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THE FEASIBILITY STUDY FOR THE ESTABLISHMENT OF A WIND POWER PLANT

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The article studies the issues of the application of Renewable Energy Source (RES) technologies for power generation on the basis of wind resources of Kazakhstan. The primary objective of this study is to evaluate the technical and economic viability of establishing wind power plants for electricity production. Throughout the research process, we computed the production program based on the region's wind resources and developed a financial model to assess the project's feasibility. Our findings affirm the effectiveness of RES, particularly wind energy technologies, in Kazakhstan. We determined that the project becomes economically viable when the selling price without VAT exceeds 24,53 tenge per kWh. Thus, the project itself can be recommended for implementation when the price exceeds the threshold level.

Keywords: wind, power, RES, investments, financial modeling.

INTRODUCTION

Kazakhstan boasts a vast reserve of wind energy, particularly notable in regions such as those adjacent to the Caspian Sea, steppes, and mountain gorges. Wind speeds reach up to 20-35 m/s during the spring and fall [1], with an estimated wind potential of 1 820 billion kWh [1]. Consequently, within the realm of renewable energy sources, wind energy emerges as a highly promising avenue for development in Kazakhstan.

The national energy system is divided into three territorial zones: Northern, Western, and Southern (Figure 1) [2]. The Northern zone encompasses hydroelectric power plants and coal-fired thermal power plants. The Western zone relies heavily on the abundant oil and gas reserves found in that region. In contrast, the Southern part lacks significant energy resources compared to the other zones and thus compensates for the shortfall by importing energy from them. The energy production breakdown is approximately as follows: 65 % of the total energy is generated in the Northern Zone, 20 % in the Southern Zone, and 15 % in the Western Zone [3].

Electricity generation in Kazakhstan is facilitated by 222 power plants under diverse forms of ownership. As of January 1, 2024, the total installed capacity of power plants in Kazakhstan stands at 24 641,9 MW, with an available capacity of 20 428,4 MW [4]. According to the Energy Capacity Balance Forecast for Kazakhstan until 2035, the Western zone is projected to continue experiencing energy deficits.

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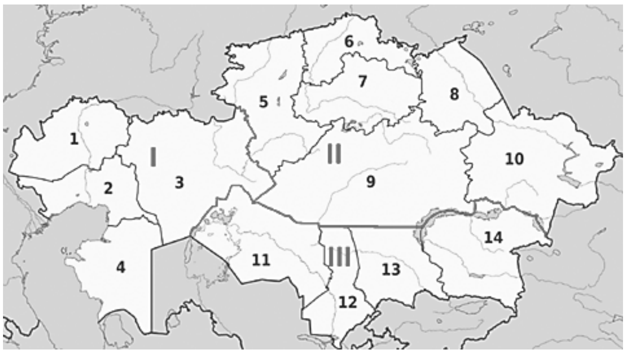

Figure 1 Energy-producing regions of Kazakhstan
I - Western zone, II - Northern zone,
III - Southern zone (4 - Mangistau oblast)

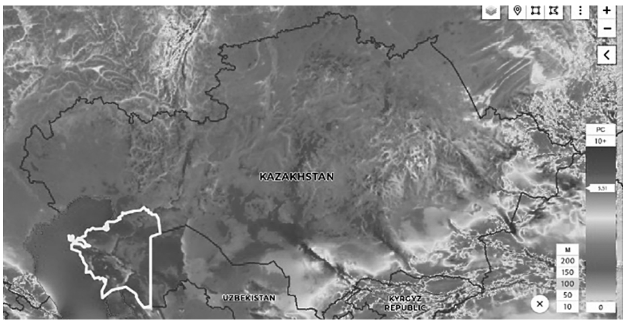

Figure 2 Wind Atlas of Kazakhstan for May 2, 2024
Average wind speed in Mangistau region
at a height of 100 m is 5,51 m/s

A study conducted by Parsons Brinckerhoff as part of the Wind Atlas of Kazakhstan Project [5] revealed promising wind resources in Kazakhstan. An area spanning over 50 000 square kilometers, traversing nine out of the country›s 14 oblasts, exhibits favorable wind speeds ranging from 7 to 8 m/s. Furthermore, certain areas boast very good wind speeds of 8 to 9 m/s, with exceptional speeds exceeding 9 m/s. Meanwhile, on May 2, 2024, the average wind speed in Mangistau Oblast at an altitude of 100 meters measured 5,51 m/s (Figure 2) [6].

GLOBAL TRENDS IN WIND ENERGY TECHNOLOGIES

Over the past decade, there have been significant advancements in onshore wind turbine technology. The development of larger and more reliable turbines, coupled with increased hub heights and rotor diameters, has led to notable improvements in performance factors.

Besides these technological advancements, the overall installation, operation, and maintenance (O&M) costs, as well as the levelized cost of energy (LCOEs), are decreasing due to economies of scale, heightened competitiveness, and the maturation of the sector. In 2021, the utilization of onshore wind power ranked second only to solar photovoltaic (PV) generation in terms of scale, with China retaining its position as the largest market, albeit with a slightly reduced share compared to 2020 [7].

The largest portion of the total installed cost of an onshore wind energy project is allocated to wind turbines, constituting between 64 % and 84 % of the total cost. Currently, nearly all onshore wind turbines are horizontal axis, with a predominant configuration of three blades positioned on the leeward side.

