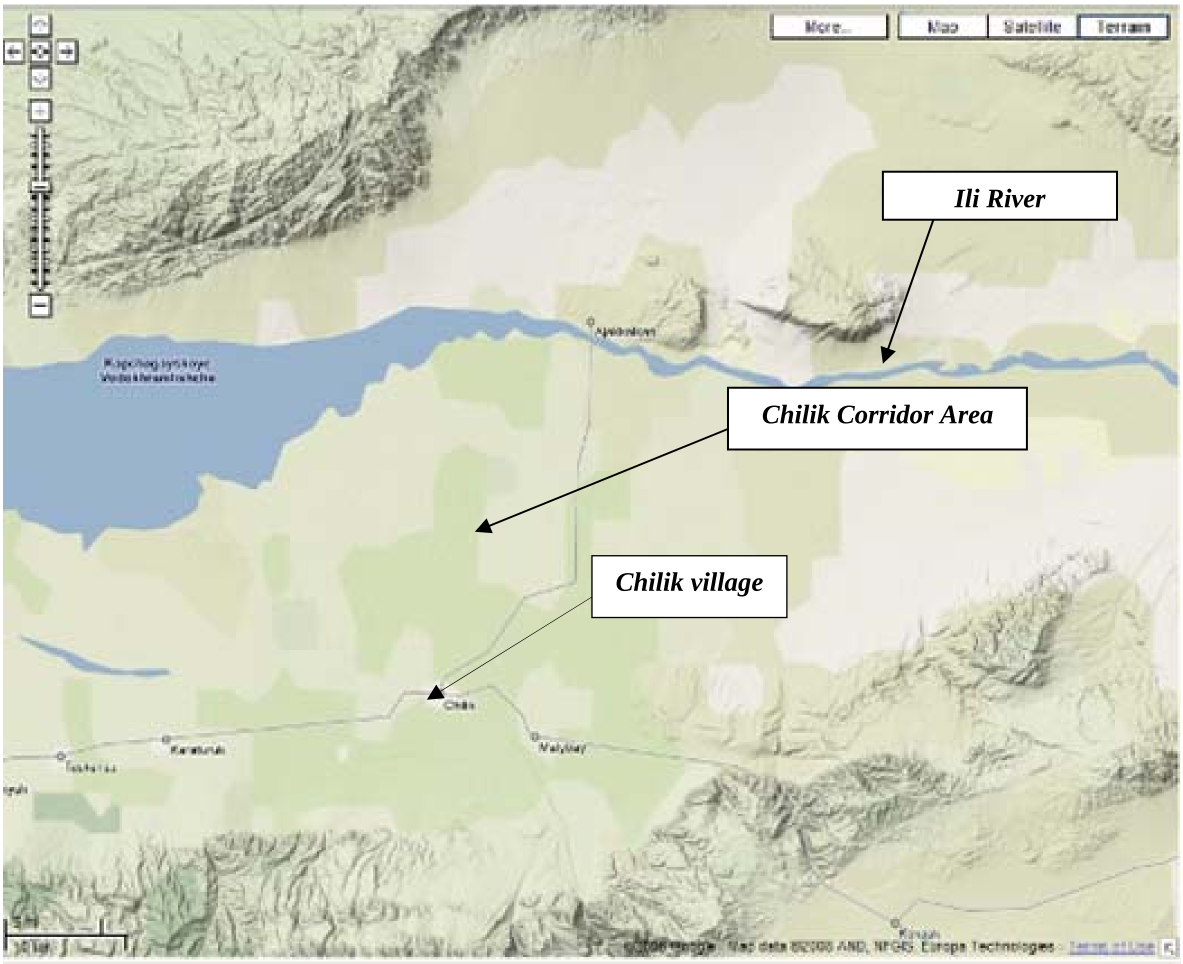
The red lines on the charts highlight the most obvious highest peak of wind speed ratio points that mean there was a possible mast shadow effect in the directions between 200 and 220 degrees. This could be due to the placement of anemometers on the mast so that the anemometer set at 10.6 m could be sheltered. The sheltering could be caused by the mast, other devices placed on the mast or an obstacle creating consistent wind speed ratio peaks.

It has also to be noted that there are some wind speed ratio points with values below one. These points are less obvious and more random in wind direction than the peaks. They denote that in these cases wind speeds at 32.4 m were less than wind speeds at 10.6m. These could have been due to the site topography effect and different wind directions at the two heights at each particular moment. The wind shear analysis will describe the main directions where the wind speeds were decreasing with height.

It has been also found during the mast shadow effect analysis that the wind speed records are mainly concentrated in the directions from 40 to 95 and from 210 to 280 degrees.

This is quite unusual for European conditions and required to be studied to be explained. As was found during analysis of the site terrain using Google Maps, this can be explained by the topography features in the whole area. The Chilik Corridor site is located in a large valley with mountain ridges at North and South. Thus the wind can mainly blow through the valley in the two directions.

The picture below is the terrain map of the region around the Chilik village.



Picture 7.10 – Chilik area of the Almaty region

7.2.5 Collection of Reanalysis Data

The reanalysis data was provided by SgurrEnergy and was taken from the NCEP/NCAR database for the 45 northern latitude and 80 eastern longitude node, the closest to the Chilik Corridor site obtainable from the database [69].

The original reanalysis data files contained records with 6 hourly time step.

The picture below is an example of the reanalysis data.

year	month	day	hour	srf.dir.2	srf.wsp.2	u10.dir.10	u10.wsp.10	gl.tmp.2
2008	1	1	0	179.17	6.9	183.5	4.91	-14.65
2008	1	1	6	184.97	6.93	156.8	3.81	-12.35
2008	1	1	12	143.37	4.86	180.67	8.5	-12.75
2008	1	1	18	180	10.2	188.53	10.11	-17.35
2008	1	2	0	189.31	12.36	198.87	8.35	-16.85
2008	1	2	6	202.7	10.62	224.46	7.57	-11.75
2008	1	2	12	227.19	9.27	159.74	8.95	-9.65
2008	1	2	18	165.58	10.84	200.66	6.52	-11.85
2008	1	3	0	183.53	8.12	187.88	6.56	-5.35
2008	1	3	6	182.23	7.71	192.76	5.43	-4.85
2008	1	3	12	190.78	4.28	177.99	5.7	-3.75
2008	1	3	18	171.61	6.17	180	6.4	-5.25
2008	1	4	0	167.15	5.85	163.2	5.54	-6.15
2008	1	4	6	135.88	4.6	129.37	5.04	-5.45
2008	1	4	12	83.66	7.24	161.27	6.23	-6.15
2008	1	4	18	141.34	5.76	162.12	3.26	-8.55
2008	1	5	0	174.81	4.42	209.74	3.22	-6.35
2008	1	5	6	144.78	2.08	110.56	0.85	-5.55
2008	1	5	12	72.65	1.68	160.11	5	-4.75
2008	1	5	18	153.85	6.13	165.96	7.01	-9.95
2008	1	6	0	155.17	7.38	165.34	6.72	-11.45
2008	1	6	6	159.7	7.78	170.84	3.14	-9.35
2008	1	6	12	111.8	3.23	182.86	4	-6.55
2008	1	6	18	183.65	4.71	164.9	6.53	-9.35
2008	1	7	0	158.36	6.78	157.38	6.5	-11.85
2008	1	7	6	154.65	6.31	149.42	5.11	-8.55
2008	1	7	12	136.79	4.53	169.09	8.45	-7.25
2008	1	7	18	173.66	9.96	167.32	4.1	-10.75
2008	1	8	0	146.04	5.91	186.2	4.63	-4.15

Picture 7.11 – Example of the Reanalysis Data

The data files included long term records from January 1st of 1988 up until June 1st of 2008. The columns # 7 (u 10. dir. 10) and #8 (u 10.wsp. 10) contain wind direction and wind speed data at 10 m height correspondingly.

All of the 20.5 years of 6 hourly records were collected together in a common site/reanalysis raw data file for simplifying further calculations and references.

These records will be needed for prediction of the long term wind resource on site and to match site and reanalysis data series with each other.

7.2.6 Averaging 10 min site wind speeds and directions up to 6 hourly

There normally should be 36 records in each 6 hour intervals. Since some of the anomalous data were previously removed and clear gaps left to keep continuous 10 min time step, there were some intervals having much less than the 36 records. In order to avoid bias, all of the intervals with less than 35 records were not counted for 6 hour averages.

The results obtained from averaging 10 min site wind speeds and directions at 10.6 m and 32.4 m to 6 hourly were necessary to match them with the reanalysis data.

7.2.7 Correlating the 6 hourly site average wind speeds and directions with the reanalysis data

The reanalysis data were sorted out according to the available site averages to provide corresponding time steps prior to correlating the data.

Correlation Wind Directions at 32.4/10 m	Correlation Wind Directions at 10.6/10 m	Correlation of Wind Speeds at 10.6/10 m	Correlation of Wind Speeds at 32.4/10 m
0.09179	0.09050	0.21376	0.24879

Table 7.2 –Correlation of the 6 hourly measured and reanalysis data

Correlation coefficients of the site and reanalysis wind direction were found to be very low whereas the correlations between the wind speeds were higher but not good enough.

Presumably the 2 degrees difference in latitude and longitude between the reanalysis and the site nodes make a significant difference in the wind data correlation.

The site wind speed at 32.4 m has the best correlation with the reanalysis 10m wind speed data.

Since the six hourly data have not showed a satisfactory correlation, both site and reanalysis data can now be converted to monthly averages to try to find better correlation and calculate long term wind resource at the site. This could be practicable if the correlation coefficients are not less than the expected minimum of 0.6-0.7 according to advice of SgurrEnergy.

7.2.8 Balancing Site Data for Monthly Averages

Because there was a lot of data removed during the previous process it is wise to check the data set again and balance it.

In order to do further calculations and perform analysis it is necessary to balance the data set as much as reasonably possible. The idea of balancing data is to get approximately equal numbers of winter and summer records ensuring also that there are not big variations in time. It is also necessary to get rid of insufficient numbers in records for monthly averaging to avoid bias caused by only several days' data being available within a month.

It has been assumed that the summer period is from the 21^{st} of March until the 21^{st} of September and winter is from 21^{st} of September until 21^{st} of March.

Normally there should be 144 rows of 10 min records during a day so there would be 4320 rows* 10 columns = 43200 measured records during 30 days that would be available for further analysis.

In this work, the initial idea was to try to provide at least 3600 data rows (25 days) within a month sufficient for non biased monthly averaging and further analysis. This also needed to ensure an approximately equal number of winter and summer records as well as a fair number of records round the clock.

After calculating the number of rows and records in each hour and month, it was found that the number of summer data rows with records sufficient for further analysis was 46618 while the number of winter data rows was 44505, which was a 2113 difference. Therefore the following data needed be removed to achieve better balancing:

From	**To**	**Number of rows removed**	**Reason**
August 1^{st}, 1998	August 3^{rd}, 1998	3071	Insufficient number of records for monthly averaging and prevailing summer records.
August 13^{th}, 1998	August 31^{st}, 1998		
September 1^{st}, 1998	September 11^{th}, 1998	1455	Insufficient number of records for monthly averaging and incomplete data rows
October 30^{th}, 1998	October 31^{st}, 1998	220	Insufficient number of records for monthly averaging
June 1^{st}, 1999	June 5^{th}, 1999	604	Insufficient number of records for monthly averaging
July 1999	July 1999	1362	Insufficient number of records for monthly averaging
January 1999	January 1999	2407	Insufficient number of records for monthly averaging and prevailing winter records
May 2000	May 2000	906	Insufficient number of records for monthly averaging

Table 7.3 – Data removed for balancing

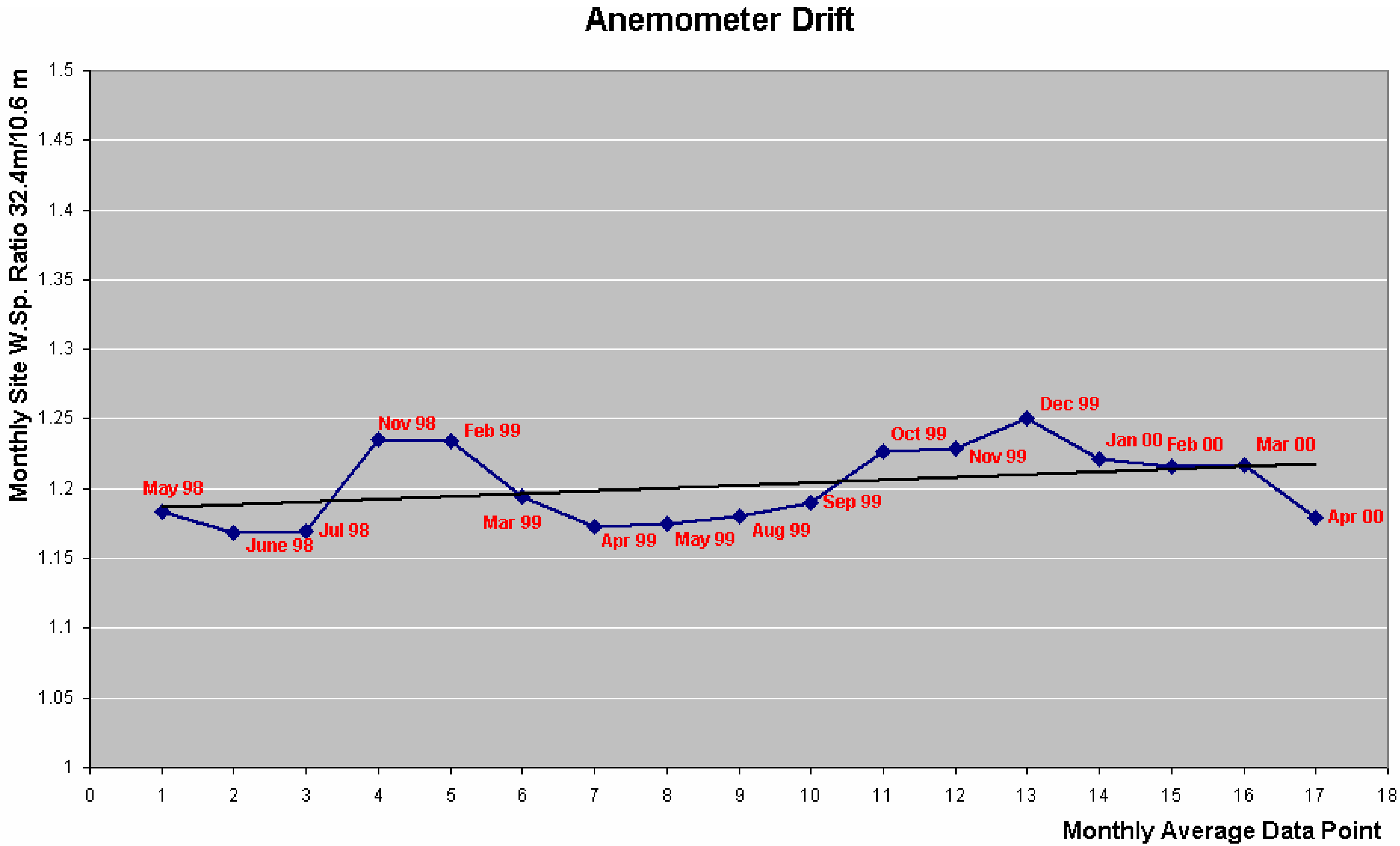
Thus, after removing the data it has been possible to achieve 36709 summer data rows and 37424 winter data rows, which is 715 records difference, giving better balancing and having got rid of insufficient and inconsistent data series.

