Wind Monitoring programme for Kazakhstan

Report

part I

Identification of potential interesting sites for further in-situ measurements

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A. Introduction

The Republic of Kazakhstan is undertaking a wind monitoring program, implemented by the UNDP with technical assistance of Energieteam as international contractor, to depict precisely the potential of wind energy in Kazakhstan for investors and wind park developers, locate the most interesting sites and provide Kazakhstan with a wind Atlas (50 meters).

At this time no large scale implementation has been realized in Kazakhstan except for one wind turbine in Djungar Gate and a 5 MW pilot project that should be built in 2006 in the same location. After a first study from Kazalenergo Project's engineers performed in June 2005, the Wind Monitoring Program is the first ambitious attempt to depict the potential of all Kazakhstan's territory for future wind park implementation.The program is divided into three parts and should normally end in July 2007.

The first part of the wind monitoring program deals with the location of sites offering interesting wind conditions for the production of energy and the selection of 6 to 10 of them for more detailed meteorological and technical potential assessment. First part also includes a precise description of the methods and work plan chosen to achieve the in-situ measurements and the Wind Atlas for delivery in July 2007.

B. Review of existing studies about wind ressource, and wind turbine potential implementation in Kazakhstan:

a. Overview of available documents and studies for the purpose of the present study

- ECN market study (1998) about conditions for potential development of remote and industrial wind energy in Kazakhstan
- Prospect study of Kazselenergoproject for potential location for wind parks
- WKN market study for all renewables in East Asia 2002
- Renewable energy country profile from European Bank for Reconstruction and Development (EBRD)_Chapter 14 dedicated to Kazakhstan.
- RISOE: Wind potential assessment for Djungar Gate and Chillik Corridor
- Study of the "fuel-energie Balance over 1990 and 2000 – 2003 periods" from Kazakhstan's ministry of energy statistics
- Energy Information Administration: International Energy Annual 2002
- Energy Sector Development Program until 2030.

b. Brief analyse and synthesis of available studies

a. The ECN's market study (1998):

This study was realized as a result of request of the Kazakhstan to get a market study for its energy sector financed for a part by the government of The Netherlands. As a condition for its financial support, the government of The Netherlands asked for a specific study focusing on the potential for wind energy in Kazakhstan.

This study gives a large overview of the energy market and energy production/consumption in Kazakhstan, pointing the difficulty of assessing precisely the former cost of electricity production, transport and distribution.

Actually, in Kazakhstan, investment, maintenance and replacement costs for the electricity production and transport structures are whether not known (for they were made by the USSR before 1989) or largely underestimate.

Furthermore, power plants now in service were mostly built during the 1960's, which means that the environmental criteria were much lower than today. It implicates that the oncoming necessity to replace the most part of country's power plant will automatically and strongly increase the cost of energy in Kazakhstan.

It also gives precise indications on the energy demand of the country in the next 10 years basing on the economical growth which started around 1995, following the crush of 1990.

Along this study, authors are identifying the technical and environmental interests of the wind energy in Kazakhstan but except for the electrification of insulate area, always have to recognize that wind energy is not economically relevant in a country producing fossil resources at a low cost if no inciting policy is led by the government.

Remark: As a market study this document is an overview of the legislation, of the economical and technological conditions in country but is not based on documentation usable to locate future wind parks or to assess the technical feasibility

of wind parks in such or such area. It is very interesting and well documented but not so helpful for the purpose of the present study.

b. Prospect study of Kazselenergoproject to locate potential sites for future wind parks:

Kazselenergoproject is a private company issued from the previous national organisation in charge with local distribution network in rural area.

In the prospect led by Kazselenergo Project, locations were chosen considering the following criteria:

- proximity of the electrical network,
- existing or previewed demand for electricity
- wind speed (see remarks about the study).

Some secondary criteria as Local geology, environmental sensibility have been taken into account but Kazselenergoproject's qualification for these secondary criteria is not proven and the resources used to back their opinion about these secondary criteria are not given in appendix nor even listed. Therefore, Energieteam considers that assessment made by Kaszlenergo project about these secondary criteria has to be considered carefully.

