Kazakhstan's Potential for Wind and Concentrated Solar Power

JAQUELIN COCHRAN
Kazakhstan Institute of Management Economics and Strategic Research

Abstract: Kazakhstan is a country rich in natural resources—particularly oil, natural gas, and coal—but it should nevertheless diversify its energy supply to include non-carbon sources. Wind and concentrated solar thermal power are particularly well-suited to this country, which has one of the best wind sites in the world and the highest per capita solar insolation. Wind energy is already competitively priced with new coal plants, and concentrated solar thermal power, which can serve both base and peak loads, will soon be competitive with natural gas. Moreover the costs of both these energies are insulated from fluctuations in fuel prices and legislation that will restrict carbon emissions, providing a level of investment certainty unavailable with fossil fuels. Together, these technologies will allow Kazakhstan to drastically reduce its reliance on coal, and could actually position the country to become a clean energy exporter in a region with high energy demands but limited generating capacity.

Keywords: Kazakhstan, Wind, Concentrated Solar Power, Energy, Carbon, Climate Change

Introduction

Kazakhstan is a country rich in natural resources—particularly oil, natural gas, and coal—but it should nevertheless diversify its energy supply to include non-carbon sources. Not only is there an environmental imperative for this shift, there is also an economic rationale. National coal production has fallen due to both an increase in mining accidents and the declining economic viability of coal in Kazakhstan (Energy Information Administration (EIA) 2008). Moreover, coal-fired power plants in Kazakhstan lack flue gas treatment, and thus cause extensive regional air pollution (United Nations Development Program (UNDP) and Global Environment Facility (GEF) 2004). The production of oil and natural gas, while a boon for the economy, has also resulted in extensive environmental damage. All three of these resources contribute to global

climate change through the emission of carbon dioxide. As international efforts to cap or tax carbon begin to gain traction, substitutes for carbon-intensive energy sources will capture a greater market share.

As Kazakhstan's economy continues to grow, its energy needs will also expand. By channeling a portion of its considerable oil and natural gas revenues into clean energy production, Kazakhstan would be able to accomplish several related objectives. Not only would it diversify its own economy and lay the foundations for a sustainable energy future, but, in a region with growing energy demands and irregularly dispersed natural resources, Kazakhstan could take a leadership role in both providing and developing renewable energy. This can be accomplished by investing now in wind and concentrated solar power.

The Need for Carbon-free Energy

Kazakhstan produced 76.3 billion kilowatt-hours (kWh) of electricity in 2007 and consumed just over that amount, 76.4 billion kWh, 85% of which came from coal (CIA Factbook 2008). Due to aging Soviet transmission and distribution lines, electricity losses average 15% (EIA 2008), reaching 30% in remote areas (UNDP and GEF 2004). Moreover, the southern transmission network, which is not integrated with the coal-producing northern regions of Kazakhstan, lacks sufficient generation capacity and was thus required to import 4 billion kWh from Kyrgyzstan and Uzbekistan in 2007 (CIA Factbook 2008).

The Kazakhstan Electric Grid Operating Company predicted electricity shortages beginning in 2009 if new power plants are not built or existing plants repaired (Almaty City Government 2007). Already in January 2008, ten days of power cuts in Almaty resulted from demand exceeding both domestic and import capacity (Almaty City Government 2008). The estimated costs for building 1500 megawatts (MW) of new power plants and repairing old plants is $3.0 billion (EIA 2008).

In this environment of rising energy demand and limited generation capacity, Kazakhstan has indicated an interest in both diversifying its energy base and reducing its carbon dioxide emissions. To manage the development of renewable resources, the government created a

Renewable Power Agency within the Ministry of Energy (Renewable Energy and Energy Efficiency Partnership (REEEP) 2007). The Ministry of Energy has also joined forces with the United Nations Development Program (UNDP) and Global Environment Facility (GEF) to implement a pilot wind energy program (UNDP and GEF 2004). After ratifying the United Nations Framework Convention on Climate Change in 1995, Kazakhstan has taken further legislative steps to meet its goal of diversified energy and reduced carbon emissions, e.g., the 1999 legislation "Electricity Development Program until 2030" targets 500 MW of wind capacity (REEEP 2007).[1] Support has also come from the Union of Power Engineers, whose president, describing the accidents that occur in outdated power plants, has advocated investment in renewable energy (Tenelbaeva 2007).

Given this political and economic context, as well as Kazakhstan's geographical endowments, there are two natural choices for Kazakhstan to achieve its energy goals—wind turbines and concentrated solar thermal plants.

Wind Turbines

Wind energy is particularly promising in Kazakhstan at the Djungar Gate, 600 km northeast of Almaty and next to China's Xinjiang Uigur Autonomous Region, the province with the highest installed wind capacity in China (Lewis 2007). Annual wind speed velocities average 10 meters per second (m/s) at a hub height of 50-60 meters (Johannes 2005), providing the potential for 1000 MW of wind capacity (Energy Sector Management Assistance Programme (ESMAP) 1997). A year-long Danish study of wind speeds describes the Djungar Gate region as the "best wind climate in the world"—the turbines would operate at a full load for over half the year (Petersen 1999). Even closer to Almaty is the Chilik corridor, 100 km east of Almaty, where annual wind speeds average 5 m/s in summer and 9 m/s in winter, the season with greater electricity demand (ESMAP 1997). A study funded by the Renewable Energy and Energy Efficiency Partnership estimates that this region also has the potential for 1000 MW of wind capacity (Cherednichenko and Cherednichenko 2007).

[1] For further legislative examples, e.g., "2030 Program of Power Industry Development" and the "2005 Plan of Action." see: Almaty Government. (2006). "2020 General Plan of Almaty Development." Official Almaty City website. 17 October. http://www.almaty.kz/page.php?page_id=380&lang=2&id=1731 [Accessed 11 April 2008].