Balancing of the records by hours of the day was possible to achieve due to consistent removing of data rows.

Hours	# Records	Hours	# Records	Hours	# Records	Hours	# Records
0	30930	7	30780	14	30900	21	30900
1	30890	8	30890	15	30900	22	30900
2	30900	9	30890	16	30900	23	30900
3	30900	10	30900	17	30900		
4	30900	11	30900	18	30900		
5	30890	12	30890	19	30900		
6	30770	13	30900	20	30900		

Table 7.4 – Number of records balanced by hours of the day

7.2.9 Anemometer Drift



Picture 7.12 –Anemometer drift check

Ideally there should be a line without downward or upward trends or the general trend line should not have a slope.

In this case the general trend line has a small slope. This could mean there was a small wear and tear of the anemometers over time.

Therefore it has been checked whether the upward and downward trends coincide with the time periods of the screened off anomalous data.

In the period between points 3 and 4, there were 85020 records removed due to missing and anomalous data series. The wrong records could have been due to physical damage to the equipment, reinstallations of instruments and/or others.

In between November 98 and Feb 99, points 4 and 5 there were 20690 records (where 20570 records from the Jan99) removed due to the same reasons however these points have a stable trend in between.

From May 99 to August 99, points 8 and 9, there were 68,210 anomalous records screened off due to the same reasons. However points 8 and 9 have a relatively stable trend in between compared to others.

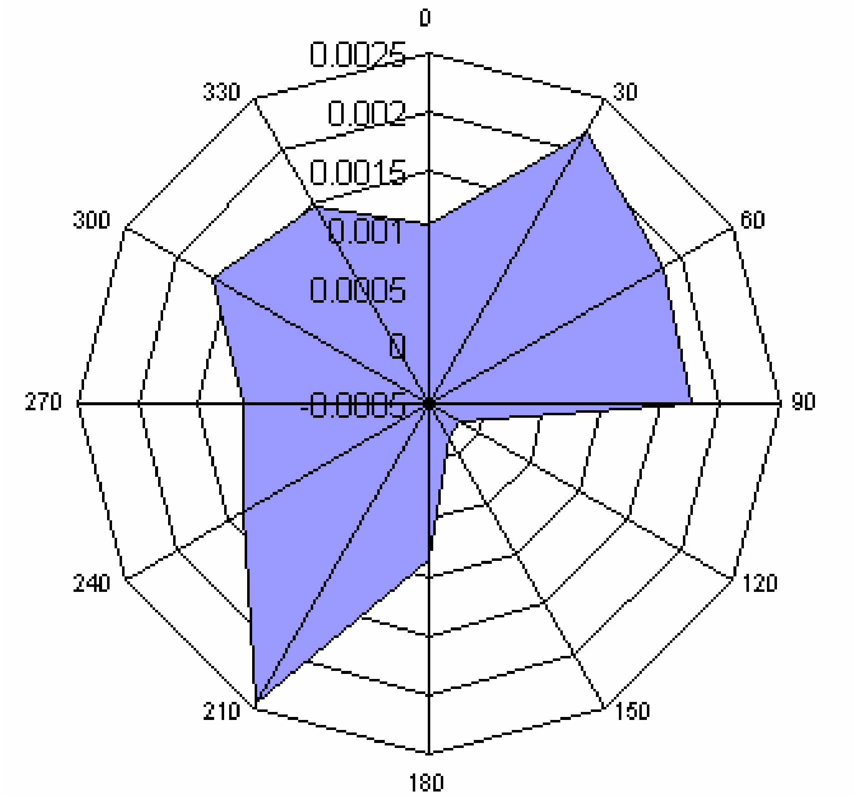
Starting from September 99 until April 00, there were only 140 records removed in total and all measuring equipment worked non stop with a maximum 30 minutes delay on two occasions so it is not likely that there was a physical damage at this time. However this interval has very unstable upward and downward trends.

7.2.10 Wind Shear Coefficients

Wind Direction Sector [Deg.]	**Sectorwise Wind Shear Coefficient**
346-15	0.103356
16-45	0.217353
46-75	0.181105
76-105	0.175283
106-135	**-0.0209**
136-165	**-0.0144**
166-195	0.084112
196-225	0.244854
226-255	0.131587
256-285	0.109135

286-315	0.163432
316-345	0.143316

Table 7.4 – Sectorwise wind shear coefficients



Picture 7.13 –Sectorwise wind shear

Wind shear coefficients α have been calculated from the law

$$(1)\ \mathbf{ln\ (Wsp.h2/\ Wsp\ h1) = \alpha\ ln\ (h2/h1)}\ [4]$$

where h2/h1 – heights of anemometers` installations;
Wsp.h2 and Wsp.h1 – wind speeds measured at the two heights correspondingly

To calculate the sectorwise wind shear coefficients, the balanced 10 min wind speed records were sorted according to the wind direction sectors, average wind speeds were calculated at each given height and for each direction sector, than the above formula was applied.

It should be noted that the wind speed can decrease with height and the sectorwise wind shear coefficients have negative values in the wind direction sectors between from **106 to 135** degrees and from **136 to 165** degrees.

Referring to the mast shadow section, it was previously found that the major wind in the Chilik Corridor blows in two direction ranges from 40 to 95 and from 210 to 280 degrees. The effect is probably caused by the big mountain ridges located at North and South sides of the valley.

Since the negative wind shear direction sectors, from 106 to 135 and from 136 to 165 degrees, are not in the range of the two main wind direction paths, 40 to 95 and from 210 to 280 degrees, the negative wind shears may be caused by an obstacle and site topography.

7.2.11 Calculating Wind Speeds at Hub Height

Wind speeds at 80 m height were calculated with 10 min time steps with reference to the wind speeds at 10.6 and 32.4 m. The above formula was applied using the heights 32.4 and 80 m, taking 10 min wind speed records at 32.4 m and the wind shear coefficients calculated for each of the available screened 10 min time step wind records.

7.2.12 Averaging Balanced 10 min Site Wind Speed and Direction Records to Monthly Values

After removing the records insufficient for monthly averaging and the ultimate-reasonably possible balancing of the site data the following results were obtained:

Point	Month	Wind Speed 10.6 m	Wind Speed 32.4 m	Wind Speed 80 m	Temperature at 4.7m	Temperature at 32.4m	Wind Direction 10.6 m	Wind Direction 32.4 m
				1998				
1	5	6.599773695	7.808001344	9.06184584	17.1687052	17.27202061	199.1430909	223.3782462
2	6	5.352023617	6.254899282	7.204969913	23.79553241	23.73916667	239.3287449	250.4499868
3	7	5.331030466	6.237694892	7.20093586	26.32986111	26.26700269	109.9096036	67.89809771
4	11	5.710319592	7.054502084	8.494439389	3.381921296	3.895578704	98.06060191	69.45965268
				1999				
5	2	5.928974932	7.32070489	8.786770159	-0.016323493	0.409402133	81.28338417	67.45117794
6	3	5.782974003	6.90958987	8.118012218	2.158691756	2.308400538	219.0556248	235.2698352
7	4	6.034551069	7.078325416	8.179362994	12.56945368	12.73650831	213.6074269	227.6669738
8	5	6.154129747	7.231435353	8.358778522	19.30379661	19.42352542	180.9935032	209.889221
9	8	5.460804392	6.445756218	7.498809325	25.96079749	26.15978943	198.8646038	251.8042404
10	9	5.586090783	6.650414544	7.788253186	19.6900903	20.00092614	229.92865	247.7964008
11	10	5.338151053	6.547649036	7.862444062	12.78964822	13.25751737	96.53549216	76.63846035
12	11	6.161901784	7.575392634	9.090419765	2.720194535	3.079365447	92.722232	74.90180549
13	12	6.141752185	7.683226529	9.331168143	-0.95031362	-0.547065412	74.02349096	68.21103491
				2000				
14	1	6.9557287	8.491910314	10.05156527	-3.889553912	-3.845908989	73.57169865	70.53503044
15	2	7.307746108	8.884658683	10.49794484	-2.210751916	-2.213314176	80.44926538	75.48544669
16	3	6.025217294	7.332685932	8.751438653	5.203942652	5.535416667	96.12834499	79.64445663
17	4	5.489497453	6.47204956	7.54113547	16.28501968	16.63824959	220.8580114	238.2909862

Table 7.5 – Mean Wind Speeds, Air Temperatures and Wind Directions on site

Notes: Wind speeds [m/s]; Temperatures [Deg. C]; Wind Directions [Deg.].

7.2.13 Calculating Short Term Wind Speeds

The short term site wind speeds are **5.96** m/s at 10.6 m, **7.17** m/s at 32.4m and **8.46** m/s at 80 m heights**.** They were calculated by averaging all of the balanced 10 minute site wind speed records for the metering interval from April 13th of 1998 to May 7th of 2000.

7.2.14 Averaging Reanalysis Wind Speed and Direction Records to Monthly Values

The following table presents mean monthly reanalysis data:

Point	Month	Reanalysis Wind Speed 10m	Reanalysis Wind Direction 10m
	1998		
1	5	4.523387097	255.5065429
2	6	3.552166667	358.3268372
3	7	3.313306452	4.07059612
4	11	4.167583333	202.154145
	1999		
5	2	4.954107143	193.1247931
6	3	4.077822581	222.8768752
7	4	3.272	214.3334451
8	5	3.791532258	34.55674213
9	8	4.361129032	43.62261907
10	9	3.874166667	330.6740976
11	10	3.215725806	223.592161
12	11	4.59575	188.7682927
13	12	5.609032258	205.5067011
	2000		
14	1	5.197580645	198.4995876
15	2	4.736465517	202.0761026
16	3	3.738467742	194.7976832
17	4	3.12025	230.5289217

Table 7.6 – Mean Reanalysis Wind Speed and Direction at 10 m

Notes: Wind speeds [m/s]; Wind Directions [Deg.].

7.2.15 Correlating Site and Reanalysis Monthly Average Wind Data

Table 7.7 present the result obtained from calculations of the correlation coefficients matching site and reanalysis data between each other.

Correlation of Wind Speeds at 10.6/10 m	**Correlation of Wind Speeds at 32.4/10 m**	**Correlation of Wind Speeds at 80/10 m**	**Correlation of Wind Speeds at 32.4/10.6 m**
0.624159	0.710091	0.749066	0.979144
Correlation of Wind Speeds at 80/32.4 m	**Correlation Wind Directions at 10.6/10 m**	**Correlation Wind Directions at 32.4/10 m**	**Correlation Wind Directions at 32.4/10.6 m**
0.989552	0.27215	0.223728	0.981605

Table 7.7 – Correlation coefficients of matching 10 m reanalysis and 10.6 and 32.4 m site wind speed data

Correlations of monthly site and reanalysis averages showed much better results than correlations of the site 6 hourly averages and reanalysis data.

Correlations of site and reanalysis wind direction, 32.4 vs. 10m and 10.6 vs. 10m, were improved from 9 % in both first cases to **22 and 27%** correspondingly, which is not very high.

The correlations between site and reanalysis wind speeds, 10.6 vs. 10m and 32.4 vs. 10m, have notably improved from 21% and 25% in the case of matching six hourly data up to **62 % and 71%** matching monthly data correspondingly.

It has been advised by SgurrEnergy that the correlations of 62% and 71%, although less than ideal still provide worthwhile indications of the site long term wind resource predictions. It is worth noting that given the correlations above, a relatively high uncertainty valueshould be applied.

These discrepancies could be due to the 2 degrees difference in latitude and longitude between the reanalysis and the site nodes. The site coordinates are N 43° 43' 13" and E 78 44' 65" whereas the reanalysis node is N 45 and E 80. In addition to this the terrain of the region is mountainous which makes its own contribution to the wind regime for sites placed at significant distances from each other.

The site wind speed at 32.4 m has the best correlation with the reanalysis wind speed data having 71% of coefficient.