Considering the implication and experience of Kazselenergoproject in the conception of the national electrical network and power supply capacity, we regard their opinion about the existing and previewed demand for power supply as highly reliable.

Furthermore, the fact that people from Kazselenergo Project have been working all across Kazakhstan for outside building as electrical lines or sub-stations gives credit to their opinion on where are the most interesting sites for wind parks. Their report is the only one based on experience.

Remarks: Accuracy of wind speed assessment and coverage of wind speed data sources

- As a developer for substation of the Kazakh electrical network and to ensure their sub-station could resist to strong winds, Kazselenergoproject has systematically gathered wind speed data from the closest meteorological station from their own substations. But the point is that they only have wind data from location close to electrical sub-station. This is rather good but not enough for wind farms can also be built along electrical lines by building new small sub-stations under the existing lines.
- The distance between two substations in Kazakhstan is often over 50 km so the methodology used by Kazselenergoproject could let aside more interesting sites located between 110 kV (or more) substations.
- To assess the wind potential of a location, Kazselenergo Project uses coming from a time period going from 1966 to 1995 for the newest data. As a consequence, the average wind speeds used by Kazselenergoproject to estimate the intersest of a site are different from those from Kazgydromet.
- For a few location like Shajan (see average wind speed listed below), the difference between average wind speed supplied by Kazgydromet and Kazselenergo project is so important that it can not be explained by the difference of time period. Considering these unexplained difference, we have decided not to use average wind speed from Kazselenergo project's report for our site selection.

Location	At 10 m height		Difference %
	Kazselenergo_project (m/s)	Kazgydromet (m/s)	
Jarminski	5,6	5	11%
Erementau	5,3	5,4	-2%
Seletinsky	5,9	5,2	12%
Balkach	5,2	4,4	15%
Arkalik	5,5	5,7	-4%
Sakryl	5,2	3,6	31%
Atirau	5,5	4,4	20%
Aktau	5.5	4,4	20%
Inder	5,4	5,1	6%
Prorva	6,2	6,0	5%
Fort -Chevchenko	6,2	6	3%
Kurdai	5,9	5,5	7%
Aralsk	4,9	4,8	2%
Karmachinska	5,5	4,4	20%
Shajan	5	2,5	50%

These differences could be explained by local conditions of the meteorological station such as vegetation or building in the closeness of the stations but as Energieteam was not sent the demanded information about stations as photo, or short description of their situation, then data from Kazselenergo project had to be let aside for the writing of this report.

c. WKN market study for all renewables in East Asia 2002

This report is a brief market study dealing with the potential of Kazakhstan in the field of renewable energies but brings no additional information compared to the study from ECN.

d. Study of the "fuel-energie Balance over 1990 and 2000 – 2003 periods" from Kazakhstan's ministry of energy statistics

The all report has not been evaluated because the report deals with many subject not related to our purpose. Only statistics usable to assess the energy balance of each Oblast have been used. Energieteam can make no relevant comment on the content of the report.

e. RISOE: Wind potential assessment for Djungar Gate and Chillik Corridor

The result of RISOE's study for Djungar Gate and Chilik Corridor are going to be used as RAW data for the calculation of the Wind Atlas of Kazakhstan because they are much more reliable than any other source of meteorological information about wind speed in Kazakhstan. The only comment that Energieteam could make is that the report should have mentioned difficulties encountered during measurement campaign with frost.

C. Proposed methodology and criteria to locate interesting sites

a. Selected criteria and quotation system

The purpose of the report is to locate monitoring sites both as possible future energy stations and to provide information for a wind atlas. Considering the size of Kazakhstan and the situation of its energy market (see above), the choice of the locations that will be equipped with wind turbines must take into account other criteria than just average wind speed.

The economical interest of sites will be examined through three criteria: **Average wind speed** and **proximity to the electrical network**. The existence of an **electrical substation close** to the location shall also be considered as a positive factor for it lowers the implementation costs and allows the energy produced to be used partly by very close consumers at low tension level.

The technical interest of implementing wind parks in an area will be examined through the **energy balance** (production / consumption) of the area. This criterion could also be considered as sociological and economical because the unbalance of energy supply as many disadvantages:

It forces KEGOC and other managers of the electrical network to transport energy over long distances which causes loss of energy in the lines and difficulties to grant a stable tension and frequency of supplied electricity.