To cultivate Kazakhstan's wind capacity, UNDP and GEF invested in a 5 MW wind farm at Djungar Gate, currently in operation. Initial cost predictions were 3.5 to 5 cents/kWh, or slightly less if machinery and turbine parts were locally produced (UNDP and GEF 2004). Even if this cost estimate is unduly low, given the turbine shortages and rise in steel prices, it is nevertheless still comparable to the cost of a new coal-fired power plant (4-5 cents/kWh without a carbon tax) (Ibid). While Kazakhstan develops the infrastructure to produce wind turbines and associated equipment like cranes, the government can obtain these supplies from neighboring China. In addition to providing electricity to the local population, an existing high-voltage transmission line will enable power to be shared with both Almaty and exported to Xinjiang, where electricity demand grows 10% annually (Black & Veatch 2005).

Expanding wind capacity in just the Djungar Gate could generate up to 1.3 trillion kWh of electricity annually (Ibid). Kazakhstan has set a goal of building 500 MW of wind capacity by 2030, but this target is too small—by way of comparison, China's wind target is 30,000 MW by 2020. Kazakhstan should exploit its many other locations that are suitable for wind farms. For example, other high-velocity wind resources (above 5 m/s) include locations along the Caspian Sea and surrounding the capital Astana. More than 50% of the country has wind speeds of at least 4 m/s, which is a speed common to European wind farms (Ibid).

Kazakhstan should thus begin its transition to carbon free energy by focusing on wind in the southeastern region around Almaty, where both wind potential and energy demands are high. With the development of expertise in this region, wind power can then be introduced to the rest of Kazakhstan.

Concentrated Solar Thermal Plants

While wind turbines already provide competitively priced electricity, concentrated solar thermal plants have tremendous potential to help Kazakhstan diversify its energy sources while reducing its carbon dioxide emissions. Unlike solar photovoltaic panels, which convert sunlight to electricity using semiconducting materials, solar thermal plants use mirrors to concentrate sunlight on a liquid, often molten salt or oil. The heat absorbed by this liquid is then used to

produce steam. As in conventional fossil-fuel plants, this steam drives a turbine that generates electricity.

Two key advantages recommend the adoption of solar thermal over solar photovoltaic in Kazakhstan. First, the materials used to produce a solar thermal plant—steel, glass, and concrete—are domestically produced and readily available in Kazakhstan. In contrast, photovoltaic panels require high-cost semiconducting materials such as silicon. Second, solar thermal plants store energy in the form of heat, which is far more efficient than the batteries used in photovoltaic systems, and allows electricity to be produced on demand, even after the sun has set. A plant that can retain this heat for 16 hours—as some plants are designed to do—can thus serve both as a base load (replacing coal) and a peaking plant (replacing natural gas).

Solar thermal is also a compelling choice when compared to fossil fuels. Prices for solar thermal energy will soon be competitive with natural gas, but as global capacity expands, design improvements are expected to further increase efficiency and reduce costs to the range of 6-10 cents/kWh (Romm 2008). Moreover, because solar thermal plants use no fuel and emit no carbon, their costs are insulated from fluctuations in fuel prices and the impacts of carbon legislation. This provides a level of investment certainty unavailable with fossil fuels. Coal-based electricity prices may be cheaper at present, but this edge could be lost if carbon is taxed or capped.

Solar thermal also provides an excellent means for growing and diversifying the economy. Operations and maintenance of a 100 MW solar thermal plant generate 94 full-time positions—across a range of educational levels and skill sets—far more than the 56 positions for a comparable combined-cycle natural gas plant or 13 positions for a simple-cycle gas plant (Stoddard et al. 2006).

Kazakhstan is ideally situated to adopt solar thermal technology, receiving 2,200-3,000 hours of annual sunshine and an insolation (direct radiation from the sun) of 1,300-1,800 kWh/m^2/yr (ESMAP 1997). Because solar thermal plants do not require a source of water for cooling, they can be easily located in arid regions of Kazakhstan where solar incidence is high and population

is low. More than half of Kazakhstan is desert or semi-desert, so there is an almost unlimited range of possible locations. Especially promising areas are found near the Caspian oil fields—an arid region with a low population but a highly developed transportation and power transmission infrastructure.

Kazakhstan can thus use concentrated solar thermal in conjunction with wind energy to replace its coal-fired power plants. Although initial costs for introducing this technology to Kazakhstan will be significant, a wealth of both international and domestic financing is available through organizations such as UNDP, GEF, and Kazakhstan's National Innovation Fund (UNDP 2006).

Conclusion

Kazakhstan is in a position to both diversify its economy and meet its electricity needs by supporting the development of carbon-free energy. Wind and concentrated solar thermal are particularly well-suited to this country, which has the highest per capita solar insolation and one of the best wind sites in the world. In the near term, Kazakhstan should expand its existing wind program to meet the needs of the electricity-deficient but wind-rich southern region. From this base, wind technology can be introduced to other regions of Kazakhstan with favorable conditions. In the long term, the government should augment wind with concentrated solar thermal plants located throughout the Kazakh steppe. Together, these technologies will allow Kazakhstan to drastically reduce its reliance on coal, and could actually position the country to become a clean energy exporter.

To achieve these goals Kazakhstan should not limit itself to existing legislation, but should set an aggressive renewable portfolio standard that requires a significant percent of electricity to be generated from non-hydro renewable sources. To catalyze investment in these sources the government should offer concrete incentives—e.g., through the National Innovation Fund and investment tax credits—that will reduce the cost of developing these industries. Investment risk is further defrayed by Kazakhstan's great potential to become an exporter of both electricity and clean energy technology to neighboring countries with high energy demands but limited generating capacity.

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