UNDP/GEF and Government of Kazakhstan project “Kazakhstan- Wind Power Market Development Initiative”

Report
Prospective of Wind Power Development in Kazakhstan

(Prepared in a frame of the UNDP/GEF and Government of Kazakhstan wind power project”)

Almaty, 2006

Content

1. Introduction

Current sustainable social and economical development of the Republic of Kazakhstan is described by year-to-year increase of Gross Domestic Product, which amounts to 8 per cent. Oil and gas and mining industries are the key contributors to such increase in GDP. The government has adopted state programs on economic diversification and agriculture and non-fossil fuel production development. The focal target set by the President for Kazakhstan is to become one of the top-50 world competitive countries.

In the meantime the economic development of the country is marked by huge energy consumption. The indicators for specific energy consumption per GDP amount to 2 toe/1000USD, and exceed corresponding indicators of OECD countries. Energy consuming economy leads to irrational use of fossil-fuel resources, reduces competitiveness, substantially contaminates environment. The Industrial Innovative Development Strategy of Kazakhstan focuses on reduction of energy consumption by half to 2015. The energy sector consumes significant energy resources causing considerable environmental contamination. Kazakhstan is the third largest emitter of energy related greenhouse gases emissions per GDP (6.11 kg CO2/USD). As a party to the United Nations Framework Convention on Climate Change Kazakhstan is about to ratify Kyoto Protocol and accept the commitment to reduce greenhouse gases emissions. Thereupon in order to provide sustainable social and economic development Kazakhstan demands efforts to improve energy efficiency and protect environment. Introduction of the renewable energy sources is one way to reduce fossil-fuel consumption and may add to mitigation of bad environmental impacts.

2. The review of energy sector of Kazakhstan

The energy sector is one of the most developed of the Kazakhstan economy. The Republic of Kazakhstan benefits from resources of fossil fuel, its reserves of which constitute 4% of the world fuel resources. In the year 2003 the total production of the energy resources in Kazakhstan formed about 105 millions toe (tonnes of oil equivalent), of which exports amounted to 55 million toe and domestic consumption formed about 50 million toe. The share of coal in the consumption of energy forms about 67%, oil - about 21%, gas - about 12%. The main consumer of fuel in Kazakhstan is the production of energy and heat. Annual consumption of the fuel by this sector forms about 25 millions toe. In the structure of the fuel balance for electricity stations coal constitutes 75%, gas 23% and black oil 2%.

Kazakhstan possesses significant resources of renewable energy in the form of hydro energy, solar energy and wind energy. The potential of hydro energy is assessed to be 170 million kWh per year and wind energy 1820 million kWh per year. However besides a small share of hydro energy in energy balance of the country (about 8 million kWh per year) these resources haven’t achieved a wide application until the present time.

The total installed capacity of electricity stations is about 18.5 GW_e. Thermal power stations form 15.42 GW_e, or 87% from the total capacity, the share of hydro stations is about 12%, and others about 1%.

The production of energy in Kazakhstan in the year 2005 formed about 67, 5 million kWh. In recent years the consumption and production of power has been increasing in line with the expansion of the economy. It is predicted that the 1990 level of energy production (87.38 million kWh) will be reached in Kazakhstan by the year 2010. The predicted growth pattern of energy consumption is shown in the table below

Years	2003	2004	2005	2010	2015
Energy consumption, millions kWh/year	62,10	63,95	67,50	83,00	97,00

Many of the existing generating stations in Kazakhstan are aging and in need of renewal. From 18,4 GW of total generation capacity, available capacity amounts to no more than about 14 GW, significantly reducing the potential for power generation. In accordance with the programme for the common energy system development of the country until the year 2010 with the prospective until 2015 for the coverage of needs in energy it is necessary to replace 3265 MW of aging capacity in order to realise 3584 MW from the same equipment. In addition there is a need to introduce 2300-2550 MW of new capacity.

The regional energy balance of Kazakhstan energy balance shows the following characteristics:

North zone, including Akmolinskaya, East-Kazakhstan, Kostanaiskaya and Pavlodarskaya regions and, where the main generation capacities of Kazakhstan are located, is energy abundant. In this region it is planned to introduce about 1035 MW of new capacity, to meet local demand and energy transmission to energy deficiency regions, as well as for export to Russia.