It sometimes causes power supply failure in remote area and even in industrial area (for example, industries installed in Fort Schevchenko are affected by unforeseen power supply failure). The cost of electricity supply failure is hard to assess but in a country with such an economical growth as Kazakhstan, it slows down the activity and could frighten investors who need the insurance that their investment will not be paralysed unexpectedly.

This balance has been assessed using results of the statistic agency of the republic of Kazakhstan for each Oblast. The numerical value used to compare Oblast was the percentages Import/needs _ Export/Needs.

b. Criteria let aside for quotation process

The environmental interest of implementing wind parks in an area was meant to be estimated by calculating the pollution that would be emitted to produce the same amount of energy using the current energy mix in the area. To that purpose we have defined 4 area (North, West, East and South), each using a different energy mix to produce its electricity (See Annexe for the characteristic of each area). But at the time of the completion of the report, not enough information had been gathered to allow an accurate assessment of the potential benefit of implementing wind parks for each Oblast. This criterion was not used to assess the interest of potential sites.

The impact of wind energy on the natural environment is known to be very limited compared to the environmental benefit but in some case, the implementation of wind turbines close to area where threatened birds species are nesting is not desirable. So cooperation with the Chokpak Ornithological station has been started to ensure that selected site are not in area where especially threatened birds nest.

The technical feasibility of building and maintaining a wind depends also from the meteorological conditions, especially frost, so this parameter will be taken into account at step 5 to ensure that selected sites can be accessed all along the years.

Raw data from close meteorological stations, including humidity level, will be used at step 5 to decide whether local conditions are acceptable or not for wind turbines.

c. Quotation rules: mark's spread and numerical function for each criterion

a. Average Wind speed:

To estimate the interest of an area at step 2 or of a specific site at step 4, we have two sources of information: data of the World Wind Atlas for the period 1994_2004, and wind speed and direction measured by 70 meteorological stations at 1 or 13 m over a longer period (generally 1966-2004). RAW data (see glossary) from these 70 stations were meant to be received and used for this report, but despite the efforts from UNDP's team and from Energieteam, they could not be delivered in time. That is why average wind speed have been used only when interesting locations were really close from the meteorological stations. In some cases, the closest meteorological was more than 50 km far and it would have been irrelevant to use it to assess a potentially interesting site.

When possible, it has been decided to use data from both sources and both were given the same weight for quotation.

Data from the WWA are calculated at 50 m which is approximately the hubs height of 1 MW wind tubines, whereas data from meteorological stations were measured at 10 m. So data from meteorological stations have been modified using a simple version of Hellman model: V50=V10^(50/10;Hellman exponent).

Mark for average wind speed= 2,5-(8-Ws50)/2 if Average wind speed<5,5.

The numerical function is linear and makes that the mark for average wind speed lays between]1,25 for 5,5 m/s; 3 for 9 m/s…] with a lower limit at 5,5 m/s at 50 m and without upper limit which means theoretically, the mark could be 3,5 for sites with 10 m/S at 50 m. This function makes that average wind speed is twice much important in the choice of sites than the other criteria which is logical considering the impact of half meter more wind speed on the profitability of a wind park.

b. Distance to the Network

The wind parks meant to be built in Kazakhstan and prospected in this study should be bigger than 25 MW. Such quantity of electricity can not be transported at low tension level for more than 15 km (for energy loss lower than 3%) and it is automatically far above the power demand at the 30 kV level so it has been decided that the connexion of previewed wind parks would be made at 110 kV.

The cost of an aerial electric line is around 20 000$/km/20 MW so the maximum cost of a 15 km long electrical line dispatching the production of a 25 MW wind park would be approximately 600 000 USD (two lines are needed for such power and distance). Compared to the cost of the wind turbines it is around 2% of the cost of the project.

It would have been possible to take into account potential sites up to 25 km far from the Network, that would have risen the cost of electrical lines up to 5 % of the amount

price (for the same 3% energy loss) but it was decided that only the most profitable sites had to be selected by this report. So a limit of 15 km was retained.