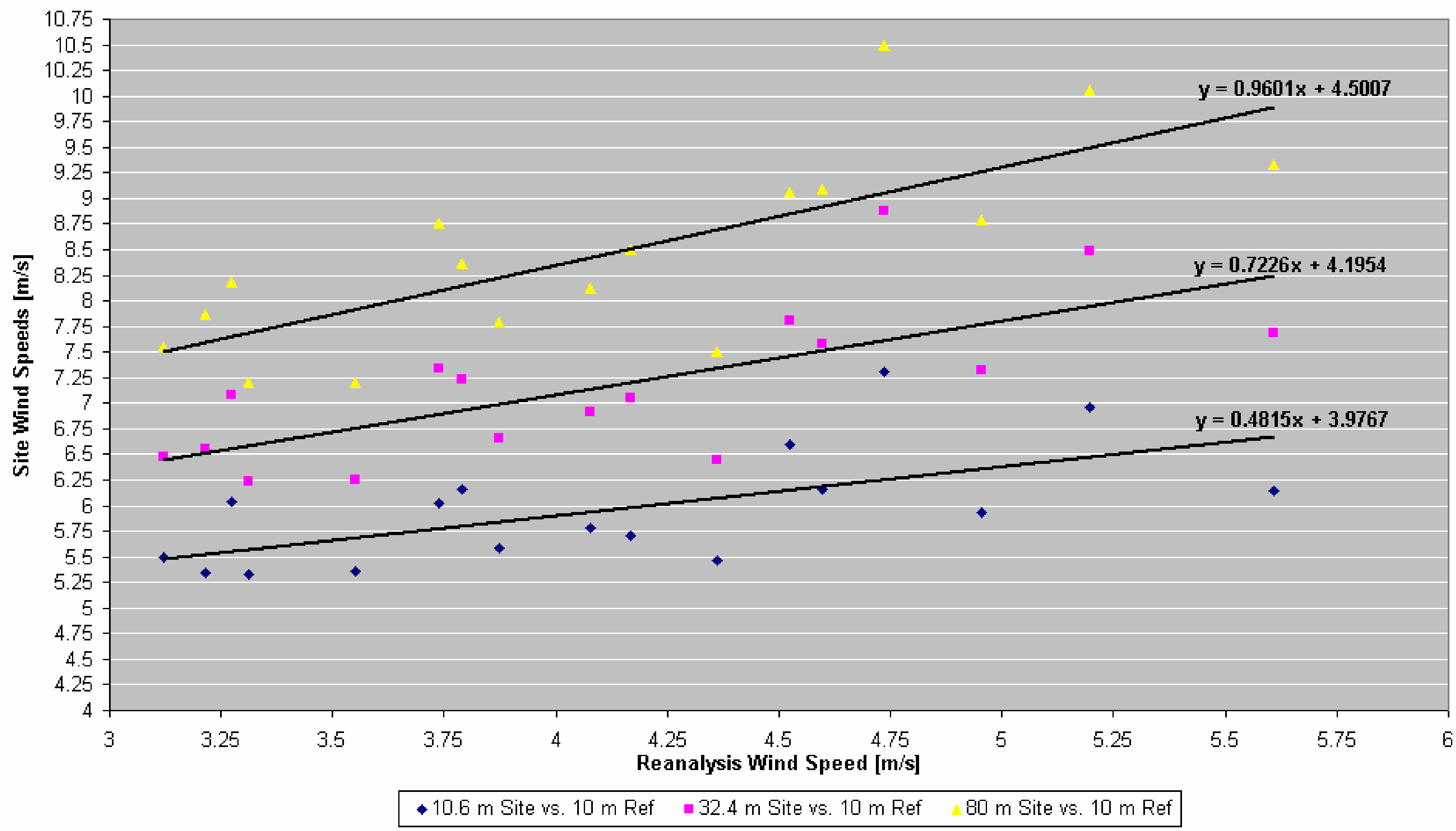
Matching site wind speeds and directions gave 98% correlation.

7.2.16 Calculating Long Term Reference Wind Speed

The long term reanalysis wind speed at 10 meters height is **4.159** m/s**.**

It was calculated by averaging all of the 6 hourly reanalysis wind speed records for the 20.5 years period together.

7.2.17 Calculating Predicted Site Long Term Wind Speeds



Picture 7.14 –Correlation of the site data with the reanalysis data

Data	Formula	Value [m/s]
LT Reanalysis 10m WSp	-----------	4.159252
LT 80 m WSp	0.9601*4.159252 + 4.5007	8.493998
LT 32.4m WSp	0.7226*4.159252 + 4.1954	7.200876
LT 10.6m WSp	0.4815*4.159252 + 3.9767	5.97938

Table 7.8 - Calculation of the long term wind speed at 80, 32.4 and 10.6 m heights

Note: underlined numbers are site short term wind speeds at the given heights.

7.2.18 Calculating Frequencies of the Measured Site Wind Speed

The numbers of occurrences in the wind speed bins were counted to obtain frequencies of the equivalent wind speeds with 1m/s step, from 0 to 32 m/s, required for Weibull wind speed probability density and prediction of annual energy yield using wind turbine power curves.

Wind Speed Range [m/s]	Equivalent wind speeds on the wind turbine power curves [m/s]
0 – 0.5	0
0.5 - 1.5	1
1.5 - 2.5	2
2.5 –3.5	3
3.5 -4.5	4
4.5 - 5.5	5
………………..	………………..
23.5 - 24.5	24
24.5 – 25.5	25
25.5 - 26.6	26
………………..	………………..
31.5 - 32.5	32

Table 7.9 - Wind speed frequency bins

Note: 4 m/s - cut in speed; 25 m/s – cut out speed.

7.2.19 Weibull distribution of wind speeds and defining Weibull parameters

The Weibull probability density method of annual energy yield prediction requires knowledge of the parameters: k (a shape factor) and c (a scale factor) [4]

Practically the parameters can be determined by visual matching of the measured wind speed frequencies with the Weibull probability distribution [35]

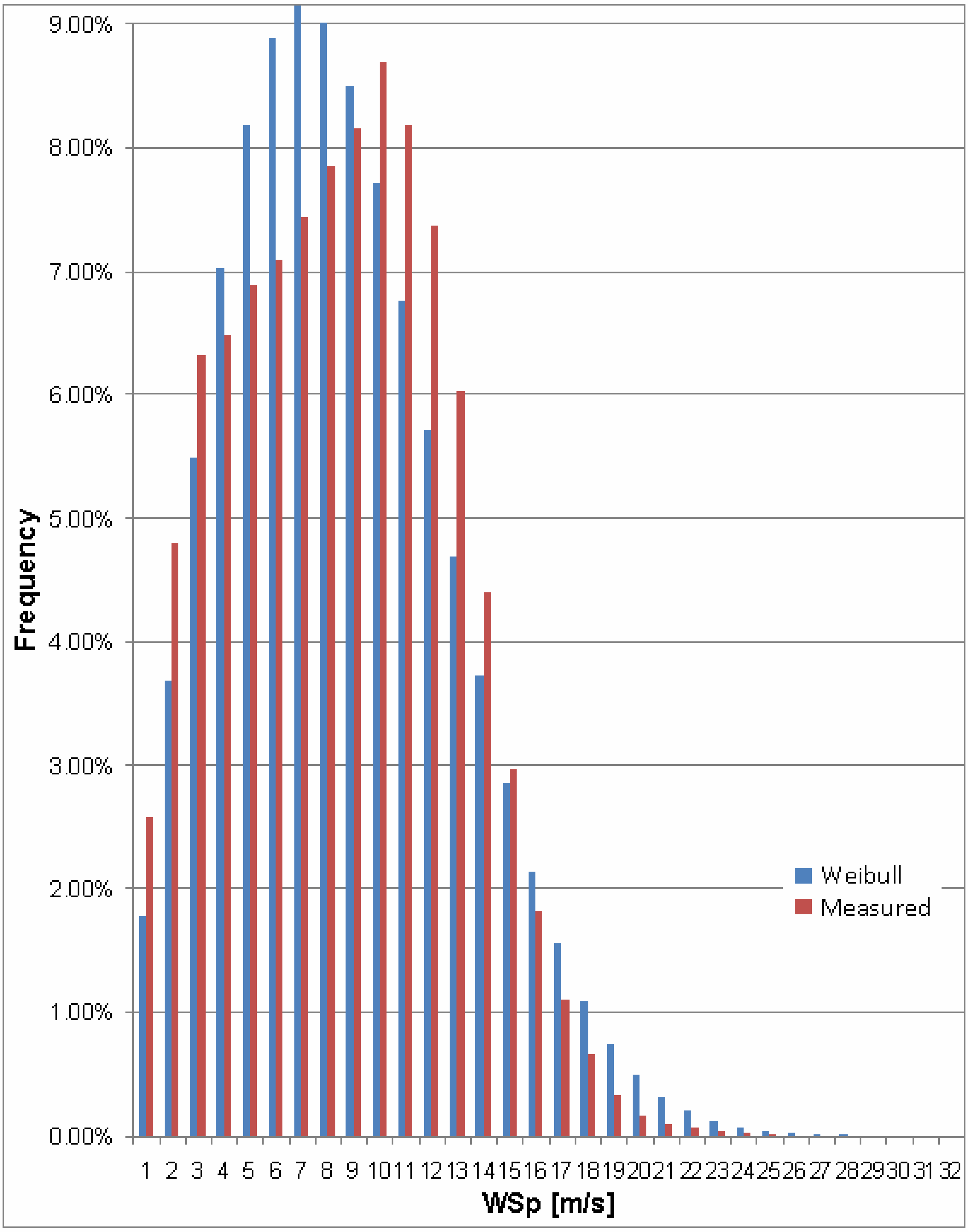
The Weibull wind speed probability density was built using the following law:

(2) **κ* WSp^(κ-1) / (A^κ) * exp(-1 * (WSp / A)^κ) = WSp Frequency** [35]

where k is a shape factor and c is a scale factor, WSp is a site wind speed at 80 m height [m/s].

(2.1) **A = WSp * c** [35]

The short term site wind speed at 80 m was taken for matching measured and Weibull wind speed distributions.



Picture 7.15 – Weibull and measured wind speed distributions' best match

Parameter k = 2.1;

Parameter c =1.14

7.2.20. Selection of the Wind Turbine Manufacturer

SgurrEnergy advised that many turbine manufacturers do not introduce new models of wind turbines into markets where they have not previously worked. They tend to use turbine which have a well established history to negate the potential for turbine failures and increase its reputation within the new market. It is also the case that intellectual property protection is paramount and turbine suppliers can be nervous introducing their most technologically advanced machines into a new market. The IP protection situation in Kazakhstan should be researched to give a more certain answer. However there have not been any publicly notable cases of complains on stealing technological ideas in Kazakhstan so far.

In order to reduce number of turbines on site, wind farm capital cost, land use and associated land taxes, it has been decided to consider large wind turbine units (around 2 MW) for the potential 50 MW wind farm.

Since there are no wind farms built and the market is not yet developed in Kazakhstan, the major world wind turbine manufacturers have been contacted to enquire about whether they would be interested to supply wind turbines to Kazakhstan.

Suzlon have expressed an interest but noted that since the market is very new it should be at least a 50 MW project at the beginning. They also suggested 2.1 MW S88 wind turbines [55].

Vestas have advised that they already have contracts in Kazakhstan for construction of some wind farms and suggested the V80 2MW turbines [54].

For these reasons the S88 and V80 have been taken for further study.

7.2.21 Calculating Annual Energy Yield Using Wind Turbine Power Curves

To calculate predicted annual energy yields using power curves of the S88 and V80 wind turbines, the long term site wind speed at the 80 m hub height (including basement) was taken for the Weibull distribution instead of the short term wind speed. The frequencies of the Weibull site long term wind speeds were converted to velocity exceedance data to obtain total predicted energy output generated during a year using their power curves.

However it should be noted that the power curves given by manufacturers are calculated with the air density value given for standard conditions, 1.225 kg/m³. Therefore an air density correction factor needs to be applied for annual energy yield prediction.

7.2.22 Air Density Correction

The average air density was calculated by applying the ideal gas law

$$(3)\ \rho = 3.437 * (P / T)\ \ [kg/m^3]\ [4]$$

where P- measured site average atmospheric pressure [kPa]; T – measured site average temperature [K]

ρ site (kg/m^3)	1.173
ρ reference (kg/m^3)	1.225
Air Density Correction Factor	0.957

Table 7.10 - Air Density Correction Factor

7.2.23 Selection of the Wind Turbine Type for the Chilik Corridor Site

The temperature differences and fluctuations are high due to climatic conditions in Kazakhstan. Hence air density changes significantly throughout a year. This factor may affect the operation of some wind turbine systems such as pitch settings.

Occurrences of extreme temperatures in winter below – 20º C usually require winterization of industrial equipment operated in Kazakhstan. Therefore it is necessary to give preference to wind turbine models designed to operate in big temperature ranges.

SgurrEnergy suggested that the low temperature Vestas LT V 80 2 MW option may be suitable as it can normally operate at ambient temperatures ranging from -30 º C to 30 º C, while -40 º C is permissible for non-operational conditions. If temperature drops below – 20 º C, the turbine is equipped with separate heaters that can raise temperature inside the nacelle.

Another important point is that the V 80 is a class I turbine compared to the S88, which is class II. With the predicted long term site wind speed at the hub height 8.5 m/s the Class I wind turbine should be more reliable [49].

For this reason, the LT V80 was chosen for the project to perform its further economical viability analysis.

Noise emission levels of the V 80 turbines can be programmed and decreased from 105.1 to 101 dB(A) to meet specific requirements of the site. However, lowering the noise emission level influences power production compared to standard. Since the site is located in the steppe area approximately 40 km away from the nearest village it has been decided to assume the standard noise level of the wind turbine for further analysis.

