IRENA CASE STUDY 2013
WIND ATLAS KAZAKHSTAN
I. NATIONAL CONTEXT

Kazakhstan is the world’s ninth largest country with over 2.7 million km² of varied terrain, which is equivalent to the whole of Western Europe. From a wind resource point of view, Kazakhstan is renowned to be one of the most appropriate countries in the world to develop wind energy. Previously there was no reliable wind data or maps, and no attempt to identify or assess the feasibility of prospective sites and regions for potential project locations. There was also no assessment of wind potential and integration of wind energy into the current power system. The absence of data was a major barrier for development and adoption of wind energy programmes and deterred investors from constructing wind farms in Kazakhstan.

To address this and other market barriers to commercial wind power development in Kazakhstan, in 1998 UNDP with financial support from the Global Environmental Facility (GEF) launched a project “Kazakhstan – Wind Power Market Development Initiative”. The project was implemented by the then Ministry of Energy and Mineral Resources (MEMR) — now the Ministry of Industry and New Technology (MINT) — of the Government of the Republic of Kazakhstan (RoK). The total cost of UNDP-GEF project was USD 2.5 million with roughly one third of the budget (USD 700 000) spent on development of a national wind atlas and the undertaking of a wind measurement programme in 15 locations across the country.

As a result of UNDP-GEF efforts, the Kazakhstan Wind Atlas has been created and published online (www.atlas.windenergy.kz). The Atlas gives long-term average wind speeds at 80 meters (m) above ground level at 9 km resolution for much of the country, and at 100 m resolution for 9 areas of particular interest. In addition, wind monitoring was conducted in 15 prospective sites and feasibility studies were prepared to facilitate investment decisions (See Table 1 and Figure 1).

THE MEASUREMENT PROGRAMME AND NATIONAL ATLAS.

The wind measurement programme in Kazakhstan has been conducted in stages.


• Site selection for pilot measurements were dictated by two primary considerations: a) both sites were located in areas facing high energy shortages.
increasing the need to explore alternative power sources) and b) information from the local hydro-meteorological service indicated the availability of good wind conditions.

- The study collected wind speed and direction measurements taken over one year from May 1998 to May 1999 at four meteorological masts in the centre of Djungar Gate and one mast in Chilik Gate. In addition, the global database NCEP/NCAR - reanalysis for 1965 - 1998 was used to assist in quantifying the year-on-year wind climate variations. Further, historical data from previous investigations were examined and compared with the present results. Five 32m masts were instrumented specifically for the wind study, but provided information on other climate statistics as well: atmospheric pressure, air temperature, air temperature gradient, atmospheric stability, wind speed profiles, extreme wind speeds, and wind gusts.

- The wind data from the five stations were analysed using the Wind Atlas Analysis and Application Program (WasP), following the procedures and guidelines of the European Wind Atlas. For all five stations, the accuracy of the wind speed measurements was verified by wind tunnel calibration using cup anemometers. The pilot study documents the existence of very high wind energy resources at both locations, with mean wind speeds and energy densities in the order of 7.5 ms\(^{-1}\) and 525 Wm\(^{-2}\) respectively, measured at a height of 10 m in Djungar Gate; the wind resource is comparable or better than that found over the North Sea to the north of Scotland. The wind resource in Chilik Corridor is somewhat lower but still substantial at 5.8 ms\(^{-1}\) and 240 Wm\(^{-2}\), respectively at the height of 10 m; this is comparable to a good open site in Northern Europe. The annual power productions from three different common wind turbines were estimated at the location of the meteorological masts. For example, a wind turbine with a rated power of 1 MW and a 50 m hub-height would produce approximately 4400 MWh (capacity factor of 50%) in Djungar Gate, which makes this location one of the best wind turbine sites in the world.

- This pilot wind measurement programme at Djungar and Chilik Gates was conducted by the Risø National Laboratory\(^1\), and Ministry of Energy and Natural Resources of Kazakhstan. Almaty Energy was responsible for planning, co-ordination, and assistance during installation and operation. Operation and maintenance of masts was ensured by MDE Consult Aps, Almaty Energy, and the UNDP-GEF Project team.

For further details about the pilot wind measurement study at Djungar and Chilik Gates, please see the technical report at www.windenergy.kz/files/1213683628_file.pdf.


- Each site recorded approximately 12 months data, collected from 50 m tubular monitoring towers. Wind speeds and directions were recorded at multiple levels (nominally 25 m and 50 m) by either Wilmers or Risoe instruments (all anemometers are calibrated to MEASNET standards) with ten minute averaged data recorded on Wilmers or Aanderaa data loggers. Generally, the monitoring sites were situated in regions of flat to undulating grasslands with minimal man-made or natural structures in the area.

- Data from each of the monitoring sites was collected monthly by UNDP-GEF project staff and verified by PB Power. The verification included the following steps:

  a) Any missing data was flagged and the date stamps of missing data noted, particularly because during the monitoring periods several of the Kazakhstan sites were affected by iced sensors (i.e. anemometers and vanes). PB examined the data for this effect and removed any data believed to be recorded while the instruments were influenced by ice.