Mark for distance to the Network: =1,25-(Distance/60) if distance<=15

The numerical function is linear on the interval [0;15] and then equal to 0. The spread of the mark is [0=1,25; 15=1,0]. So Even a site located below a line can not be granted with more than 1,25 because we consider that this criterion affects only 3 % of the cost of the project and so should not be overestimated.

c. Electrical substation within 15 km from the site

If a wind park is connected to an existing electrical sub-station, then only reinforcement costs are to be expected because the infrastructure exists and only some additional equipment may have to be implemented. The cost of reinforcement is between 0 for sub-station with large available capacity to 100 000 USD / 25 MW for sub-station with no more available capacity.

In case a new sub-station is necessary then the minimum cost is around 600 000 USD for a small wind park of 10 MW, 1 Millions USD for 25 MW and 2,7 Millions USD for a 110 MW Wind park. 110 MW is the biggest power Energieteam had to build a sub-station for so we can not estimate the cost of a sub-station above this power.

As a consequence, the additional cost is between 6 % for small parks to less than 3% for big wind parks so the existence of an electrical sub-station within 15 km has been valued at the same level as the distance to the Network.

It is a binary function [1,25 if there is a sub-station; 1 if not].

d. Energy balance of the Oblast:

Basing on the data of the Statistics Agency of the Republic of Kazakhstan, Energieteam has assessed the percentage of energy imported of exported by each Oblast comparing to its needs.

Oblast	Need kTep	Production kTep	Import kTep	balance %
Kysylordinskaja	118,9	31	87,9	**74%**
Süd-kasachstanische	1093,6	348,9	744,7	**68%**
Akmolinskaja	414,5	140,1	274,4	**66%**
Gambylskaja	601,4	210,9	390,5	**65%**
Kostanaiskaja	1119,5	472,2	647,34	**58%**
Aktübinskaja	750,2	521,2	229	**31%**
Ost-kasachstanische	2423,2	1738,9	684,3	**28%**
Karagandinskaja	3671,1	3643,4	27,7	**1%**
West-kasachstanische	155,4	195	0	**-25%**
Mangystauskaja	677,7	865,1	0	**-28%**
Atyrauskaja	490,3	706	0	**-44%**
Nord-kasachstanische	312,1	537,7	0	**-72%**
Pavlodarskaja	3192,6	8492,8	0	**-166%**
Almaatinskaja	295,6	1492,9	0	**-405%**

Source: Bericht "Brenstoff-energie Balans für 1990 und 2000 - 2003"
Statistikagentur des Kasachstan, Almaty 2004

Balance= Import/Needs% if export =0; Balance= Export/Needs%

As written in the definition of retained criteria, the energy unbalance of Oblast can cause sociological, economical and even environmental consequences. It is hard to define the weight of such a criteria but it was decided that it would not be linear. UNDP and Energieteam have decided that an Oblast exporting energy should be slightly disadvantaged whether an Oblast importing energy should be significantly advantaged.

As a consequence, the numerical function giving mark for the energy balance criterion is composed of two different linear functions:

Energy balance mark=1+(%import/3,4) if Import>0; 1-(export/40,5) if import=0

The spread of marks is [0,9 for the most exporting oblast; 1,25 for the most importing oblast]

d. Methodology

a. Step 1: First calculation

Basing on:

- Data from the World Wind Atlas for Kazakhstan (or equivalent reliable source)
- 100 meters step topographical model from NASA
- Roughness length: 0,018 (steppe) for all in Kazakhstan
- Element size for calculation: 20*20 km
- Raw data (wind speed and direction) from Kazakh meteorological station over the same period were meant to be included, at least one per area from the World Wind Atlas but despite efforts from Energieteam and UNDP, it was not possible to get these data before the end of part I (Cf chapter “limits of part I report). Only average wind speeds from these stations were sent to Energieteam at the time of the writing of this report.

Energieteam will run with WASP (see glossary) a rough calculation of the wind potential in Kazakhstan. Energieteam will use the first calculation to list all areas corresponding to the criteria described above (electrical network proximity, apparent accessibility…) and whose average wind speed (for roughness length 0,018) is over 6,0 m/s at 50 m.

Considering that a first approach has been realized by Kazselenergo Project’s team to select site basing on their criteria, this list will automatically be added to the precedent one.

