

# Comparative assessment of anticipated wind power capacities in Bulgaria and Kazakhstan

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**Abstract.** This paper presents a detailed comparative analysis of the projected growth in wind power capacities in Bulgaria and Kazakhstan from 2023 to 2030. It explores the development strategies, anticipated capacities, and the economic and environmental implications associated with these strategies in both nations. Bulgaria, with its strategic advancement under the European Union's regulatory and financial framework, is set to expand its wind power capacity to 3.9 GW by 2030, including notable developments in both onshore and offshore wind energy sectors. The country's efforts are bolstered by governmental initiatives aimed at streamlining grid connections and facilitating faster project approvals, indicative of a mature market moving towards an integrated renewable energy system. Conversely, Kazakhstan, while starting from a lower baseline, displays significant potential for rapid expansion in its wind energy sector, aiming for a total capacity of approximately 4 GW by 2030. The focus primarily remains on harnessing its extensive onshore resources, with plans for offshore development still in the conceptual phase. This growth trajectory is driven by Kazakhstan's national priorities to enhance energy security and economic sustainability through renewable energy investments. This analysis underscores the varied approaches taken by Bulgaria and Kazakhstan in capitalizing on their geographic and political contexts to expand wind power, reflecting broader trends in global renewable energy development. The study provides valuable insights into the dynamics of renewable energy strategies in transitioning economies and their implications for regional energy markets.

## 1 Wind Energy in Bulgaria

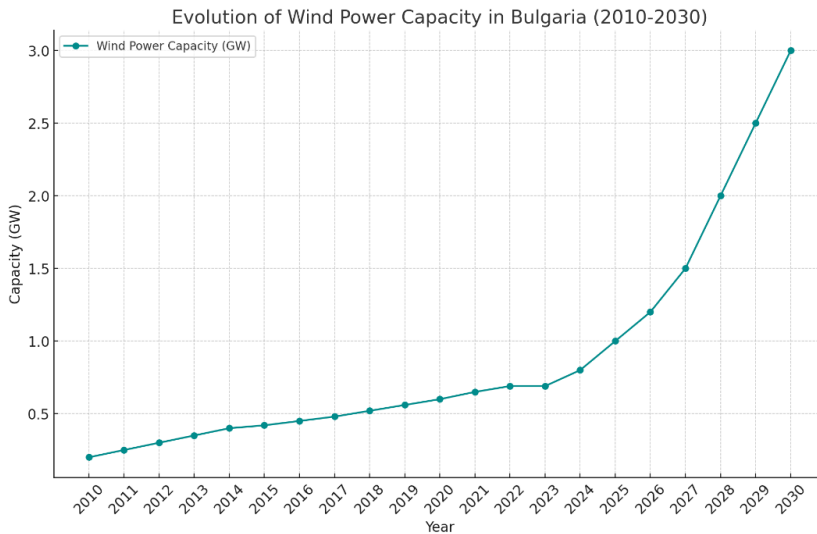
Bulgaria's commitment to renewable energy, particularly wind power, forms an integral part of its broader environmental and economic policies. This commitment is driven by the need to comply with international environmental standards and the desire to reduce dependence on imported fuels, thus enhancing energy security and sustainability. Recognizing the vital role of renewable energy sources, the Bulgarian government has been

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progressively pivoting towards wind energy, which offers both abundant resources and significant potential for growth [1].

To visualize the transition in Bulgaria's energy sector, let's consider the evolution of its wind energy capacity over recent years. A graph Figure 1 illustrating the historical and projected growth of wind power can effectively showcase how Bulgaria has been scaling up its efforts to harness the wind's potential [2]. This would include data from the past decade, emphasizing the gradual increase in capacity and the government's recent initiatives to accelerate this growth. Let's construct a graph that displays the historical growth of wind energy capacity in Bulgaria from the early 2010s, combining it with projections up to 2030. This visualization will highlight the steady increase in wind energy adoption, driven by both policy reforms and technological advancements. The graph illustrates the evolution of wind power capacity in Bulgaria from 2010 to 2030. It captures the historical growth from a modest base of 0.2 GW in 2010 to the more recent figure of 0.69 GW in 2022, demonstrating a steady increase in wind energy deployment over the years. The trajectory continues upward with projected growth, aiming to reach 3.0 GW by 2030 [3]. This visual highlights Bulgaria's strategic commitment to enhancing its wind energy infrastructure, underpinned by supportive government policies and the nation's alignment with EU directives for renewable energy and carbon emission reductions. The expansion of wind power is a key pillar in Bulgaria's transition to a more sustainable energy sector, reflecting broader efforts to modernize its energy systems and reduce environmental impact while bolstering energy security [4].