The Western Zone (Aktyubinskaya, Atyrausskaya and West-Kazakhstan regions) is energy deficient by a volume of 0, 84 million kWh/yr. It is planned to introduce about 1 300MW of new capacity fuelled by gas. Taking into account that Kazakhstan is going to join WTO and the threat of gas prices increasing to the international normal level, the cost of energy in this region is likely to significantly raise.

The Southern Zone (Almatinskaya, Zhambilskaya, Kyzylordinskaya and South Kazakhstan regions) there is an energy deficit (see table below).

Energy balance of Southern Zone.

Period	2005	2010	2015
Energy demand, millions kWh/yr	12,5	14,7	17,0
Energy production by local energy stations, millions kWh/yr	7,75	7,7	8,35
Transmission North-South, millions kWh/yr	3,5	7,0	7
Deficit, millions kWh/yr	1,25	0,0	1,67

In order to cover the southern power deficit a second 500 KV North-South transmission line has been planned. However it is forecast that within the period 2010 to 2015, taking into account growth of energy consumption, there will once again be an energy deficit in the South.

By the year 2015 it is planned to introduce new hydro stations in the South zone, Maynakskaya hydro station with a capacity of 250MW and Kerbulakskaya hydro station with a capacity 50MW. However, the introduction will not cover energy deficit. In order to cover energy deficit in South zone as per Program of common electro energy system development of the country for the period until 2010 with the prospective until 2015 it is proposed to construct small hydro stations and wind capacity of 50-125MW capacity.

One of the issues, concerning all Kazakhstan regions, is of the supply of energy to remote rural consumers. The large scale of the territory of Kazakhstan and low the density of population in rural area means that significant rural transmission lines extension is necessary, which currently forms about 360 thousands km. Maintenance of the power circuits for such an extension, as well as significant losses (25-50%) of energy transmitted will greatly increase energy cost. Analysis shows that the real cost of power transported to remote consumers with small capacity may reach up to 5 cents/KW/h, which makes energy supply of remote small consumers economically unfeasible. An economic alternative for power supply to remote consumers would be distributed small scale generation using renewable sources of energy. However, this potential remains unrealized.

In addition there is the issue of environment pollution by the electricity generation sector. Particular emphasis on coal energy causes significant damage to environment and health of population. The concentration of harmful substances in smoke gases from coal-fired power stations in Kazakhstan exceeds international standards by several times. Emissions of harmful substances to the atmosphere by power stations exceed 1 million tonnes per year, and the total volume of polluting substances to the environment exceeds 11 millions tonnes. An estimate by experts of the cost of environmental and social damage caused by coal-fired power in Kazakhstan is 7, 7 tenge/KW/h and exceeds the cost of the energy. Consequently the issue of reducing the coal-fired stations environmental impact appears very clear.

Thermal power stations are one of the primary sources of green house gas emissions in Kazakhstan. The share of this sector forms about 43% of total GHG emissions in Kazakhstan. It is supposed that by the year 2010 the volume of GHG from energy sector will exceed the level of the year 1990. Kazakhstan is the participant of UN Framework Convention on Climate Change and has responsibilities on reduction of influence on climate change. In this connection there is a necessity to reduce GHG emissions by the energy sector, which can be made by decentralization of the power sector, increasing energy efficiency and the extension of renewable energy sources utilization.

3. World trends in power sector and wind power development

Utilization of organic fuel forms the basis of world energy at present time. As per data of International Energy Agency (IEA) for the year 2003 world energy production 16 691 TW/h. The share of energy produced with the use of organic fuel forms about 66, 4%; the share of large hydro stations - 15,9%; nuclear energy – 15,8%; renewable sources – 1,9%. Such factors as increasing energy consumption, limited reserves of energy sources, instability of energy markets and the global threat of climate warming are significant influences on energy developments at the beginning of the 21st Century. It is the aspiration of all countries to provide energy security and independence from unstable energy markets and to limit GHG emissions, connected with global climate warming These factors lead countries to the necessity to diversify energy structures, as well as extend the utilization of renewable energy sources. Research has shown that to stabilize the GHG content in the atmosphere, the share of RES in world energy balance by the year 2050 must constitute about 18% or even more.