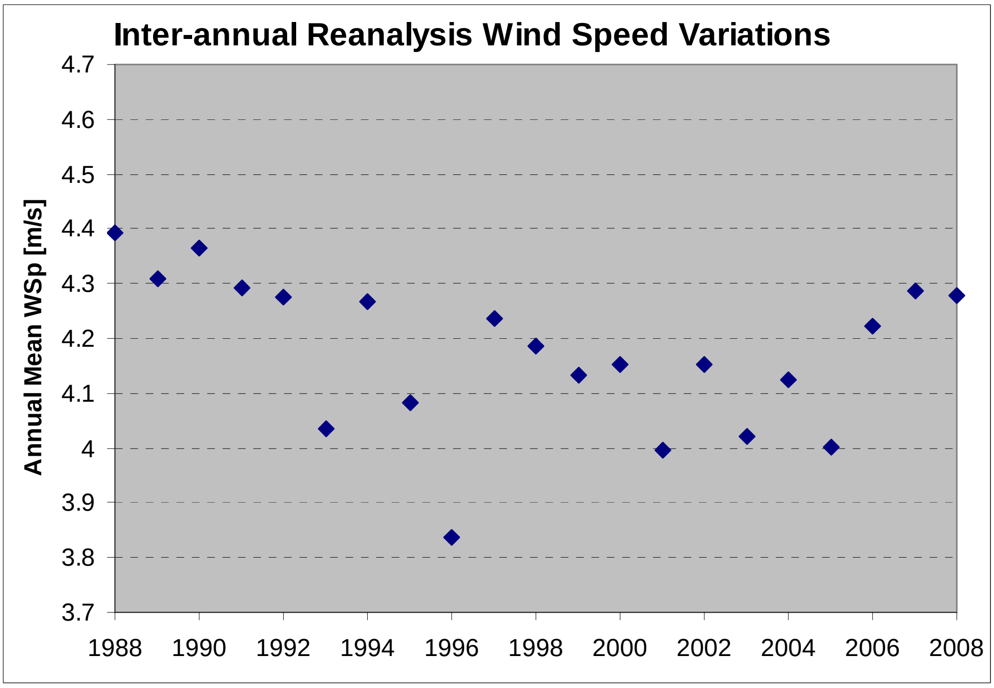
7.2.24 Expected Power Losses

#	Loss	Value	Comments
1	Wake Loss	Up to 10 %	The value for wake loss was deemed not unreasonable by SgurrEnergy. The losses will depend on the particular land chosen for placement of turbines on site. Since the Chilik Corridor area is large (hundreds of square km) the wake loss could be reduced by the proper placement and modeling of the wind farm operation.
2	Electrical Transmission Efficiency	3 % [SgurrEnergy, APC]	The minimum value is chosen based on the assumption that wind farm output metering is at the turbine bases. Though, the loss can be increased if metering takes place at the substation. Almaty Power Consolidated representatives confirmed that the value should be reasonable.
3	Substation Availability	1%	SgurrEnergy typically assume 24 - 48 hours/year of substation down time. Since local grid operators have not serviced wind farms before and the substations are not new and subject to severe seasonal climate variations it is better to assume the down time of 72 hours/year. The assumption is that the substation will have the down time of about 72 hours a year in total and this would be periods of average power outputs. Subtracting 72 hours from the frequencies of the wind speeds at the average power outputs gives about 1 % loss.
4	Loss due to grid availability	0.7 %	SgurrEnergy typically assume 24 hours/year of grid down time. Since the local power lines are not new and subject to severe climates it is better to assume the down time of 48 hours/year. The assumption is based on that the down times would occur in periods of average power outputs. Using the frequencies of the wind speed and turbine power curves gives a loss of about 0.7 %.

5	Loss due to turbine availability	3%	SgurrEnergy typically assume 97% availability for most types of turbines. Though this value can be replaced by a more appropriate value according to the warranted availability of the wind turbine manufacturer. Unfortunately it was not possible to obtain this from Vestas for Kazakhstan conditions therefore the value advised by SgurrEnergy is assumed.
6	Icing Effect on Turbine	2% [35]	This value takes into account periods of turbine shut down because of icing on blades.
7	Wind Hysteresis	0.05 %	Once site wind speed overcomes maximum operational speed of the turbine (25m/s) for a predefined interval it will shut down until it comes down to the restart wind speed (20m/s). Based on the site wind speed distribution and the V 80 105.1 dB(A) power curve data, the loss is estimated at 0.05%.
8	Contamination and degradation of blades	Up to 1.25%	Contamination may happen due to dust or insects in the air. The degradation will have much greater effect towards the end of the project than at the beginning. The losses will depend on how well the wind turbines will be maintained by the developer. The losses can be reduced by proper and proactive maintenance. SgurrEnergy suggested applying relatively high loss for steppes due to increased dustiness. In addition to this point, the Ili River and Kapchagay water reserve are known to have a lot of flies. The sand blown from their shores towards the steppes can reach the wind farm having abrasive influence. Though, it should be noted that the site is quite far from their shores which mitigates the impact compared to an immediate proximity case. This issue will need to be further investigated when allocating the wind farm site to have a better idea of potential impact and to select proper design of blades.
9	Ancillary systems	0.25%	The turbines may need to draw some power using the cold climate systems. The loss value was suggested by SgurrEnergy.

10	Wind Speed Inter-Annual Variations	0.05%	This loss results from the fact that wind energy is not linear. The low wind speed years would reduce the predicted energy yield. On the other hand, high wind speed years would give energy gains. These variations can cause changes in the calculated energy yield over the project life time. In this study, the long term reanalysis data were analyzed for inter-annual wind speed variations. It is assumed that the general site wind variations correspond to the reanalysis wind variations. The data analysis showed there should be long term wind speed reduction due to the Inter-Annual variations. The value of energy yield loss was found based on the standard deviation of the reanalysis average annual wind speed distribution, site long term wind speed and the turbine power curve data.
11	Grid Code Losses	0%	Attention should be paid to the possibility that energy can be lost if the wind farm has to comply with grid code requirements. Due to grid code requirements there may be some forced operational changes and interruptions for indefinite periods. The grid code losses could not be estimated. The grid operator could not advise it since there is no experience of wind farm operations so far. This issue will need to be stipulated in the power supply agreement. If the losses are incurred developer would need to be compensated.
The total value of losses assumed for annual energy yield prediction – 21.3%			

Table 7.11 - Expected Annual Energy Yield Losses



Picture 7.16 – Inter-Annual Reanalysis Wind Speed Variations

7.2.25 Summary of the Results Obtained

Wind turbine type – Vestas Low Temperature V 80 2MW;

Hub height (including basement) – 80 m;

Number of turbines – 25 units;

Weibull A - 9.68;

Weibull k - 2.10;

Weibull c – 1.14;

Site Long Term Wind Speed at the hub height - 8.494 m/s;

Average Wind Shear – 0.166

Maximum Possible Annual Load on Site - 7786.38 hours

		After Air Density Correction	Including the Energy Yield Losses
Turbine Yield (MWh):	7856	7522.72	5920.83
Wind Farm Annual Production (GWh)	196.39	188.07	148.02

Table 7.12 - Annual Energy Yield

Capacity Factor (incl. losses) - 33.795%

7.2.26 Uncertainty in the Energy Yield

It is difficult to quantify uncertainty in the energy yield prediction because it depends on many independent factors. Therefore the uncertainty estimation is mostly based on expert judgment approach and experience [35].

The table below represents sources of uncertainty at different stages of the energy yield procedure and gives the overall uncertainty on the energy yield prediction.

Since there is no experience of a wind farm development in Kazakhstan at present, it is necessary to gain an understanding about the experience of uncertainty estimation from other countries. According to the industry research conducted by SgurrEnergy the overall uncertainty in energy yield prediction is estimated from 10% for a flat site and up to 18-25% for a complex site.

The overall uncertainty value for this site is extreme according to the expert judgment. It is due to the combination of not using wind flow models in this area and lack of information.

#	Source of Uncertainty	Wind Speed (%)	Energy (%)	Energy (GWh)
1	Site Measurement Accuracy	10%	13.9%	20.5
2	Long Term Wind Speed Prediction	-----	-----	-----
3	Accuracy due to the site topography and terrain	-----	-----	-----
4	Power Curve Uncertainty	-----	5	7.4
Overall Uncertainty		14.3	25.5	37.74

Table 7.13 - Estimation of the uncertainty

Judgment about uncertainty sources and estimation of the overall uncertainty:

1 - Site measurement accuracy uncertainty mainly comes from the fact that it would be necessary to know specific information on what kind of equipment was used, whether there were any changes, physical damage, wear, tear or icing of any instrumentation during the metering period. It is not clear how the metering equipment was calibrated also.

There was a lot of error data and the information would help to have an idea on what was the reason of this.

There was no information about how the mast and metering instrumentation were placed and whether there were any deviations from standards. It is not clear whether the cases of increasing wind speed ratios in the directions between 200 and 220 degrees were due to sheltering of the lower anemometer by the mast or another obstacle, or if it was normal natural occurrence in these directions.

The small slope in the anemometer drift check makes a minor contribution, compared with the other factors, to the total site measurement accuracy uncertainty.

In addition to all of this, the cases of measured wind speed decreasing with height (negative wind shears) in the wind direction sectors from 106 to 135 degrees and from 136 to 165 degrees contribute to the uncertainty. The uncertainty should be not less than 10% [35].

2 - A high uncertainty in the long term wind speed prediction is mainly concerned with the correlation between the site and reanalysis data.

It is normally preferable to use reliable meteorological station records as a reference data. However the data were not available during this project and therefore reanalysis data were taken.

The differences of almost 2 degrees in latitude and longitude of the site and reanalysis point coordinates under the conditions of complex topography in the region make significant contribution to the uncertainty.

3 - The site topography and terrain issue is one of the main concerns. Attempts to find a digital height map of the area during this project were not successful. Since the topography of the Chilik Corridor is complex this map would be very helpful for the analysis. The wind regimes could change considerably, should the wind farm be placed at a different place other than the metering point in the large Chilik Corridor area.

4 - A standard uncertainty of 5% was taken into consideration for using power curves in the energy yield prediction [35]. This includes an error of the wind speed distributions` visual matching.

8. Planning of the wind farm construction and operation

8.1 Obtaining and Extension of the State License

The RoK "Law on Licensing" of January 11th 2007 regulates licensing of industrial activities. Its subordinate legislative act is RoK Government "Regulation on licensing and qualification requirements for particular types of industrial activities" of December 28th 2007. These particular types of industrial activities include:

- Production, transmission and distribution of electrical and thermal energy, operation of electrical power stations, networks and substations;
- Purchasing of electrical energy with the purpose of resale;

The licenses are issued on the particular types of activities and the scope of the license is described in the separate document attached to the license. The licenses are valid in all regions of Kazakhstan. The licenses can be general or for one use only. They can not be passed to another physical or judicial person.

The licenses are issued by the state institution designated by the RoK Government. The above listed activities are licensed by the RoK Agency on Regulation of Natural Monopolies (RoK ARNM) [62].

To obtain the general license, a wind energy developer shall submit the following documents [62]:

1. Written application on the general license;
2. Verified copies of the company statute and state registration of the legal entity;
3. Verified copy of the company's registration in the tax police;
4. Receipt of payment of the licensing fees on the types of activities applied (amounts of the fees are not constant and would need to be checked on place);
5. Information and document verifying qualification of the company management and personnel.

In addition, to obtain the license attachment with the scope of industrial activities the following documents to be applied [62]:

6. Written application on the specific types of activities;
7. Verified copy of the general license (if applying for additional types of activities);
8. Information and document verifying qualification of the company management and personnel. The qualifications must meet industrial criteria for the specific types of activities applied.

After registration of the application on the general license and/or types of activities, the designated state institution will review documents submitted and forward details of the application to other competent state institutions to get their decisions about compliance with other relevant industrial aspects. These aspects will include environmental protection, radiation, occupational, epidemiological, fire, emergency, electrical, industrial and technical safety, labor and social protection. The application will be reviewed within maximum of 30 working days after which the official decision shall be made [62].

Subsequent control of the licensed companies is performed by means of status reports covering the specific licensed types of activities. These reports shall be submitted to the state institution issued the license annually by the March 1st of the next year. They must be completed in the standard approved form that can be found in the licensing regulation [62].

In addition, there will be office and/or site visits performed by the state inspections supervising particular regulative aspects to verify compliance and authenticity of the submitted information.

The licensing control is also carried out on the basis of analysis of information available in mass media, any written applications from the citizens and other companies [62].

Abeyance and withdrawal of the license are performed according to the RoK "Law on Administrative Violations".

8.2 Environmental Impact Assessment of the Potential Wind Farm

According to the new RoK Environmental Protection Law, every new industrial project has to be assessed on its environmental impact. The wind farm developer would have to conduct the assessment immediately on site during the permitting process. The documented results shall be submitted to the local sanitary-epidemiological and environmental protection departments for their revision and agreement. Any identified specific problematic issue concerned with the environmental impact of the wind farm will have to be studied in detail and reasonable alternative or mitigation solutions must be agreed the state departments.

In general, due to the lack of experience in wind energy development, active environmental protection regulations in Kazakhstan are not well developed for the wind energy industry yet and could be more simple and quick to apply than the UK regulations. However, proper environmental impact assessment according to the best international standards would be recommended to avoid possible problems in future when the regulations will take specific wind energy issues into account.

The following notes are a preliminary assessment of the possible environmental impacts. A separate official environmental assessment would have to be carried out in detail should the wind farm to be commissioned.

- **Noise and visual impacts.** These are one of the main problems of wind farms in the UK. It should not be such a problem in Kazakhstan due to its large territory and considerably lower population density. The Chilik Corridor area is not well populated, having a few villages and large areas of open land outside them. The site picked for metering is in the steppe, about 40 km away from the Chilik village and 10-15 km from the busy motorway. Therefore any negative noise or visual impact issues are not foreseen at this site.