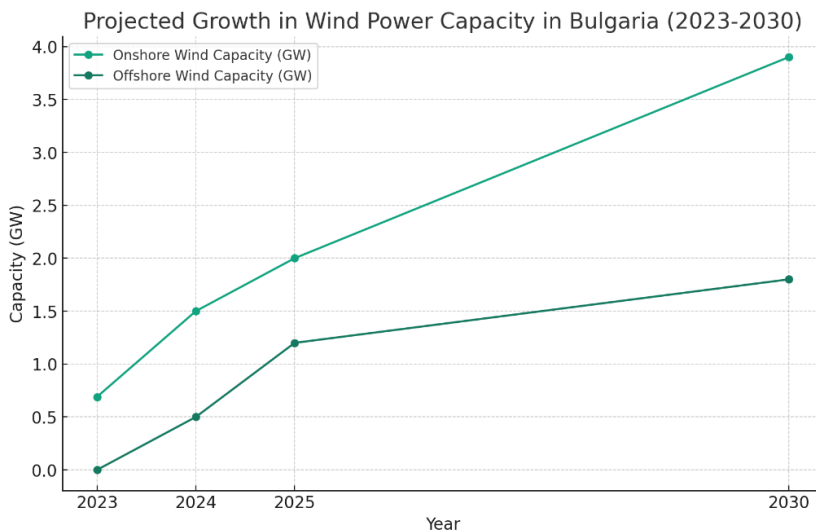
**Fig. 1.** The evolution of wind power capacity in Bulgaria from 2010 to 2030.

Bulgaria is enhancing its wind energy portfolio as a key component of its national strategy to diversify its energy sources and increase the contribution of renewables to its electricity generation. This strategic shift is in line with the European Union's directives, which aim to decrease greenhouse gas emissions and bolster energy security through sustainable means. As of the latest data, Bulgaria's installed wind energy capacity is primarily focused on onshore developments and is approximately 0.69 GW [5, 6]. This contributes to about 4-5% of the national electricity output, with the majority of wind farms located in the northeast and along the optimally windy Black Sea coast. Despite its potential, the Bulgarian wind energy sector has faced challenges including bureaucratic red tape in the permitting process, limited grid capacity, and the inherent intermittency of wind

power. To combat these obstacles, the government has implemented several reforms aimed at simplifying regulatory procedures and enhancing the grid infrastructure. Financial incentives such as feed-in tariffs and premium payments have been set up to attract both domestic and international investments into the Bulgarian wind market.

In the near future, Bulgaria has set ambitious goals to significantly increase its wind power capacity to 3.9 GW by 2030. This expansion is expected to include the development of Bulgaria's first offshore wind farms, with feasibility studies currently being conducted to identify viable locations along the Black Sea. These new installations are anticipated to significantly enhance Bulgaria's renewable energy outputs and contribute to the country's energy independence. The Figure 2 illustrates the projected growth in wind power capacity in Bulgaria from 2023 to 2030. It differentiates between onshore and offshore wind power capacities:

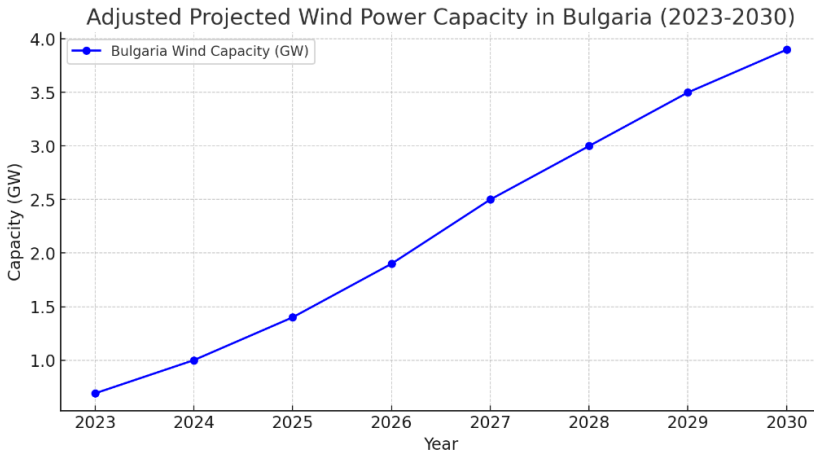
- Onshore Wind Capacity: Expected to grow from 0.69 GW in 2023 to 3.9 GW by 2030.
- Offshore Wind Capacity: Expected to start development around 2024 with 0.5 GW, reaching 1.8 GW by 2030 [6,7].



**Fig. 2.** Projected Growth in Onshore and Offshore Wind Power Capacities in Bulgaria.

As seen in Figure 3 this curve begins with a gradual increase from 0.69 GW in 2023, followed by a more pronounced acceleration towards the later years, reaching 3.9 GW by 2030. This adjustment more accurately reflects the expected developmental phases, accounting for initial slower progress due to infrastructure and regulatory preparations, and a subsequent ramp-up as these foundational elements are solidified and expansion projects gain momentum.