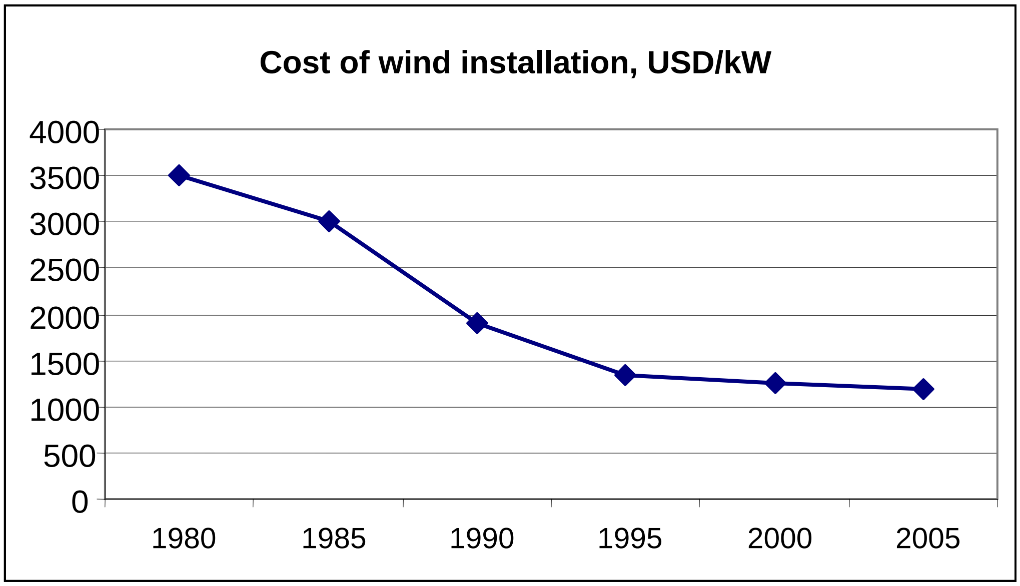
One of the most dynamically developed commercial types of RES is wind energy. At present time installed capacity of wind farms (WF) forms about 60 000 MW or 1.5% of world generation capacity. Wind energy demonstrates constant growth of capacity of about 20-30% per year. The interest to wind energy development is explained by the following factors:

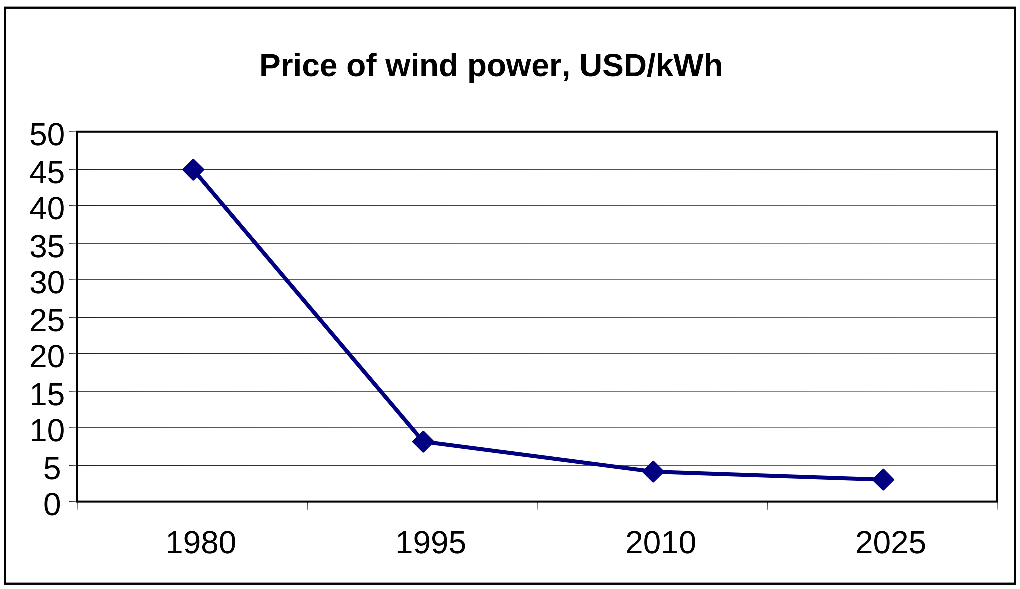
- Renewable source of energy, independent from fuel prices
- Absence of harmful substances and GHG emissions
- Developed world market of wind installations
- Competitive cost of installed capacity ($1000-1400 USD/ KW)
- Competitive cost of energy, independent from fuel cost
- Short terms of WF construction with adaptation of WF capacity to the required load
- Possibility of decentralized provision with energy of remote areas

The growing scale of wind farm construction, associated with increasing wind turbine efficiency and the reduction of capital cost, significantly increased the attraction and scale of wind energy utilization. At the present time about 60 countries of the world have WF in their energy structure.