- **Electromagnetic, radar, radio, TV, telephone connection interference.** This could be an issue and needs to be additionally investigated in Kazakhstan to involve all relevant parties. Since the area has villages it should have radio, TV, telephone and cell connection towers close to them. The "Kazakhtelecom", "KCell", "KMobile" and "DALACOM" companies would need to be officially contacted to clarify and agree this issue. The issue would also need to be agreed with the RoK Ministry of Defense to avoid interference with military radars that could be in the area of the wind farm.
- **Flora and Fauna (Birds).** The territory in the Ili River valley does not have rich vegetation. Most of it consists of low grasses. It should be expected that the wind farm site has a similar situation since it is the same area. The most important point is that the site is not classified as a protected area. Therefore the province's environmental department should not have any problems with it. However the routes of birds' migration and places of their nesting must be investigated and agreed with the Almatinskiy Nature Reserve administration and local conservancy department to have a clear idea on whether there could be an adverse impact or not;
- **Land Use Impact.** This area does not have any protected or agricultural territories.
- **Aviation Interaction**. The closest airport is the Almaty International Airport, which is 110 km from the site.
- **Public Safety Issues**. Risks from accidents associated with wind turbines such as blade, ice throws, tower failure, and fire should be greatly reduced due to the remoteness of the site from populated areas.
- **Seismic.** The Almaty province has seismically active areas and therefore it would be necessary to discuss the wind farm construction project with the state seismic research institute to ensure the site is not on the place of tectonic breaks. The design of wind turbine installation on site must consider seismic stability aspects and be performed according to the applicable construction regulations and standards.
- **Geological.** The data of pervious geological surveys could be obtained from the construction department of the province administration during the process of permitting agreement. However since the area of Chilik Corridor is large it should be possible to select a suitable site to avoid problems. It is known that the surface earths in that area could include sands and clays. The latter would be preferred for construction of solid seismically stable wind farm

basements. However a professional detailed geological survey is recommended to be included in the environmental impact assessment prior to construction.

It is recommended to co-operate with a reliable local consultancy that is licensed and competent to perform industrial environmental monitoring to make environmental assessment of the wind farm site including all of the relevant aspects. This should not normally take a lot of time or cost a lot of money. However Kazselenergoproject, UNDP and RoK ME&MR may have complete environmental assessments in future when wind farm sites come to be tendered.

8.3 Construction and Grid Connection Issues

8.3.1 Construction Permits

The requirements concerning permits to construction of social and industrial objects are regulated by the RoK "Law on Architectural, Town-Planning and Construction Activities" of July 16th 2001. This law describes general requirements that are applicable for a wind farm construction. The following shall be done prior to start the construction [59, 63]:

1) Complete preliminary technical-economical justification of the project. That will be submitted with the application for the land permit.
2) Obtain positive decision of the local administrative department (Akimat of the Almaty Province in this case) concerning sharing the demanded land territory for the wind farm construction. The application shall be made according to order prescribed in the RoK Government "Regulations on Registering and Issuing of Initial Materials for Planning and Designing of Construction Projects" # 425 of the May 6th 2008.
3) Apply official letters to the local Energonadzor (electrical inspection), Environmental, SES (epidemiological and hygiene), Fire, Emergency and UGKN (industrial-technical) inspections to obtain their preliminary agreement or corrective action notes for construction of the wind farm on the site. This may require on field inspections.
4) Obtain permits of the state Architectural Inspection on accomplishment of the building and assembly jobs, according to the RoK SNIP 1.03-06-2002 "Construction Organisation of Construction Enterprises, Building and Structures".

Note: SNIPs are subordinate legislation acts-standards; it stands for Construction Norms and Rules.

The following subordinate legislative regulations will be applicable and important to comply with, concerning the wind farm construction issues [59]:

- SNIP 1.03-05-2001 "Occupational Health and Safety in Construction"

- SNIP 1.03-03-2001 "Follow on supervision of the developer-companies of the construction projects"
- GOST 26433.0-85 System of ensuring precision of geometrical parameters in construction. Rules of measuring in construction. General regulations.
- GOST 26433.1-89 System of ensuring precision of geometrical parameters in construction. Rules of measuring in construction. Factorial elements.
- GOST 26433.2-94 System of ensuring precision of geometrical parameters in construction. Rules of measuring parameters in construction of buildings and structures.

Note: GOSTs stand for State Standards.

The project will be required to be designed according to the above listed regulations in order to obtain and extend necessary permits and to submit successful annual compliance reports as described in the licensing procedure.

For a new foreign developer, it is recommended to make agreement with a reliable licensed local construction contractor who would perform construction of the wind farm having all of the required systems on place to facilitate obtaining the permits. Otherwise the developer may need to obtain additional license on construction.

It needs to be investigated through the relevant legislation whether the wind energy developer would have to have this license.

Once the land and building-assembly jobs permits have been obtained and applicable regulations that will be inspected by the abovementioned departments have been adopted for the project's design, the wind farm construction can be started [59].

8.3.2 Power Purchase and Grid Connection

It will be necessary to negotiate terms and conditions of the power purchase with the APC management.

The Chilik power line is operated by the APC. Therefore it will be necessary to obtain and review Technical Conditions from the line operator prior to connect the wind farm to the grid.

In order to obtain the document, the following need to be provided to APC [59]:

1) Official letter for grid connection and power sale on the name of Mr. Pavlov Alexander Markovich General Director of APC. The application should include technical information about the project;
2) Copy of the company state registration document;
3) Copy of the company license;
4) Copy of the land permit act;
5) Site location map;

6) Description of the project;
7) Acts of the state inspections;
8) Any previous agreements (if available);
9) Some other documents might be inquired on place if relevant

The decision making process is likely to be the following [59]:

- If the APC general director gives preliminary approval on the project and agrees its terms and conditions, he will probably forward the matter to the Mr. Umbetov Muhit Abikeevich the APC Deputy Director on Transmissions and Distribution Lines for his consideration;
- The deputy director should forward the matter to the Issyk district power lines branch that operates the 110kV line and the substations. The district branch should further provide all technical prerequisites and deal with the grid connection issues.

8.3.3 Project Commissioning

When the wind farm construction is finished and the issues of power purchase and grid connection have been solved, the wind farm will need to go through the official process of commissioning, usual for commissioning of industrial plants [59].

This will require presence of representatives of the relevant state inspections and local administration (Akimat) on site to verify quality and compliance of the newly built project. In order to do this, official invitation letters shall be sent to their registries several weeks in advance before the commissioning date.

Upon successful commissioning, each representative will leave his/her signature in the protocol.

9 Economical Feasibility and Benefits of the Project

9.1 Information about the Software Used to Create Economical Models

The "RETScreen Clean Energy Project Analysis" software has been used in order to perform feasibility analysis of potential investments into the Chilik Corridor wind farm. The main purpose of the RETScreen software is to facilitate project evaluation process for decision makers.

The software analyses Internal Rates of Return (IRR) or, in other words, return on the capital invested into the project.

Investments may include owned (equity) and borrowed capital, by entering appropriate debt ratio, which makes it useful in real situations.

It also important that the RETScreen tool analyses carbon dioxide emission reductions based on the fuel type used for power generation in the country and can provide equivalents to the emissions reduction values. This could especially be useful if there were approved legislative acts providing payments for emission reductions in Kazakhstan.

For specific information about the software please go to www.retscreen.net

9.2 Assumption Made for Analysis of the Project's Feasibility

According to the latest estimations conducted by the Kazselenergoproject, for the 45 sites allocated for potential wind farms around the Kazakhstan, the total capital cost of a wind farm should vary from 224 – 225 millions KZT per MW of installed capacity [60].

These values could seem to be low compared with the UK costs [35]. Therefore it was necessary to check other information sources on whether the costs should be acceptable.

At present, the project of the pilot wind farm in Dzhungar gates has been officially supported and approved by the RoK ME&MR. In the case of successful experience, the 5 MW wind farm is likely to be enhanced up to 50 MW [44]. The total capital cost of the 5 MW pilot wind farm has been estimated at $ 5.5 million. The RoK Government shall find a private investor for the project on $5 millions. Upon completion of construction GEF shall provide $1 million to make for reduction of production cost of 20% [67]. According to this estimation the capital cost of the wind farm should not exceed $ 1.1 million/MW which is even lower than the Kazselenergoproject estimations.

The 225 millions KZT per MW capital cost have therefore been accepted for the feasibility study of the potential 50 MW wind farm in Chilik Corridor.

The average value of official exchange rates for the period from Jan 2007 up to date has been assumed for further calculations, which is 243 KZT/£ [30].

Thus the total capital cost of the wind farm has been assumed to be 925,925.93 £ / MW.

According to the British Wind Energy Association (BWEA) the value of annual operation and maintenance costs are normally in range of 2-3% of the capital cost [65]. The value of 2.5% has been assumed in this analysis.

According to forecast of the RoK National Bank, if world oil prices are be above $ 60 per bbl, the level of inflation in Kazakhstan is expected to be 8-9% in 2008 and 2009. The main factors affecting inflation in the country are high rates of demand growth, inflows of foreign currency, high rates of annual wage growth, general growth of production costs, and low competition on the services and goods markets [30]. The value of 8.5% has been accepted in this analysis as predicted long term inflation level.

The cost of borrowing capital in Kazakhstan is normally in range of 7- 12% [30]. However, since the developers in Kazakhstan would not have any positive experience of a similar project in the past and in the absence of effective legislative mechanisms supporting wind energy, it would be considered as a high risk investment project so that bank interest rate (IR) would likely to be high. A rate of 12% was therefore used in the calculations.

The 15 years loan term and 20 years project life have been assumed appropriate for this project, based on a study of the wind energy case studies from the RETScreen database [64].

The 30%, 50% and 70% of equity capital are very often taken as investment cases [64]. However the analysis also considered scenarios with 0% and 100% of equity capital. The borrowed capital would be invested by the bank. Thus debt ratios of 100%, 70%, 50%, 30% and 0% have been tried.

According to the APC, the company would take in the order of 1.5 - 3 KZT/kWh for transmission and distribution services thus the wind power sale cost would be around 5 KZT/kWh (20.58 £/MWh) today. This is an approximate estimation since it is commercial information and could not be confirmed for this project. The real power purchase price may vary depending on agreement [59].

Note: The RETScreen tool analyses pre tax values only. The corporate, property and land taxes should be further negotiated with the RoK Government according to the investment preferences described in the RoK "Law on Investments"of 8th January 2003. These taxes could be reduced or totally exempted based on the financial situation, feasibility and state priority of the particular project.

9.3 Financial Analysis Results Table

#	IR	Debt Ratio	**Sale Cost** [£/ MWh]	**Prod. Cost** [£/ MWh]	IRR-equity	IRR-assets	**Equity p.b.** [years]	**Simple p.b.** [years]
1.1	12%	100%	20.58	42.3	Positive	-5.16%	Immediate	24.52
1.2	12%	70%	20.58	36.6	2.41%	-2.06%	18.53	24.52
1.3	12%	50%	20.58	32.9	3.94%	0.21%	17.21	24.52
1.4	12%	30%	20.58	29.1	5.15%	2.62%	15.74	24.52
1.5	**0%**	**0%**	**20.58**	**23.5**	**6.48%**	**6.48%**	**13.13**	**24.52**
2.1	12%	100%	45.27	42.3	Positive	9.71%	Immediate	8.35
2.2	**12%**	**100%**	**51.44**	**42.3**	Positive	**12.28%**	Immediate	**7.17**
2.3	**12%**	**70%**	**45.27**	**36.6**	**27.10%**	**12.42%**	**5.48**	**8.35**
2.4	**12%**	**50%**	**45.27**	**32.9**	**23.56%**	**14.36%**	**5.80**	**8.35**
2.5	**12%**	**30%**	**45.27**	**29.1**	**21.53%**	**16.40%**	**5.99**	**8.35**
2.6	**0%**	**0%**	**45.27**	**23.5**	**19.66%**	**19.66%**	**6.16**	**8.35**
3.1	7%	100%	32.92	33.6	Positive	6.02%	Immediate	12.46
3.2	**7%**	**70%**	**32.92**	**30.5**	**19.88%**	**8.22%**	**7.63**	**12.46**
3.3	**7%**	**50%**	**32.92**	**28.5**	**17.13%**	**9.78%**	**7.96**	**12.46**
3.4	**7%**	**30%**	**32.92**	**26.5**	**15.50%**	**11.39%**	**8.15**	**12.46**
4.1	12%	100%	32.92	42.3	Positive	3.72%	Immediate	12.46
4.2	12%	70%	32.92	36.6	15.53%	6.47%	10.38	12.46
4.3	12%	50%	32.92	32.9	14.84%	8.46%	9.47	12.46
4.4	12%	30%	32.92	29.1	14.38%	10.57%	8.89	12.46
3-4	**0%**	**0%**	**32.92**	**23.5**	**13.93%**	**13.93%**	**8.34**	**12.46**

Table 9.1 - Result Obtained Using RETScreen Financial Models

Notations of the table:

 # - number of scenario and condition;

Debt Ratio – A software user can enters the debt ratio (%), which is the ratio of debt over the sum of the debt and the equity of a project [64].

IR – bank interest rates or cost of borrowing capital in Kazakhstan (%);

Sale costs – the currently expected cost of grid import and the prices that would make the project feasible;

Prod. Cost - Since the RET Screen software does not calculate cost of electricity generation, the production cost values had to be calculated separately based on the total project expenses and payment in the different financial scenarios given by the Software and the expected power productions of the wind farm over the 20 years.