\(^1\) Now Danish Technical University (DTU)
Time traces for each anemometer were analysed to show spurious or erroneous data;
- Direction traces and wind roses were analysed to highlight faulty vanes;
- Normalised wind speed plots were analysed for evidence of any tower sheltering effects.
- It should be noted that many of the sites exhibited a degree of tower sheltering on the side-mounted anemometers which were corrected by PB to closer reflect the ‘free stream’ wind speed;
- Diurnal plots of wind shear and wind shear plots binned by direction were analysed for occurrences of erroneous shear that may have been attributed to a malfunctioning anemometer.
- Diurnal average plots of wind speed were analysed to consider the profile of wind in the region of the monitoring tower;
- Wind speed and the direction frequency table were analysed to highlight any dominant wind regime at the site, and also helped to highlight spurious wind speed or directions being recorded.
- Verified wind data from each site was co-related with a long-term reference dataset to predict the expected wind resource at each site. Reference data was supplied by UNDP-GEF project from meteorological sites local to the site monitoring towers and also obtained from a re-analysis dataset by the National Centres for Environmental Predictions (NCEP - www.ncep.noaa.gov) and the National Centre for Atmospheric Research (NCAR - www.ncar.ucar.edu/). The reference site choice was dictated by the quality of the reference data and the strength of the correlation with the on-site data.
- As the upper level instruments at all of the sites were not at the selected hub-height, parametric wind shear analysis was performed on each long-term dataset to derive long-term hub-height wind data. The hub-height for the energy assessment was chosen by PB to be 80 m and the Vestas V82 1.65 MW turbine was used as a representative turbine type in the energy modelling across all eight sites. Wind turbine layouts were created by PB to provide an indicative energy assessment of the site. This generally resulted in nominal 40 MW layouts with 6 rotor diameter spacing, except for the Kordai site where site topography prevented this arrangement.
- In 2007 a decision was taken to expand the scope of measurement programme and add additional five sites across Kazakhstan. The sites were selected based on Kazakhstan Wind Atlas in consultation with MEMR and other stakeholders. UNDP-GEF project team carried out the measurement programme in 2008-2010 under the overall guidance and technical support from PB Power.
Development of Kazakhstan Wind Atlas was initiated in 2007 by UNDP-GEF project to visualise wind resource potential and combine wind measurements.

The wind atlas of Kazakhstan combines maps of long-term wind speed distribution from the territory of the Republic of Kazakhstan, administrative maps of Republic of Kazakhstan and maps of power infrastructure of the Republic of Kazakhstan. All cartographical information is presented in a pdf format.

The wind map represents a distribution of long-term wind speed at height of 80 m. The resolution of the wind map of whole territory of Kazakhstan is 9 km. There is a number of selected areas of Kazakhstan with the resolution of 10 ms (see Figure 1).

The wind atlas of Kazakhstan was prepared by UNDP-GEF and MEMR with technical support from PB Power and WindlabSytems (Australia); it employed WindScape software, anathospheric model designed to represent wind conditions at any point on the globe.

**KAZAKHSTAN WIND ATLAS**

- **IMPACT OF THE PROGRAMME**

  UNDP-GEF project has demonstrated that Kazakhstan has some of the world’s best conditions for wind energy development. Using its huge wind resources, Kazakhstan can meet its own energy needs, and could one day even become an exporter of clean and inexhaustible wind energy, directly and indirectly. Based on its practically infinite wind resources, the country could become a Eurasian hub, e.g. for energy intensive industries and for environmental friendly production of energy intensive products, made with wind". (Lettice, 2011)

  A study by Parsons Brinckerhoff, commissioned by UNDP-GEF Project during the preparation of the Kazakhstan Wind Atlas, showed that over 50,000 km² of territory across 9 of the country’s 14 oblasts had good wind resource (7 ms⁻¹-8 ms⁻¹) and that parts of the Almaty province contained areas of very good (8 ms⁻¹-9 ms⁻¹) and exceptional wind speeds (>9 ms⁻¹). The study estimates the potential wind resource in Kazakhstan to be in the region of 929 billion kWh per annum i.e. a wind energy capacity of 354 GW. This is 8 times greater than the current available power generating capacity.

Figure 1: Wind Map of Kazakhstan at 80 m and 9 km resolution. Source: www.atlas.windenergy.kz/
IMPACT OF THE KAZAKHSTAN NATIONAL WIND ATLAS AND MEASUREMENT PROGRAMME

Commercial wind farms will normally require on-site data monitoring and robust wind resource assessment (using long-term data and statistical techniques) for development. This work has been completed for 15 prospective wind farm sites in Kazakhstan with a combined potential installed capacity in excess of 500 MW.

The development and publication (www.atlas.windenergy.kz) of the Kazakhstan Wind Atlas was a very significant step in developing an active wind energy industry in Kazakhstan. It has allowed potential developers to access good quality resource information remotely. It has also allowed other stakeholders within Kazakhstan to easily view the location and magnitude of wind energy resources at a national level for the first time.

Wind data and findings of the wind measurement programme laid the basis for the development and subsequent adoption of the National Wind Power Development Programme and target. The objective of the Programme is to achieve a target of 750 million kWh of electricity generation from wind energy in Kazakhstan by 2015 and 5 billion kWh by 2030. This production figure equates to approximately 250 MW and 2000 MW of wind capacity respectively.

Further, the Law about the Support of Usage of Renewable Energy Sources (The RES Law) was adopted in 2009 following preparatory work by the MEMR and the UNDP-GEF. Its creation is a very significant achievement as it provides a legal foundation for developers to base commercial decisions and it further enhances the reputation of Kazakhstan as a country intent on developing its wind energy potential.

Given that there was no support in place for wind energy generation when the project began; there has been substantial progress in laying the groundwork for a robust wind energy market in Kazakhstan. The renewable energy law has opened the door to renewable energy development, while the completion of the wind atlas and the project feasibility studies has created a new set of transparent resources for prospective developers and investors. Finally, the focus on institutional capacity building within the government and among external stakeholders has put wind energy “on the map” institutionally and enabled the development of new administrative functions and processes. Wind development has now begun in Kazakhstan, with the first 1.5 MW commercial wind project commissioned in December, 2011, with a plan to expand this project to 10 MW by 2014. Another 45 MW project is under construction, and there are several other projects that are at advanced stages of development, including projects in Djungar and Chilik Gates.

For more information please visit www.windenergy.kz.