43 countries of the world have National Wind Development Programs with the installation of hundreds and thousands of MW capacity in the short and medium term. These Programs are often accompanied by the development of an indigenous wind construction industry, manufacturing machinery and components locally to increase economic value and reduce costs.

In recent years there has been significant progress in the reduction of wind installation costs and cost of power generated by wind farms. According to a study of wind power development in the US, the cost of wind equipment and of wind power will be decreased by a further 30% because of increasing efficiency of wind turbines.





It is estimated that by the year 2013 installed capacity of wind farms in the world will form about 150 000MW. Small wind energy for individual and collective energy consumers is successfully developing. Thus, in USA the volume of sales of small wind installations with capacities in the kW range has reached 14MW per a year. The growth of small wind energy is explained by the growing needs of energy supply where access to centralized energy supply is difficult or economically unjustified, as well as providing independence from the rising price of energy.

Wind energy development is not considered only as an additional energy source but as a support to energy security and dependence of economies on the price of fuel, emission reduction and social-economic development.

4. Prospective of wind energy development in Kazakhstan

4.1. Wind potential in Kazakhstan

Kazakhstan is exceptionally rich in wind resources. About 50% of Kazakhstan's territory has average wind speeds about 4-5 m/sec at a height of 30m, the deminimus figure for good technical potential wind energy development. In some estimates the wind potential of Kazakhstan forms about 1820 billion KW/h per year spread over the significant territory of Kazakhstan. Most windy sites are located in Caspian sea area in Atyray and Mangistay oblasts, in center of Kazakhstan in Akmola, Karaganda oblasts and some areas in the South of Kazakhstan. A country wide-wind atlas is available (Annex 1.) With a density of wind capacity about 10 MW/sq.km there is a possibility to install thousands MW of wind farms in Kazakhstan.The success in developing wind energy in Kazakhstan is largely dependent of the availability of reliable meteorological data on wind potential. Detailed meteorological data is used in feasibility studies for the justification of the construction of large wind farms. Detailed wind data is gathered using specialist meteorological equipment mounted on masts at a height of 30-80 meters over a minimum of one year. Such measurements have been accomplished for Djungar Gates and Chylyk Corridor in a frame of the UNDP/GEF project on wind energy in 1998-2000. Thus, in Djungar Gates – wind potential is estimated as 525W/m2, in Chylyk corridor is about 240W/m2 accordingly. Power production of wind turbines in these places could achieve 4400kW/h/MW and 3200kW/h/MW respectively. The data confirm about excellent wind potential in Djungar Gates and good wind potential in Chylyk Corridor. Both sites are considered as very perspective for large wind farm construction.

The UNDP project on wind energy continue carry out detailed wind study on most promised sites in Kazakhstan in order to evaluate wind potential and to prepare the Kazakhstan wind atlas. The data will be used for the feasibility study for wind farm construction and small wind installation.

On the basis of study, funded by UNDP and executed by Kazselenergoproekt and Energieteam Company (Germany), a list of prospective sites was prepared for the construction of large wind farms in Kazakhstan. The sites for the construction of wind farms were selected on the basis of long-term data from meteorological stations on average wind speed, computer analysis of Kazakhstan territory taking into account the following factors:

1. availability of electricity grid and sub-stations for transmission of wind power;
2. suitability of the topography and the altitude of the site;
3. presence of electricity consumers;
4. presence of transport communications;
5. practicality of wind farm construction;
6. presence of preliminary developmental works of wind farms construction;

The list includes 20 sites around territory of Kazakhstan and attached as Annex 2.

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4.2. Feasibility of wind farms

Economical aspects of wind energy development

Kazakhstan is exceptionally rich in wind resources. Many sites around the territory of Kazakhstan have average yearly wind speeds of 6 m/sec and above, the level that provides acceptable technical performance for a wind energy development. The cost of energy from a wind farm in such places will be about 5,5 to 6,5 cents/kWh taking into account the necessary performance of the capital invested. This compares very favourably with the alternative of generating power from high cost gas and coal when including the cost of long distance transmission.