IRR-equity - The RETScreen software calculates the pre-tax IRR on equity (%), which represents the true interest yield provided by the project equity over its life before taxes. It is calculated using the pre-tax yearly cash flows and the project life by finding the discount rate that causes the net present value of the equity to be equal to zero. Hence, it is not necessary to establish the discount rate of an organisation to use this indicator. The organisation interested in the project can compare the internal rate of return to its required rate of return (often, the cost of capital). The IRR is calculated on a nominal basis, which is including inflation [64].

IRR-assets – Like the IRR-equity, the software calculates the pre-tax IRR on assets (%), which represents the true interest yield provided by the project assets over its life before taxes. It is calculated using the pre-tax yearly cash flows and the project life by finding the discount rate that causes the net present value of the assets to be equal to zero. Hence, it is not necessary to establish the discount rate of a company to use this indicator. The company interested in the project can compare the internal rate of return to its required rate of return (often, the cost of capital). The IRR is calculated on a nominal basis that is including inflation [64].

Equity payback - The software calculates equity payback [years] or time-to-positive cash flow on equity, which represents the length of time that takes for the owner of a project to recoup its own investment out of the project cash flows generated. It considers project cash flows from its inception as well as the leverage (level of debt) of the project, which makes it a better time indicator of the project merits than the simple payback [64].

Simple p.b. - The RETScreen Software calculates the simple payback period, which represents the length of time that it takes for a proposed project to recoup its own initial cost, out of the income or savings it generates. The basic premise of the simple payback method is that the more quickly the cost of an investment can be recovered, the more desirable is the investment.

The simple payback method is not a measure of how profitable one project is compared to another. Rather, it is a measure of time in the sense that it indicates how many years are required to recover the investment for one project compared to another. It should not be used as the primary indicator to evaluate a project but it is useful as a secondary indicator to indicate the level of risk of an investment. A further criticism of the simple payback method is that it does not consider the time value of money, nor the impact of inflation on the costs [64].

9.4 Discussion and Comments of the Financial Analysis Results Table

Scenario I In the conditions of the scenario I, with the current power purchase cost 5 KZT/kWh (20.58 £/MWh), the production costs overcome the sale price. Moreover if the bank loan is 100 or 70% it overcomes the consumers' price, which is currently 33 £/MWh in Almaty city. In the first two cases IRR-assets are negative that means the whole project will not pay for itself during the 20 years. Further reductions of production costs are due to reduction of debt ratio. The less money borrowed the less the total project expenses would become. Nevertheless it is still more expensive to produce power than it is sold into the grid. When the bank debt is 0% the production cost is the least achievable, which is 23.5 £/MWh, and IRR-assets is expectedly 6.48% but there is a lot of uncertainty and unacceptable risk. The positive IRR-assets, when production costs are higher than sale prices, are due to the 8.5% inflation rate and if inflation was not counted they would become negative. For instance, if inflation is 0% the 6.48% IRR-assets become -1.9%. The equity IRRs are also due to the inflation and their payback period.
Thus, the current power purchase price makes the project not feasible for investors.

Scenario II Since the current electricity purchase price is not feasible, gradual increasing of prices was tried to check what would be the minimum price that could make the wind farm viable. Even at 10 and 10.5 KZT/kWh the project's IRR–assets do not overcome the IR 12% so it would cost more to borrow capital than the project assets would return.

11 KZT/kWh (45.27 £/MWh) was found to be the minimum sale price where IRR-assets generally exceeded cost of borrowing. However if the debt ratio is 100% the IRR-assets (9.71%) will still be less than the cost of borrowing. In this case the minimum feasible sale price would be 12.5 KZT/kWh (51.44 £/MWh), which would bring 12.28 % return.

<u>Note:</u> these are pre-tax calculations and the real desirable price should be slightly more depending on conditions of the preference agreement between the developer and RoK Government.

In spite of the pre tax count, the returns on equity capital are considerably high. It should be noted that the less equity invested the less risk of investments and higher rates of equity return. It may be an option for a developer under certain conditions but one needs to note that it reduces overall project asset returns because more money has to be borrowed.

In this scenario production costs do not change compared to the previous scenario. However it is important to note that periods of simple payback reduced almost three times compared with the previous scenario.

Thus, the project can be feasible if power purchase price would have a value of more than 11 KZT/kWh (4.53 p/kWh) depending on tax conditions.

If there is borrowed capital, the equity payback periods are generally less than 6 years. If the project is fully financed by the own capital its cash flow becomes positive in 6.16 years if the wind power could be sold at 11 KZT/kWh.

Scenario III The 12% interest rate is very high. It has big impact on the project feasibility making it more expensive. So this scenario considers what should be the minimum power sale price for the project assets return to overcome the bank interest rate if it could be as low as 7%. Reduction of bank interest rate reduces the cost of power production compared to previous scenarios.

Generally, the project could become feasible at 8 KZT/kWh (32.92 £/MWh). Though, 100% loan would still be very expensive and not feasible. In all other conditions IRR-assets exceed the 7% bank interest rate. However, every single condition needs to be check whether it would meet the required rate of return of the interested company.

This scenario of low bank interest rate provided considerably good rates of return and payback periods of equity capital, but less than in the second scenario.

Scenario IV This scenario provides comparison to Scenario III on what would happen if the power purchase price would remain 8 KZT/kWh and bank interest rates were not reduced.

At this sale price, the returns on equity overcome the cost of borrowing but general project asset returns are less than 12% IR.

Simple payback periods correspond to Scenario III but equity paybacks are higher due to higher project leverage. The equity payback periods are mostly less than 10 years.

Since the cost of capital overcomes rates of return on project assets and risk of investments is high it is not a feasible case and 7% IR is required for 8 KZT/kWh sale price.

9.5 Emission Reduction Analysis – Environmental Benefits of the Project

Emission Analysis

Base case electricity system (Baseline) Country - region	Fuel type	GHG emission factor (excl. T&D) tCO2/MWh	T&D losses %	GHG emission factor tCO2/MWh
Kazakhstan	Coal	1.520	15.0%	1.788
Electricity exported to grid	MWh	148,022	T&D losses	
GHG emission				
Base case	tCO2	264,698		
Proposed case	tCO2	0		
Gross annual GHG emission reduction	tCO2	264,698		
GHG credits transaction fee	%			
Net annual GHG emission reduction	tCO2	264,698		
	is equivalent to	549,619	Barrels of crude oil not consumed	
GHG reduction income				
GHG reduction credit rate	£/tCO2			

Picture 9.1 - RETScreen Emission Analysis Model

Note: Transmission and distribution losses of the electricity exported to the grid have been counted before therefore they have not been entered into the model.

As seen from the model, the software can also provide equivalents to the CO2 emissions based on the type of fuel chosen. The equivalents to the annually reduced 264,619 tCO2 emissions were the following: 53,813- Cars & light trucks not used; 107,626,207 - Litres of gasoline not consumed; 264,698 - People reducing energy use by 20%, 224,993 - Acres of forest absorbing carbon or 91,052 - Hectares of forest absorbing carbon and 89,124 tons of waste recycled [64].

Conclusion

The country consumes large amounts of electricity to maintain stable industrial growth, per unit of GDP. Irrational power consumption causes significant environmental pollution and decreases competitiveness of the country's economy.

The actual environmental problems of Kazakhstan are very serious and its current electricity production sector is not sustainable.

The RoK Government realizes the problem and it has been already addressed in several governmental programs. One of the solutions of sustainable development of Kazakhstan's energy sector is the introduction of environmental friendly technologies such as wind power.

It has been made clear that the oil and gas sector of the country will play an important role in terms of increasing investments and improving the economy. But Kazakhstan does not want to rely on the development of oil and gas production sector only. The oil and gas revenues should help other economy sectors to develop.

In the example of the Chilik Corridor, current electricity sale prices in the Almaty region, where electricity tariffs are one of the highest in the country, can not justify building a new wind farm. The study showed that the power sale price would need to be increased significantly to make it possible.

However under the current conditions of growing electricity deficiency and aging of the main generation plants in Kazakhstan it is clear that the country has to introduce some new installed capacities in near future. New power plants will be required to be designed according to modern environmental regulations that are stricter nowadays than they used to be when the most of the old plants were built.

The share of coal power plants in the energy balance is very big, which is not sustainable in terms of environment and life quality indicators that the country is worried about. It could be partially replaced by renewables that would reduce their environmental impact.

In the real situation, the availability of good wind resources around the country and the need to import electricity favor the construction of wind farms. Electricity imports from abroad to the Almaty city are high. If the 50 MW wind farm were built it would replace the imports only partially. To provide energy independence of the city some additional solutions would still be required.

Future growth of electricity cost in Kazakhstan seems to be inevitable to allow replacement of old generating capacities and building new sustainable power plants including wind farms.

The increase of prices should be gradual and smooth not to cause economical destabilization in the country. Energy producing companies will have to justify their sale prices to the RoK Government (represented by the RoK ARNM with regards to power market issues).

If tariffs grow, wind power may become a feasible subject for providing viable electricity supplies.

The main advantage of wind farms compared to other types of power plants will be their short periods of construction. Therefore they may become a good short term solution in the near future if RoK Government provides adequate supporting mechanisms.

However wind energy is not going to be the main source of electricity and other types of energy sources such as nuclear and hydro will probably become a long term solution to the expected demand growth and replacement of old units.

The speed and rates of wind energy development will depend on constant governmental support and policies in many respects. Its success will depend on further studies of the allocated sites and positive experience of the pilot project in Dzhungar Gates. Should the project be successful it can engage the entire wind energy sector and accelerate its development in the next few years.

It is not only an important issue for Kazakhstan but for the International society that the country would considerably contribute to the global reduction of GHG emissions. For this reason, development of renewable energy sectors in Kazakhstan is worthy of international attention today. The country has ratified UNFCCC and it is willing to approve the Kyoto protocol to become an Annex I country, therefore some visible changes are expected in the near future. In this situation, it is necessary to emphasise that the RoK Ministry of Environmental Protection and UNDP have drafted the project of RoK "Law on Renewable Energy" that should provide supporting mechanisms for renewable energy.

One of the most important barriers to wind energy exploitation in Kazakhstan at present is that the grid operating companies may not agree to provide reasonable conditions for wind energy developers as long as they have cheaper options. There is no obligation for them to purchase renewable energy today if it costs more unless the RoK Government puts adequate supporting legislation in place.

The issue of feasibility of new renewable energy plants is promised to be fixed once the project of the RoK Law on Renewable Energy is approved. However it is rather too early now to say how soon it would start working effectively. New wind farms would not pay back even at the current highest prices. Construction of new hydro and nuclear power plants are not likely to be economically feasible either.

Bank interest rates in Kazakhstan are generally high and it may not be possible to obtain a reasonable cost of borrowing capital if the risk of investment is high. This influences the cost of electricity production. Even if the cost of borrowing capital could be as low as 7% the current electricity sale price would not make the wind farm financially feasible.

Kazakhstan has many environmental problems and public opinion on renewable energy is generally positive. These factors and the fact that the country has ratified UN FCCC and it is going to approve the Kyoto Protocol should open new financial opportunities for international wind energy developers in future.

International governments should pay attention to this issue. Wind farms could replace some of the old coal generating capacities. If Kazakhstan would build several wind farms the global environmental benefit would be significant. The study showed that the 50 MW wind farm with capacity factor 33.8% could provide the annual benefits in CO2 emissions reduction of 264,619 t which is equivalent to 53,813 cars & light trucks not used; 107,626,207 liters of gasoline not consumed; 264,698 people reducing energy use by 20%; 224,993 acres of forest absorbing carbon and 89,124 tons of waste recycled (according to the RETScreen software). Along with the CO2 emissions, the wind farms could reduce large amounts of other harmful substances including SO2, NOx and ash emitted from the thermal power plants and improve local air quality.

This study provided technical-economical analysis of the potential 50 MW wind farm in the Chilik Corridor. However there are several issues that would need to be additionally investigated:

1. Competent and professional environmental assessment;
2. Whether it is required to obtain a construction license to participate in design and planning activities of the wind farm construction;
3. The actual capital cost of the wind farm construction will need to be estimated in detail on site since the Kazselenergoproject only provides general estimations for all sites in Kazakhstan.

Concerning the issue of increasing energy efficiency (energy consumption and GHG emissions per GDP), the current low electricity tariffs are not likely to help in achieving this target. In addition to the need of renewable energy support there must be something that would encourage industrial and private consumers to save energy. If electricity remains to be as cheap as it is now nobody will try to save it and industrial companies will not attempt to decrease power intensities of their products. A rise in electricity price will cause rise of prices in other economic sectors and make life more expensive. However local producers of goods and services will be forced to modernize their technologies and the process of price rises may be smoothed for people by means of improved efficiency and consequent energy savings. The RoK Government would need to provide continuous monitoring and control of the process of price rises in the different economic sectors.