The map of 66 selected area after step 1 is shown in Annex 1.

b. Step 2: First quotation

Each of the selected area will be assessed and a mark given regarding a list of criteria (see criteria’s description and the spread of marks above).

Remark: Wind speed is given by two different sources, the World Wind Atlas and local meteorological station. Both are equally taken into account to give marks to

locations but when no station is available near the location, only wind speed from the WWA was used.

The best area after step 2 will be positioned on the map of Kazakhstan until minimum 10 different area from the World Wind Atlas are retained. The mean of this process is to avoid all selected sites to be in only two or three WWA areas (2,5°*2,5° in geographical coordinates, approximately 200*220 km).

c. Step 3: second calculation

In order to locate precisely the windiest sites in the 10 to 15 area previously selected, a more detailed calculation will be run. It must be made clear that sites selected made at step 1 and step 2 was only to determine which from the WWA's areas in Kazakhstan were the most interesting regarding wind potential. As elements used for step 3 calculation are different and much more precise than those used at step 1, it is likely that new site will appear that had been ignored at step 1. Regarding this, a new list of potential sites will be proposed using the results from step 3 calculation.

- World Wind Atlas for Kazakhstan (Time period 1995-2004),
- Element size: 5*5 km,
- Roughness model (relatively imprecise),
- NASA topographical model (10 m step between lines).
- Raw data (wind speed and direction) from Kazakh meteorological station over the same period were meant to be included, at least one per area from the World Wind Atlas but despite efforts from Energieteam and UNDP, it was not possible to get these data before the end of part I (Cf chapter "limits of part I report). Only average wind speeds from these stations were sent to Energieteam at the time of the writing of this report.

A brief comment will be written for each interesting area found on the result map of each of the 15 WWA areas, explaining the interest of the site and the reason why it has been retained for step 4 or let aside. Out the 15 area, a minimum of 24 sites will be selected for step 4, from as many different areas as possible.

d. Step 4: second quotation

Basing on the computation made at step 3, the most interesting sites will be listed and given marks once again regarding all criteria, including the result of Wasp calculation (step 3).

e. Step 5: Visit of the best ranked sites for final selection

The 10 to 12 best ranked sites after step 5 will have to be visited to check if the locations have the expected characteristics. The accessibility, characteristics of the soils, vegetation will also be assessed during the report. A brief report will be written for each site visited including the map (1/100 000) of the location, the road usable for transportation, the location of electrical grid and information gathered about icing phenomenon frequency, local temperature along the year…

At the end of step 5, the 8 most suitable sites for future large scale wind turbine implementation will be selected and the report sent to the manufacturer of mast so that he can choose anchors adapted to each site's soil.

D. Step I: Area selection

a. Description

To achieve this step, Kazakhstan had to be divided into 8 Regions (see annex 1) because of the limits of Wasp (maximum number of points per computation: 500 000 the software uses to perform the calculation).

At step I, the same legend has been given to all 8 regions result maps to ease the understanding of results and the comparison between sites from different regions. As a consequence, some parts of Kazakhstan have no colour in the map presented below. It means that the average wind speed for these sites is below 5 m/s and is of no interest for future wind parks.

a. Naming of the area selected at step 1:

Each selected area is given a name like **"Area I_1_6,5"** which means that this area is located in region I (near Almaty), is the first selected in this region, and that the calculated wind speed for this area is 6,5 m/s.

Remark on the area selection process: In mountain area (I, II, III, VIII), some windy sites have been deliberately let aside because their altitude was so high (above 1500 m) than obviously no wind park could be built in these locations.

b. Djungar Gate and Chilik Corridor:

These two specific sites have been let aside in this report because both are already selected for the implementation of the first 500 MW of wind energy in Kazakhstan. Furthermore they both (especially Djungar gate) benefits from a physical effect called Venturi effect that can not be computerized with WASP which increase locally the wind speed (See also the chapter: limits of methodology used).

So it is normal if wind speed calculated by WASP at step 1 and even 3 are below very local measured wind speed as Djungar Gate or Chilik Corridor.. Frequently this kind of effect can be anticipated by observing maps and wind main directions