In order to fully understand the role of wind it is necessary to consider a number of issues. Wind energy is naturally intermittent in nature and therefore can only form a part of any energy system; it is necessary to balance wind power with schedulable forms of generation. Nevertheless, the incorporation of wind energy to a system will reduce the overall dependence on fossil fuels.

Kazakhstan traditionally relies on its vast reserves of coal for power generation. This coal is located largely in the Central of the country, around Karaganda, and Ekibastus. The majority of power generation plant serving the country are also located in this area, with large transmission lines delivering power to where demand exists. In Western Kazakhstan it is expected that gas production associated with the petroleum industry will provide a future source of electricity.

Accordingly, many places in Kazakhstan rely on power to be transmitted over very large distances from the centres of power generation. Such transmission results in significant losses of power due to aging transmission infrastructure, inefficiency and also from theft.

In the United Kingdom the total power production is nearly 300 bn kWh/year, carried on a transmission system of 14 000km. Therefore, the density of power on the system is 21MWh/km. In Kazakhstan 67 bn kWh are carried on a system of 24 000km, equivalent to 2,8MW/km. In other words the Kazakhstan power industry must invest in 10 times as much infrastructure for an equivalent amount of transmission as the UK. Such reliance on infrastructure means either significant cost, or significant losses due to long transmission and aging systems.

Increasing power supplies to such remote areas to meet expanding demand would involve significant capital expenditure to upgrade, replace and renew transmission infrastructure in addition to the capital expenditure for the upgrade, replacement and renewal of generation plant.

By placing appropriate generation close to the point of demand in such areas, capital expenditure on transmission infrastructure can be reduced and losses avoided. The structure of transmission charging in Kazakhstan is to pay a transmission charge that varies with the location of the consumer. This system does not incentivize efficiency and does not allow the recognition of savings to the overall network through local power generation.

If an allowance is made for the necessity of capital expenditure on infrastructure in the commercial assessment of a project, then the price per kWh supplied locally to the generation plant that is required by a wind power project is balanced by the associated savings in transmission improvements.

This cost compares with the energy from new coal energy station. Thus, for regions with very good wind potential and an energy deficit, wind farms can be an economical alternative for the construction of new coal power stations, at the same time possessing indisputable ecological advantages.

Coal fired power stations currently operating in Kazakhstan are selling electricity at a price of about 1 US cent/kWh, broadly similar to the marginal cost of operation. New capacity, which will be necessary to meet the rapidly increasing demand for power in many areas of the country, will not be able to operate at such low income levels but will charge at a level to cover the cost of capital investment.

Power is transmitted by the state owned electricity transmission company, Kegoc, with a charge structure based on the location of the customer. There are eight transmission regions each with a unique flat charge. Regional charge bands are loosely based on average transmission distance and bulk volume of electricity supplied.

In order to meet increasing demands for power in areas remote from the centers of power production it is necessary to consider the investment required to upgrade and expand existing and to construct new transmission infrastructure.

The true price of power supplied to a remote area of Kazakhstan therefore should reflect the marginal cost of production + the cost of capital employed in new plant + marginal cost of transmission (which must include losses)+ the cost of capital employed in the new infrastructure. The price of power from a newly-constructed local wind farm compares well to this total when the true costs are reflected.

Unfortunately the current convention of charging flat rates for transmission does not facilitate savings on cost of capital required for infrastructure expansion, or on losses, by reflecting the true cost of transmission over long distances. A wind power generation project located in a remote area serving local demand saves the network a significantly greater amount than a wind farm located close to, and operating in direct competition with, a coal-fired power station. The savings can be demonstrated but unfortunately, for the wind farm to be able to benefit from the system savings, it will be necessary to create a charging mechanism that balances the inequality.

Over the past 20 years it has become normal global practice to compensate for disadvantages in the market by granting renewable energy generation certain privileges. State regulation provides support for the development of renewable energy and can be combined with international financial mechanisms such as the flexible mechanisms of the Kyoto Protocol. Regulation can ensure that the true value of wind energy is reflected in the incomes while Carbon Credits generated by a wind farm can be traded on international markets to provide a valuable additional income. However for the use of Kyoto Protocol mechanisms it is necessary for ratification by Kazakhstan.