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ANNEX I

[MWh]

	Receipts in total	including			Expenditure in total	including		
		Produced	From other province	From abroad		Consumed	Provided to other province	Provided abroad
Kazakhstan	***105496641.9***	***71656550.6***	***29885045.2***	***3955046.1***	***105496641.9***	***71881238.6***	***29885045.2***	***3730358.1***
Akmola	3304336.2	696344	2584692.2	23300	3304336.2	3206521.2	97815	
Aktobe	3194845.6	1740739		1454106.6	3194845.6	3194845.6		
Almaty	4939074.1	4278664	660410.1		4939074.1	3566456	1372618.1	
Atyrau	2709160.2	2551960.2	48400	108800	2709160.2	2709160.2		
East-KZ	8892466	7236967	1630599	24900	8892466	8165100	556566	170800
Dzhambyl	3956318.9	1597945.4	1785487.2	572886.3	3956318.9	2812262.8	1144056.1	
West-KZ	1222591.1	897491.1	30900	294200	1222591.1	1222591.1		
Karaganda	14614619.7	11,286,425.7	3252494	75700	14614619.7	14370525.7	244094	
Kostanay	4887500.4	1611671.2	3222052	53777.2	4887500.4	4887500.4		
Kyzylorda	1319525.6	660225	567300.6	92000	1319525.6	1199139.2	120386.4	
Mangistau	3312424.8	3312424.8			3312424.8	3233124.8	79300	
Pavlodar	30929997.1	30,767,409	115912.1	46676	30929997.1	12672317.2	14944052.8	3313627.1
North-KZ	2227640.8	1976752	234488.8	16400	2227640.8	1733912.8	247797	245931
South-KZ	2890156.8	998756.8	1478300	413100	2890156.8	2890156.8		
Astana city	1941333.4	1478827	462506.4		1941333.4	1885111.6	56221.8	

Almaty city	**15154651.2**	**563,948.4**	**13811502.8**	**779200**	**15154651.2**	**4132513.2**	**11022138**	

Table A1 - Total Electricity Balance in the RoK during 2006 [28]

ANNEX II

[MWh]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
399155.5	**402651.9**	384452.7	337704.5	310162.3	303608.3	305516.1	**291077**	322124.2	335259.4	358562	382239.3
Total - 4,132,513.2											

Table A2 - Seasonal Consumption of Electricity in Almaty city during 2006 [28]

	1995	1996	1997	1998	1999	2000
CIS						
Armenia	4,35	3,88	3,66	3,28	3,09	3,13
Belarus	2,36	1,63	1,85	1,54	2,18	2,51
Kazakhstan	**4,01**	**2,80**	**2,35**	**2,20**	**2,82**	**2,81**
Kyrgyzstan	8,24	7,87	7,13	7,07	10,56	...
Moldova	0,83	0,83	0,78	0,71	0,94	0,70
Russia	2,55	2,02	1,95	2,98	4,37	3,38
Ukraine	5,24	4,11	3,55	4,13	5,59	
Others						
UK	0,30	0,29	0,26	0,25	0,25	0,23
Germany	0,22	0,23	0,26	0,26	0,26	0,27
Italy	0,22	0,20	0,22	0,22	...	...
Canada	0,96	0,94	0,91	0,92	0,88	0,82
China	1,44	1,32	1,26	1,17	1,21	1,22
Republic of Korea	0,42	0,44	0,52	0,75	0,66	0,58
USA	0,45	0,44	0,45	0,44	0,42	0,30
Turkey	0,51	0,52	0,54	0,54	0,59	0,56
France	0,32	0,33	0,36	0,35	0,36	0,38
Japan	0,19	0,21	0,24	0,27	0,24	0,22

Table A3 - Electricity Consumption of GDP (kWh per $1 of GDP) [32]

ANNEX IV

National Parks and State Nature Reserves in the Republic of Kazakhstan [67]

1. Aksu Zhabagly (South Kazakhstan-Dzhambul Provinces)

The Aksu Zhabagly State Nature Reserve (AZSNR) reserve has been established since 1927 and named after the rivers of Aksu and Zhabagly.

The total area of the reserve is 128.1181 thousands he.

The geographical location of the area is 53 km in-between the 70° 18' - 70° 57' of the east longitudes and 41 km in in-between 42° 08' - 42° 30' of the northern latitudes (by the co-ordinates system of 1942).

The main part of reserve's area is located on territories of the Tolebiyskiy and Tyulkubasskiy areas in the South Kazakhstan Province and the rest is located on a territory of the Zhualinskiy area in the Zhambyl Province.

Picture A1 - Aksu Zhabagly State Nature Reserve [56]

Notations:

заповедник Аксу-Жабаглы – Aksu-Zhabagly reserve

с. Жабаглы – Zhabagly village

It has amazing mountainous landscapes of the north-west Tallas Alatay and Uragam range. The Aksu river canyon is one of the most amazing and pictorial places in the reserve. This canyon has heights between 300 and 500 meters.

The reserve has 1737 types of plants (Ivashenko, 2002), 47 species of animals (10 in the Red Book), 239 species of birds (11 in the Red Book). The species include Siberian Goats, roes, marals, wild boars, weasels, griffins and others.

The two birds' species, crake *(Crex crex*) and white-winged woodpecker (*Dendrocopos leucopterus*), are classified as the protected by the *International Union for Conservation of Nature and Natural Resources (IUCN)*. The other rarest ones include snow leopards, Turkestan's caracals, argali, Tien Shan bears, golden eagles, saker falcons and serpent eagles. The snow leopards (*Uncia uncia*) are also classified as the protected specie by IUCN. The West Tien Shan's marmots and some argali species are vanishing.

It also has paleontological buries Karabstau and Akbastau on the hills of Karatau mountain. They are imprint of the rarest species of fishes, mollusks, tortoises, insects of the Jurassic age and others dwelt here 120 millions years ago in a sea basin used to be on this place.

2. Naurzumskiy (Kostanay province)

The Naurzumskiy State Nature Reserve (NSNR) has been established since 1934with the purpose to preserve Naurzum`s pinery and the lochs that are nesting-places for different waterfowls.

The territory of the reserve is 191.381 thousands he.

The reserve's area forms a part of Naurzumskiy and Auliekolskiy areas in the Kostanay province.

The geographical coordinates of the reserve's border points are:

- at north - 51o 52’ 40.3” northern latitude and 063o 55’ 18.2” eastern longitude;
- at south - 51o 12’ 17.1” northern latitude and 064o 39’ 46.6” eastern longitude;
- at west - 51o 30’ 18.0” northern latitude and 063o 42’ 32.4” eastern longitude;
- at east - 51o 28’ 52.7” northern latitude and 064o 45’ 10.4” eastern longitude.

Picture A2 - Naurzumskiy State Nature Reserve [56]

The reserve has 961 types of plants, 44 species of animals, 282 species of birds (44 are the rarest, 36 in the RoK Red Book, 23 in the IUCN). One of the most amazing dwellers of the reserve is a very rare egret.

3. Kurgaldzhinskiy (Akmola province)

The Kurgaldzhinskiy State Natural Reserve (KSNR) has been established since 1968 with the purpose to preserve nests of the rarest birds' species such as pink flamingo (Phoenicopterus rubber). The Tengiz (*оз.Тенгиз*) loch is the main nesting place of the pink flamingoes.
The total area of the KSNR reaches up to 258.963 thousands he, where water area takes more than half (197919 he).

The reserve is located in the central part of Kazakhstan, between the geographical co-ordinates, from 68º38´ to 69º41´ eastern longitudes and from 50º10´ to 50º43´ northern latitudes. It is placed at the turn of Akmola and Karaganda provinces. Its entire territory belongs to the

Korgaldzhinsk area of the Akmola province though. The capital of RoK is 170 km north-west direction from the reserve, and its is possible to drive there within a couple hours.

The KSNR is classified as a highly protected natural resources with the republican significance and is a direct subordinate to the Forestry and Hunting Department of the RoK Ministry of Agriculture whose office is in the Astana.

Picture A3 - Kurgaldzhinskiy State Nature Reserve [56]

Notations:
Коргалжинский заповедник – Kurgaldzhinskiy reserve
оз.Тенгиз – Loch Tengiz; **оз.Кокай** – Loch Kokay;
оз.Сулганкельды – Loch Sulgankeldy; **оз.Исей** – Loch Issey

The reserve has 331 types of plants, 41 species of animals (24 in the IUCN), 328 species of birds (where 39 in the RoK Red Book, 24 in the IUCN). One of the most amazing dwellers of the reserve is a very rare egret.

Air fauna is rich here. The rarest birds are Dalmatian pelicans, mute swans and flamingoes.

The Tengiz-Kurgaldzhinsk lochs are rich with high concentrations of numerous waterfowls during the migration periods. At these periods, the lochs are home for several thousands of wigeons (Anas penelope – 40,000), wild ducks (Anas platyrhinus – 20,000-40,000), dunbirds (Aytea ferina – 150,000), rufous-crested ducks (Netta rufina – 50,000), bald-coots (Fulica atra -

40,000), ruffs (Philomachus pugnax 100,000) and for the red-necked phalaropes (Phalaropus lobatus 50,000-80,000).

Therefore the reserve has become world renowned and has been included into the UNESCO list of specially secured marsh-loch landscapes.

4. Almatinskiy (Almaty province)

The *Almatinskiy State Nature Reserve* (ASNR) has been established since 1961.
It is located at the south-east Kazakhstan, in the center of the Zailiyskiy Alatay mountain range that is the northern part of Tien Shan mountain system.

The altitudes on ASNR territory vary between 1500 and 4979 meters above sea level. The highest point of the nature reserve is the peak *Talgar* (4979m). Also, there are four other highland points above 4500m, which are peaks *Aktau* - 4686 m, *Korp* - 4631 м, *Bogatyr* - 4626 m and *Metallurg* - 4600 m. In addition to this, it is worth to note that altitudes on the main mountain ridge pertaining to the ASNR territory are all higher than 4200 m.

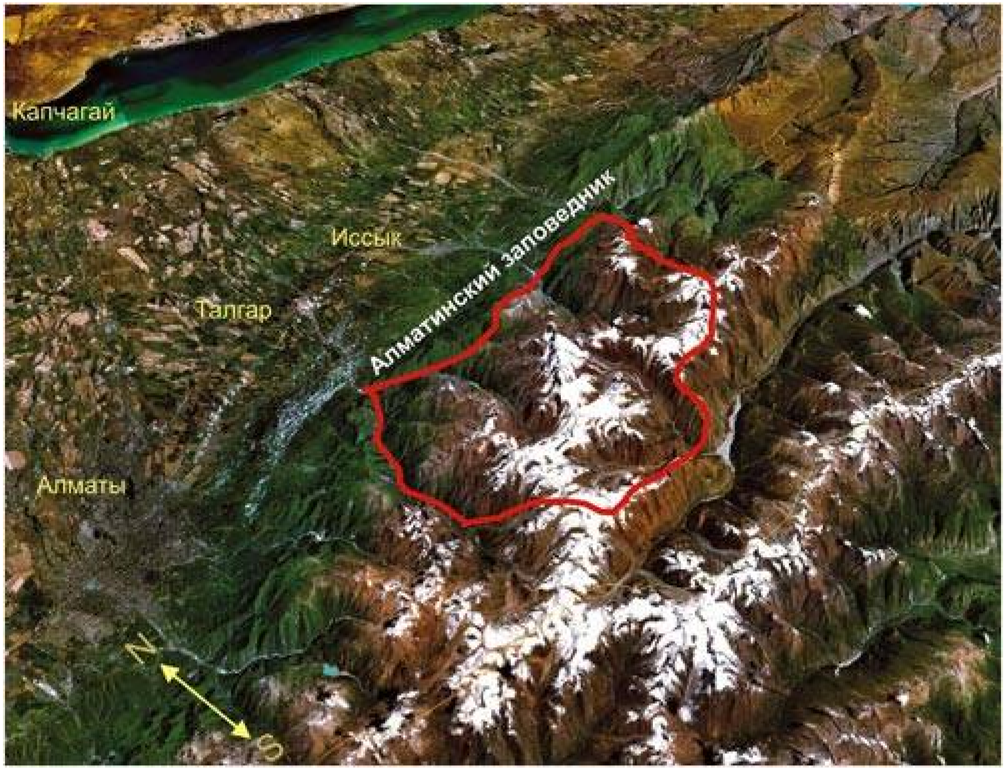
In terms of administrative division, the reserve is on the territories of *Talgarskiy* and *Enbekshy-Kazakhskiy* areas of the *Almaty* province.

Geographical co-ordinates of the central point in ASNR are 42^{o}96'05' eastern longitude and 77^{o}22'33" northern latitudes. The total area of the entire protected territory is 73.7 thousands he. The administrative office of ASNR is located in the *Talgar* town, which is about 25 km from the city of *Almaty*.

The nature of the Almatinskiy preserve is pictorial. It has glaciers, snowfields and rocks.

One of the most amazing natural sites here are so called "singing dunes". The sand hills up to 150 meters height produce noise when moving on their surface.

The territory of ASNR is under the danger of avalanches in the most of winter and especially in the early spring. Also, there are dangers of mudflows and landslides in summer time when melting of glaciers is especially intensive (July). The reserve is normally closed for tourists and anyone else during these periods if there is a high risk.



Picture A4 – Almatinskiy State Nature Reserve [56]

Notations:
Алматинский заповедник – Almatinskiy reserve;
Алматы – the city of Almaty
Талгар – Talgar town; **Иссык** - Yessyk town;
Капчагай – Kapshagay water storage reservoir

The ASNR has counted more than 1000 types of plants (50 are the rarest), 42 species of animals, 200 species of birds. The Tien Shan brown bear (Ursus arctos isabellinus), snow leopards (Uncia uncia Screber) and the Turkestan's caracals (Lynx lynx isabellinus) are extremely rare animals. Ten species of birds are in the Red Book of Kazakhstan; where the six species have their permanent nests in the reserve - golden eagles (Aquila chrysaetus), beard birds (Gypaeus barbatus), himalayan griffons (Gyps himalaensis), barbary falcon (Falco pelegrinoides), ibis-bills (Ibidorhyncha struthersii), whistling thrushes (Myophonus caeruleus); the three species are occasionally met during summer - black storks (Ciconia nigra), booted eagles (Hieraaetus pennatus), eagle owls (Bubo bubo); and the peregrin falcons (Falco peregrinus) fly in here during winter.

5. Markakolskiy (East Kazakhstan province)

The *Markakolskiy State Nature Reserve* (MSNR) has been established since 1976 with the purpose to preserve and study nature of the Southern Altay. It is located in the *Kurchumskiy* district of the East Kazakhstan province. Geographical co-ordinates of the central point in MSNR are 48° 45` eastern longitude and 85° 45` northern latitude. Total area of the MSNR is 75040 he. The highest point in the MSNR is the hill *Aksu*, which is 3304m above sea.