Turbines featuring larger rotor diameters enhance energy capture at sites with comparable wind speeds. Moreover, the prevalent adoption of higher hub heights enables access to stronger wind speeds within the same location. These advancements often result in substantially higher power output, given that power generation increases exponentially with wind speed. Additionally, the increased turbine capacity facilitates the development of larger projects and lowers the overall installed cost per unit for certain cost components, measured in megawatts.

Between 2010 and 2021, notable changes in average turbine capacity and rotor diameter have occurred in key onshore wind energy markets, with Brazil, Canada, China, and Germany leading the way. In these countries, the average rotor diameter and turbine capacity of newly commissioned projects surged by over 70 % during this timeframe. In terms of percentage increases, Brazil experienced the most significant rise in turbine capacity (121 %), trailed by Sweden (116 %) and Canada (108 %). Meanwhile, Canada led the way in rotor diameter growth (116 %), followed by China (91 %) and Brazil (80 %). By 2021, Canada boasted the highest turbine rating, while Vietnam claimed the distinction of having the largest turbine rotor diameter. Across the board, the average country-level turbine capacity ranged from 2,0 MW to 4,3 MW, with rotor diameters spanning from 99 m to 147 m.

Between 2010 and 2021, the weighted average global levelized cost of electricity generated by onshore wind (LCOE) plummeted by 68 %, dropping from $0,102/kWh to $0,033/kWh. Moreover, in 2021 alone, the LCOE saw a 15 % year-on-year decrease. Notably, in 2021, approximately 69 gigawatts (GW) of new onshore wind projects brought online boasted an LCOE lower than that of the least expensive new source of fossil-fueled electricity generation.

Between 2010 and 2021, the weighted average total installed cost of onshore wind power globally experienced a significant decline of 35 %, decreasing from $2,042 per kilowatt (kW) to $1,325/kW. In 2021, the weighted average total installed cost of onshore wind power varied by country/region, ranging from approximately $926/kW to $1 892/kW. Notably, China and India exhibited weighted average total installed costs that were 20-67 % lower compared to other regions.

In 2021, average onshore wind turbine prices ranged between $780/kW and $960/kW. Across most regions, prices had declined significantly from their peak levels in 2009, dropping by 48-62 %. Particularly noteworthy is China, where wind turbine prices plummeted by 84 % from their 1998 peak of $2 585/kW to an average of $425/kW by 2021.

Technological advancements have contributed to a substantial improvement in the global weighted average capacity factor of onshore wind power, which surged by nearly one-third, rising from 27 % in 2010 to 39 % in 2021.

TECHNICAL CHARACTERISTICS OF THE WIND TURBINE ACCORDING TO THE PROJECT

The selected product for the project is the Goldwind 171-6,25MW-HH105m wind turbine model, manufactured by Xinjiang Goldwind Science & Technology Co., Ltd., commonly known as Goldwind. Goldwind is a leading Chinese multinational wind turbine manufacturer headquartered in Beijing, China. Gold wind turbine model - 171-6,25MW-HH105m in a quantity of 12, providing a total hourly capacity of 75MW is considered to meet the needs of the project [8].

The Goldwind GW 171/6 250 turbine model has a rated capacity of 6,25 MW. It begins operating at a wind speed of 2,5 m/s and reaches its maximum operational speed at 24 m/s.

The Goldwind GW 171/6 250 turbine features a rotor diameter of 171 meters, providing a rotor area of 22,966 square meters. Equipped with three rotor blades, it utilizes a planetary gearbox with three stages. The generator, manufactured by Xinjiang Goldwind Science & Technology Co., Ltd., operates in permanent synchronous mode and is a single generator with a voltage of 950V. The mains frequency of the GW 171/6 250 turbine is 50 Hz.

The Goldwind GW 171/6 250 turbine utilizes steel tube/hybrid construction for its tower. Goldwind places particular emphasis on coating as a corrosion protection measure for the tower.

The Goldwind GW 171/6 250 turbine model has been available for sale since February 19, 2022.

THE ASSESSMENT OF ECONOMIC EFFICIENCY OF THE PROJECT

The project entails the construction of a wind power plant in Mangistau Oblast, where favorable wind speed conditions have been observed.

The capital investment required for constructing a 75 MWh wind power plant (WPP) is estimated at KZT 54,4 billion or approximately 120 million US dollars.

Annually, this WPP is projected to generate 259 MW of electricity. With a plant capacity factor of 38,3 %, the revenue from electricity sales upon reaching design capacity is estimated at approximately 7,5 billion tenge per year. The anticipated average annual net income stands at around 3 billion tenge, with an average profitability level of 46 %.

At an electricity sales price of 24,53 KZT/kWh or $0,053/kWh (excluding VAT), the net present value (NPV) for the calculation period reaches zero tenge. The internal rate of return (IRR) mirrors the discount rate at 11,5 %. Project-wise, the simple payback period (PBP) is projected at 11 years, while the discounted payback period (DPBP) extends to 28 years.

CONCLUSION

Based on the preliminary assessment of the investment project for electricity production from wind resources, it's evident that the project becomes financially viable when the sales price of electricity, excluding VAT, surpasses the threshold value of 24,53 tenge/kWh or $0,053/kWh. Therefore, it's advisable to proceed with the implementation of the project when electricity prices exceed this threshold level.

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Note: The responsible for English language is Dana Rahimbekova, Kazakhstan.