It is not suggested that wind power should replace coal or gas-fired power generation. Wind is a complementary form of generation that adds additional value to a fossil fuel based generation system. A system without wind power may be reliant on large, centrally located, environmentally damaging power plant transmitting power over long distances. It is sensitive to world fossil fuel prices and to physical damage to the system. By including wind in the system, a degree of security is provided from fluctuations in fuel prices, physical security of the network is enhanced and cost effective power can be provided to outlying regions of the country.

Ecological aspects of wind energy development

Wind farms do not consume organic fuel and by this way do not emit to the atmosphere products of fuel combustion neither do they produce solid waste products. Each KW/h of energy from wind farms, which replaces energy from coal station, prevents harmful emissions to the atmosphere of sulfur oxides, nitrogen oxides, fly ash and greenhouse gases, as well as storing of ashes-slag waste products. The installation of a 500MW wind farm with yearly production of 1.5 million MW/h of energy will prevent yearly emissions to the atmosphere of:

- 1, 5 ml tons of GHG
- 12000 tons of sulfur oxide
- 7800 tons of nitrogen oxide
- 12 600 tons of fly ash

as well as of the dumping of 420 000 tonnes of bottom ash/slag material.

The down side to the development of windfarms includes the possible bird strikes. Research has shown the impact on birds is significantly less than that from collision with auto transport, buildings, constructions and others. Noise is insignificant and is mitigated by the installing turbines remote from habitation, at least 1km from the nearest dwelling.

Social aspects of wind energy development

The development of wind energy has the following social effects:

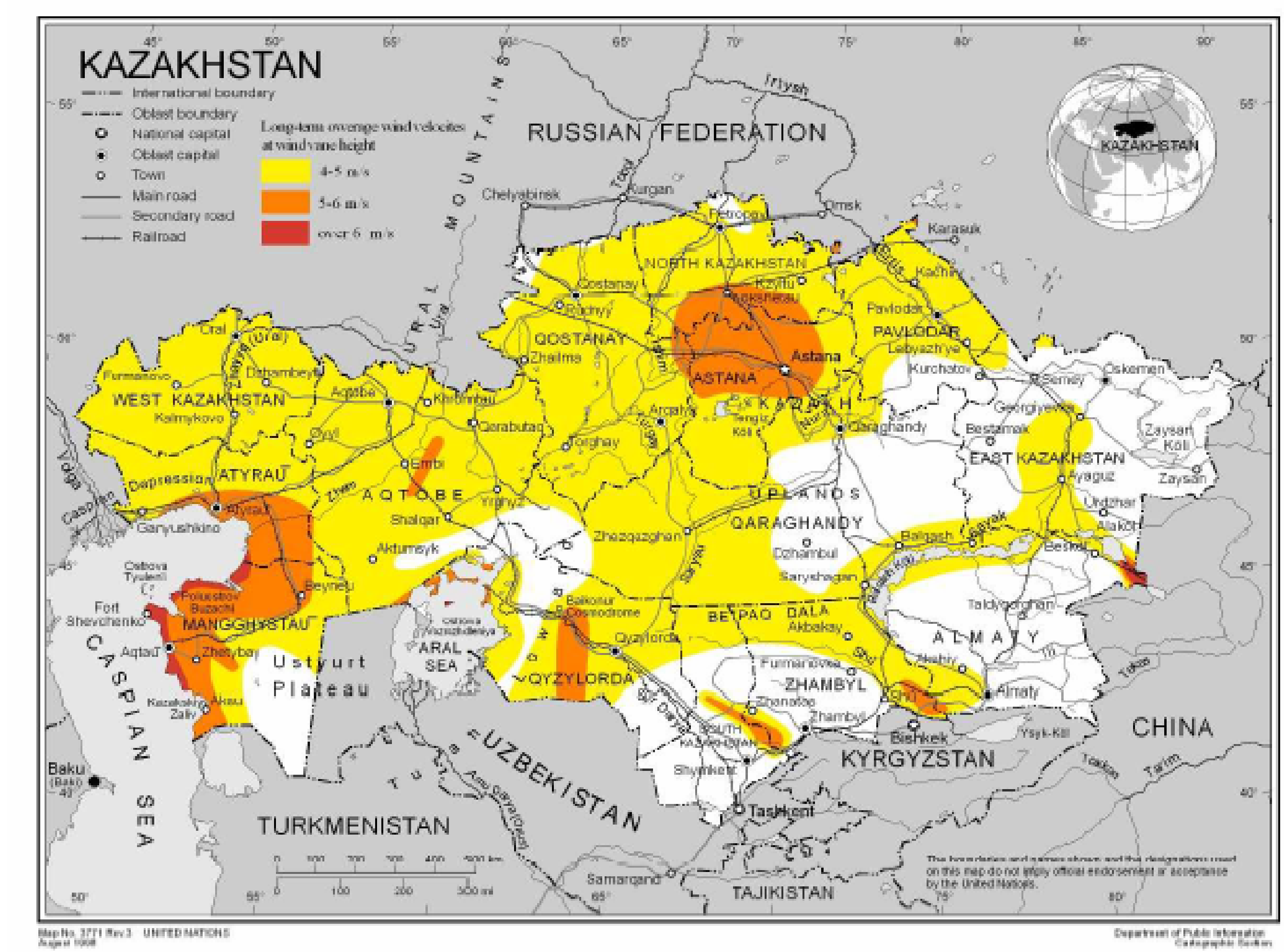
- creation of conditions for social and economical development in energy deficient regions and remote rural regions by the improvement of access to energy,
- contribution to the development of local industry, small and medium business and the creation of new jobs,
- contribution to country industrialization and the development of modern technologies, science and techniques.