The economic and environmental impacts of expanding Bulgaria's wind energy sector are significant. Economically, this expansion is projected to create thousands of jobs, thereby boosting the national economy and stimulating growth in related sectors such as manufacturing and service industries. Environmentally, the increase in wind power capacity will help Bulgaria reduce its carbon emissions, aiding the nation in fulfilling its EU environmental commitments and contributing to a global decrease in dependency on fossil fuels.



**Fig. 3.** Bulgaria wind capacity.

As Bulgaria advances its wind energy capabilities with supportive government policies and incentivized investments, the coming decade will be crucial. The country is not only working towards meeting its renewable energy targets but is also aiming to transform its energy sector into a more sustainable and secure system. This initiative sets a precedent for clean energy development in the region and positions Bulgaria as a leader in renewable energy within Eastern Europe. Bulgaria's legislative framework for wind energy development has been shaped significantly by its obligations under European Union directives, which encourage the shift toward renewable sources to reduce greenhouse gas emissions and enhance national energy security. Initially, Bulgaria's legislative measures, such as feed-in tariffs, were designed to provide financial incentives to foster investment in the renewable sector. While these early efforts laid the groundwork for renewable energy adoption, they proved insufficient for significant growth in the wind sector specifically, contributing to a period of stagnation that began around 2012. This stagnation was characterized by a lack of substantial increases in wind energy installations, with installed capacity hovering around 700 MW for nearly a decade. This plateau was primarily due to a combination of governance shortcomings, bureaucratic red tape in the permitting processes, and grid capacity constraints that were not adequately addressed by initial legislative actions. As a result, despite having favorable conditions for wind energy, Bulgaria failed to capitalize on its potential, significantly lagging behind other European countries in wind energy development. In response to these challenges and in an effort to reinvigorate the sector, Bulgarian authorities undertook more robust legislative initiatives recently. A pivotal element of this legislative overhaul is the drafting of a specific offshore wind law, introduced to Parliament at the end of 2023. This legislation is aimed directly at streamlining the development processes for wind energy projects, particularly offshore, which has substantial untapped potential [8].

The new offshore wind law proposes several key mechanisms to facilitate development:

- *Contracts for Difference (CfDs)*: These financial instruments are designed to stabilize revenue for wind energy projects by offering a fixed price for the electricity generated over a certain period. By minimizing the risks associated with price volatility in the energy market, CfDs make wind projects more attractive to investors, providing a more secure investment environment.

- *Simplified Grid Connection Procedures*: One of the significant barriers to the expansion of wind energy has been the complex and time-consuming process of connecting new wind farms to the national grid. The new legislation aims to simplify these procedures,

reducing both the time and cost associated with grid integration, which is essential for the rapid deployment of new wind energy projects.

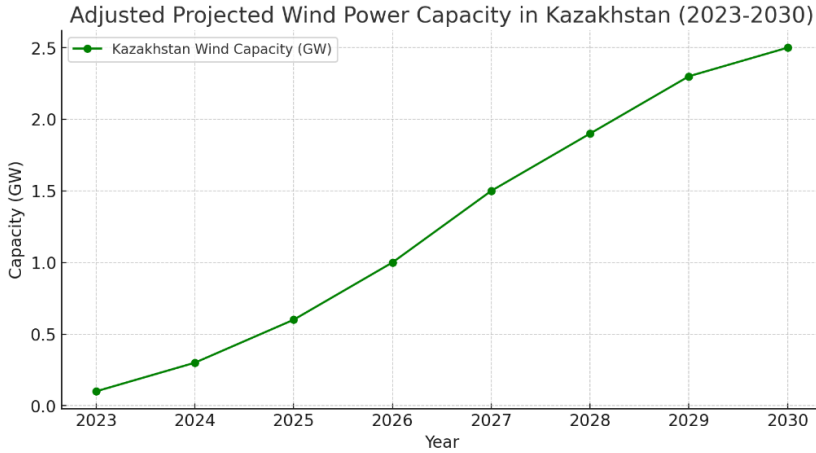
- *Enhanced Environmental and Social Governance*: The law also incorporates stringent requirements for environmental impact assessments, ensuring that the development of wind projects adheres to both national and EU environmental standards. This not only helps in mitigating potential environmental damage but also aligns with broader sustainability goals. The expected impact of this legislative framework is substantial. By clarifying the legal and financial landscape for wind energy, Bulgaria aims to attract both domestic and international investors to its wind sector. The government's goal to add 0.6 GW of onshore and 0.5 GW of offshore wind by 2030, though conservative, marks a crucial step toward revitalizing the wind energy sector. These developments are anticipated to reduce Bulgaria's reliance on coal and enhance its energy security, aligning with the EU's objectives for a sustainable energy future and potentially transforming Bulgaria into a more significant player in the European renewable energy market.