The reserve is 250 km to the east from *Kurchum* village and 500 km to the south-east from the administrative center of the *East Kazakhstan* province *Ust-Kamenogorsk*.

Picture A5 - Markakolskiy State Nature Reserve [56]

Notations:

Маркакольский заповедник – Markakolskiy reserve;

The large mountain loch *Markakol* is one of the most amazing sites here. It lies at 1485 meters above seal level, and has the deepest point in 27 meters. The loch is home for the rarest specie of white fish.

The MSNR has counted 721 types of plants, 59 species of animals, 211 species of birds (140 are residents. The main species of animals are marals and bears. Among the 211 species of birds, 12 species are endangered where 8 species have their permanent nests in MSNR. These are black storks (*Ciconia nigra*), whooper swans (*Cygnus Cygnus*), fish hawks (*Pandion haliaetus*), imperial eagles (*Aquila heliaca*), golden eagles (*Aquila chrysaeto*), white-tailed eagles

(*Haliaeetus albicilla*), saker falcons (*Falco cherrug*), peregrin falcons (*Falco peregrinus*), cranes (*Grus grus*), little bustards (*Otis tetrax*), great black-headed gulls (*Larus ichtiaëtus*) and eagle-owls (*Bubo bubo*).

6. Ustyurtskiy (Mangistau Province)

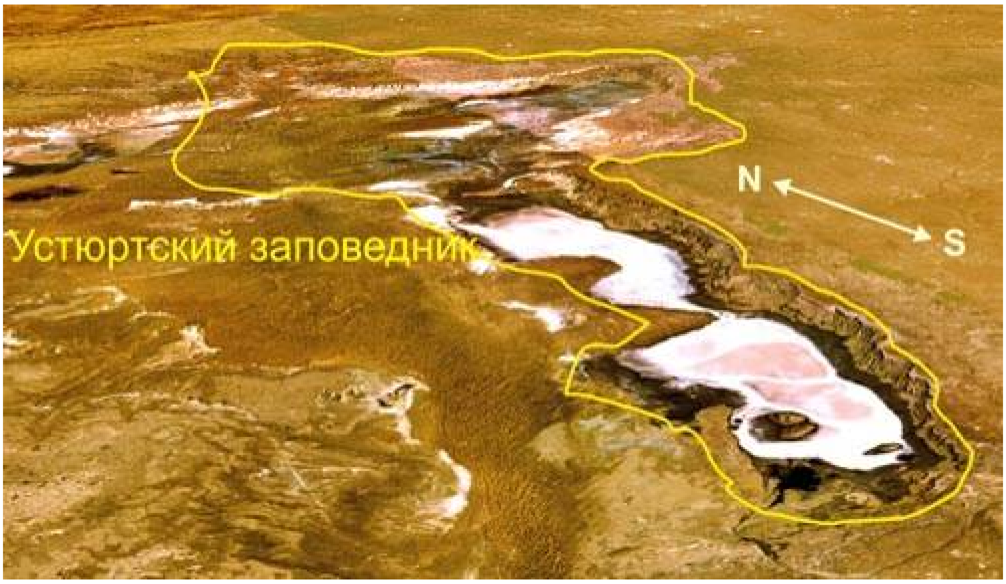
The *Ustyurtskiy Sate Nature Reserve* (USNR) has been established since 1984 and named after the Ustyurt tableland.

It is located in the south-west part of the *Ustyurt* tableland, pertaining to the territory of *Karakiyanskiy* district of the *Mangistau* province.

Extension of the USNR territory is 43 km in-between the 54^{o} 09' - 54^{o} 55' of the east longitudes and 95 km in in-between 42^{o} 34' - 43^{o} 23' of the northern latitudes (by the co-ordinates system of 1942).

Total area of the USNR is 223.342 thousands he, taking western part of the Ustyurt tableland. The reserve does not have constant waterways. It has some closed cavities. The biggest one is the Barsakelmes cavity having the 70x30 kilometers area. The highest point in the reserve is 340 m above sea level and located at the western part of Ustyurt tableland. Its lowest point is 52 m below sea and located at the northern part.

The administrative office of USNR is in the *Zhanaozen* town, which is 110 km from the reserve. The administrative center of the Mangistau province, *Aktau* town, is 150 km from the reserve.



Picture A6 - Ustyurtskiy State Nature Reserve [56]

It has 261 types of plants, 45 species of animals, 111 species of birds (11 in the RoK Red Book) and 22 species of vermigrades. Grew *monitor lizards* are included into the Red Book. Other rarest species are *Ustyurt`s moufflons, long-spined hedgehogs, goitered gazelles, caracals, golden eagles, serpent eagles, carrion-crows, saker falcons*.

7. West Altayskiy (East Kazakhstan province)

The West Altayskiy State Nature Reserve (WASNR) has been established since 1992 and it is the youngest national park in Kazakhstan.

The WASNR is located at the north-east of the Kazakhstan's part of *Altay Mountains*, which is at the border of the East Kazakhstan province, on the territories of Ridderskiy and Zyryanovskiy administrative districts. Geographical coordinates of the reserve's border points are:

- at north - *50°33'20"* northern latitude and *84°03'50"* eastern longitude;
- at south - *50°11'13* northern latitude and *84°07'10"* eastern longitude;
- at west - *50°10'50"* northern latitude and *83°57'50"* eastern longitude;
- at east - *50°14'20"* northern latitude and *84°16'30"* eastern longitude.

Total territory of the WASNR is 56.078 thousands he.

The north-eastern part of the reserve borders with the *Altay Republic* (*Russia Federation*)

The highest point of WASNR is 2598 m above sea level.

The reserve is 47 km from *Ridder* town, which is 130 km from the administrative center of the *East Kazakhstan* province *Ust-Kamenogorsk*.

Picture A7 - West Altayskiy State Nature Reserve [56]

One of the most amazing places here are light (Siberian larch) and dark (noble fir and white wood) coniferous forests.

It has 564 types of plants, 52 species of animals, about 130 species of birds.

The six species of the birds are in the RoK Red Book:

1. Black storks (*Ciconia nigra*) - 3 category (rare specie);
2. Saker falcons (*Falco cherrug*) - 1 category (vanishing specie);
3. Peregrines (*Falco peregrinus*) - 1 category (vanishing specie);
4. Golden eagles (*Aguila chrysaetus*) - 3 category (rare specie);
5. Eagle owls (*Bubo bubo*) - 2 category (contractile specie);
6. White-tailed eagles (*Haliaeetus albicilla*) - 2 category (contractile specie)

8. Barsa-Kelmes (Kyzylorda province)

The *Barsa-Kelmes State Nature Reserve* (BKSNR) has been established since 1939 and placed on the Isle of the same name. Its total territory takes 30 thousands he.

Clustered spots of the reserve are located in the northern part of the *Aral Sea*, on the *Barsa-Kelmes* peninsula (used to be an Isle) and the *Karsakulan* tract.

Total area of the *BKSNR* is 160826 he. In terms of administrative division, it is located in the *Aralskiy* district of the *Kyzylorda* province.

Picture A8 - Barsa-Kelmes State Nature Reserve [56]

Flora in the *BKSNR* accounts for 250 types of plants. There have been counted 40 species of animals (*koulans and goitered gazelles* are in the RoK Red Book*, others include saiga antelopes, corsac foxes and wolfs*), 170 species of birds (24 are rare and vanishing), 120 species of spiders

(3 types of scorpions. *Leptodrassus vina, Latrodectus tredecimguttata, Eresus niger, Argiope lobata* are the rarest ones), 20 vermigrades in the nature reserve. It is worth to note that number of birds' species used to be 319 at the beginning of the XX century. However it reduced down to 170 due to anthropogenic and natural changes in the region.

9. Alakolskiy (Almaty East Kazakhstan provinces)

The *Alakolskiy State Nature Reserve* (AlSNR) has been established in 1998 on the territories of *Alakolskiy* district of the *Almaty* province and the *Urdzharskiy* district of the *East Kazakhstan* province. The central administrative office of AlSNR is in the Usharal town of the *Alakolskiy* district.

AlSNR consists of two parts. The first part is on the southern shore of the Loch *Sasykol*, in the delta of the *Tentek River*. The second part is on the isles of Loch *Alakol*. The two parts are 40 and 70 km correspondingly from the *Usharal* town. The Usharal is 282 km from the administrative center of the Almaty province *Taldykorgan* town, 582 km from the city of Almaty and 510 km from Ust-Kamenogorsk.

Thus, total area of the reserve forms 20743 he (part1 – 17423 he, part2 – 3320 he), where 18453 he are in the Almaty province and 2290 he in the East Kazakhstan province.

Reference geographical co-ordinates of the reserve:

Part1 - 46°25' northern latitude and 81°08' eastern longitude;

Part2 – 3 isles including 46°11' northern latitude and 81°47' eastern longitude; 46°07' northern latitude and 81°51' eastern longitude; 46°06' northern latitude and 81°53' eastern longitude.

Picture A9 - Alakolskiy State Nature Reserve [56]

Another interesting fact is that the reserve is approximately 50 km from the Dzhungar gates place, which is near the Usharal town, where UNDP and RoK Government are planning to build the first pilot 5 MW wind farm. For many years, the site has been known as one of the windiest places in the Central Asia. There have been a number of accidents when the wind toppled goods wagons over.

The Loch Alakol is home for unique specie of relic-gull that was the main reason for establishing the natural reserve in this area.

Fauna of the youngest nature reserve has to be yet fully studied. According to preliminary estimation there are 12 species of fish, 14 species of vermigrades and 2 species of amphibias whose residence yet to be proved, 35 species of mammals and 269 species of birds (135 are residents and 134 seasonal migrating). The highest concentrations of birds are observed in the water-marsh landscapes of the Lochs *Baibala, Karamoyin and Chagaly*, which are in the Tentek River delta of part1.

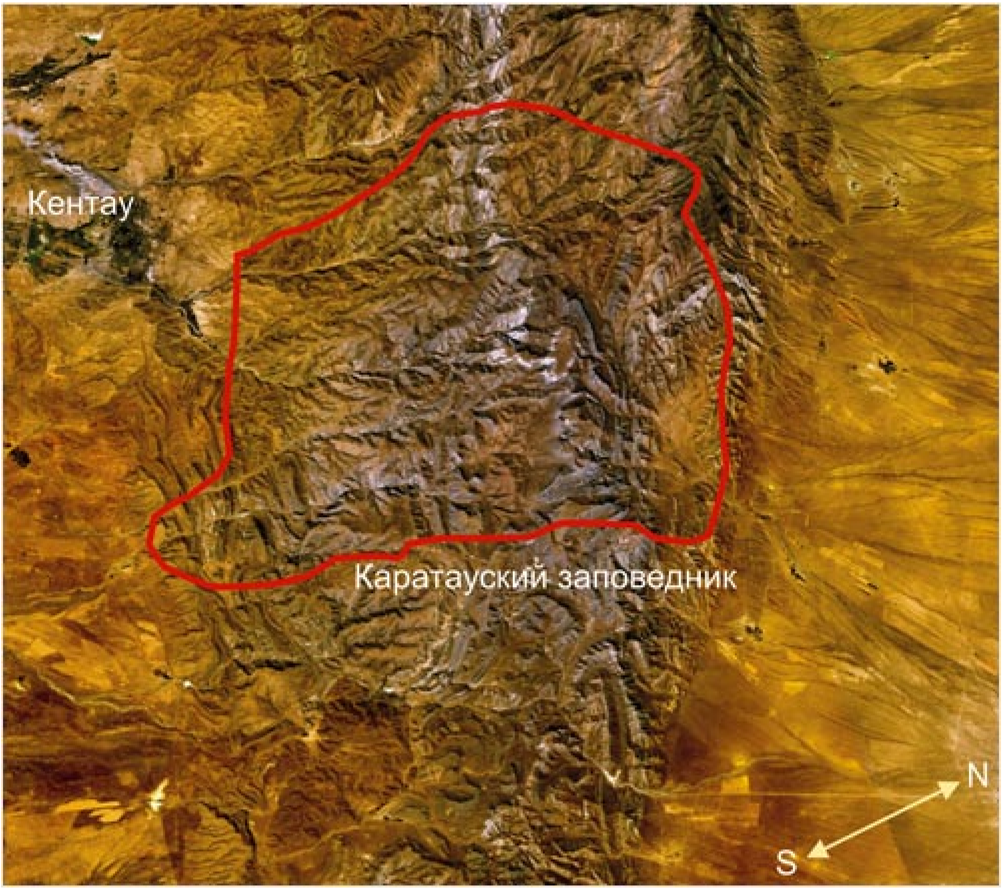
10. Karatauskiy (South Kazakhstan provinces)

The *Karatauskiy State Nature Reserve* (KSNR) is located in the central part of the *Karatau mountain ridge*, which is a branch of north-western *Tien Shan* on the territory of the *South Kazakhstan* province. It borders with the *Mounkum*, *Kyzylkum* and *Betpakdala* deserts. The highest point of the reserve is the *Myzhilki* hill 2167 m above sea level.

Extension of the KSNR borders are 28.3 km from 68°38' to 68°50' of the east longitudes and 23.6 km from 43°36' to 43°49' of the northern latitudes.

Total area of the reserve is 34.3 thousands he.

Administrative office of KSNR is 17 km from the reserve's borders, in the *Kentau* town, which is 40 km from the ancient (city) *Turkestan* town.



Picture A10 - Karatauskiy State Nature Reserve [56]

The reserve has counted 360 types of plants (42 in the RoK Red Book), 42 species of mammals and about 80 species of birds (7 in the RoK Red Book),

The most pictorial are the six carnivore birds - *(Falco cherrug) saker falcons, (Aquila chrysaetos) golden eagles, (Neophron) neophrons, (Circaetus) serpent eagles, (Andropogon) bluegrasses,* and *dwarf eagles*. All of them are among the 7 protected species counted in the reserve.