Thus, Kazakhstan possesses significant energy resources such as fossil fuel, and has established a developed power industry, which secures energy consumption and covers power demands of the country for long term perspective. Yet, the analysis demonstrates the irrational use of energy resources. Kazakhstan's GDP proves to be a rather power-consuming one and significantly exceeds the corresponding indicators of the developed countries, causing decline in the economical competitiveness of the country. Mainly Kazakhstan relies on coal reserves for centralized power generation and transmission, and such state of affairs results in significant power losses and extensive environment contamination.

Kazakhstan possesses significant renewable energy resources primarily hydro and wind energy. Successful use of such renewable sources may provide local energy supplies and contribute to network security and stability, cost reduction and environmental preservation in long term prospective.

Kazakhstan is rich in wind energy resources and has big wind energy development potential. Meanwhile the power industry of Kazakhstan does not seem to apply this modern and highly-developing technology. One of the barriers is lack of the legislative and regulative support, which would take an account of the renewable energy benefits for the community within the market boundaries of the power industry.

Annex 1.



Wind atlas of Kazakhstan

Annex 2

The list of prospective sites for wind farms construction

№ п/п	Site name	Region	Average yearly wind speed as per meteo data m/sec	Recommended capacity of WF, MW
1	Zharminskaya	East-Kazakhstan	5,6	40,0
2	Yereimentau	Akmolinskaya	5,4	35,0 (20)
3	Seleyinskaya	Akmolinskaya	5,9	40,0 (20)
5	Stepnogorsk	Akmolinskaya	5,2	Not defined
6	Balkhash	Karagandinskaya	4,4	10,0
7	Yegindybulak	Karagandinskaya		Not defined
8	Karkaralinsk	Karagandinskaya	4,3	Not defined
9	Ulitau	Karagandinskaya		Not defined
10	Arkalyk	Kustanaiskaya	5,7	10,0
11	Sakryl	West-Kazakhstan	5,2	10,0
12	Atyrau	Atyrausskaya	4,4	40,0
13	Atyrau Karabotan	Atyrausskaya		Not defined
14	Akkystau	Atyrausskaya	5,5	50,0 (20)
15	Inder	Atyrausskaya	5,4	20,0
16	Prorva	Atyrausskaya	6,2	40,0 (20)
17	Fort-Shevchenko	Mangystausskaya	6,0	40 (20)
18	Sai-Utes	Mangystausskaya		Not defined
19	Kurdai	Zhambilskaya	5,1	20,0 (10)
21	Aralsk	Kyzylordinskaya	4,9	10,0
22	Karmakchinskaya	Kyzylordinskaya	5,5	20,0 (5)
23	Chayan	South-Kazakhstan	5,0	40,0 (20)
24	Sastobe	South-Kazakhstan		Not defined
25	Djungar Gates	Almatinskaya	7,5	50
26	Chylyk corridor	Almatinskaya	5,8	100