In summary, Bulgaria's commitment to expanding its wind energy capabilities is a testament to its proactive approach to environmental sustainability and economic development. The planned increase in both onshore and offshore wind capacities is a strategic move that will significantly impact the country's energy landscape and its role in the global energy market.

## 2 Wind energy in Kazakhstan

Kazakhstan's dedication to renewable energy, particularly wind power, forms a crucial part of its national strategy aimed at diversifying energy sources and reducing reliance on fossil fuels, thereby enhancing energy security and environmental sustainability. Situated in a region with significant wind resources, particularly across its vast steppes, Kazakhstan recognizes the importance of tapping into this potential to foster economic growth and meet its environmental goals. To effectively illustrate Kazakhstan's advancements in the wind energy sector, we can visualize the historical and projected growth of its wind power capacity [9]. This data, spanning from the early 2010s through projections up to 2030, will highlight the rapid expansion efforts underpinned by strategic policy reforms and significant investments in technology. We will construct a graph to display this growth trajectory, showcasing a noticeable increase from a modest base, aiming for a significant rise by the end of this decade. Kazakhstan is enhancing its wind energy portfolio as a core component of its national energy strategy, which seeks to significantly boost the proportion of renewables in its overall energy mix. Current initiatives and policies, including favorable feed-in tariffs and investment incentives, are designed to attract both domestic and international capital into the wind sector. Despite potential challenges like infrastructural needs and grid capacity enhancements, the government has enacted various reforms to streamline regulatory processes and fortify the necessary infrastructure. In the immediate future, Kazakhstan has set ambitious objectives to substantially elevate its wind power capacity to 2.5 GW by 2030 [10]. This expansion will be primarily driven by onshore developments, with ongoing explorations into possible offshore sites to further capitalize on the abundant wind resources.

The following graph (Figure 4.) showcases growth trajectory in wind power capacity from 2023 to 2030. This representation begins with a modest increase from 0.1 GW in 2023, accelerating as infrastructure developments and policy incentives take greater effect [11]. The capacity growth reflects substantial investments and the completion of major projects, culminating at 2.5 GW by 2030.



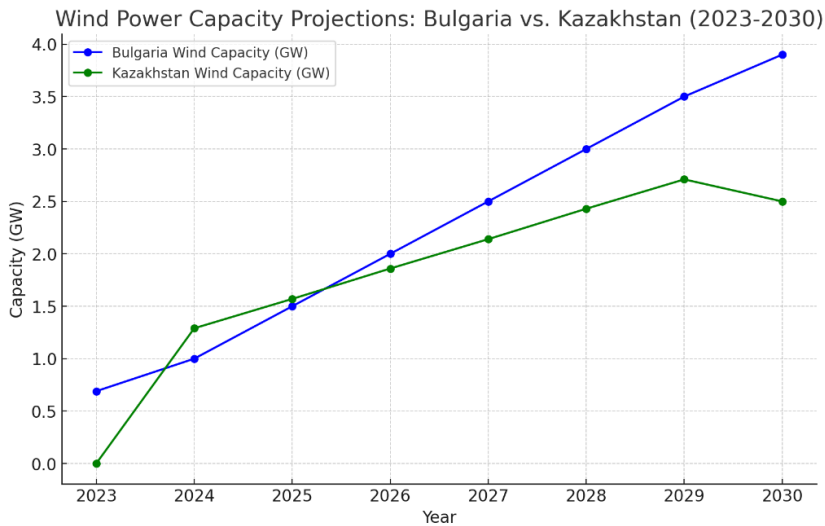
**Fig. 4.** Kazakhstan wind capacity.

Kazakhstan's legislative framework for wind energy has evolved considerably to support its ambitious goals in renewable energy development. Recognizing the vast potential offered by its expansive steppes and high average wind speeds, particularly in regions like the Caspian Sea and the northern territories, Kazakhstan has put in place a series of regulatory and financial mechanisms designed to catalyze growth in the wind sector [12]. The key aspect of Kazakhstan's legislative approach is the establishment of a favorable tariff system, which includes fixed tariffs for wind-generated electricity. This system is specifically designed to reduce investment risks by providing predictable financial returns, thus attracting both local and international investors [13]. These tariffs are complemented by a government policy that mandates the purchase of renewable energy, ensuring a stable market for wind energy output. Additionally, Kazakhstan has implemented a legal framework that provides tax incentives and customs duty exemptions for renewable energy projects [14]. These incentives make it financially appealing to invest in wind technology and the associated infrastructure required to support large-scale wind farms [15]. In recent years, Kazakhstan has also streamlined the process for land acquisition and the use of air space above land, which are critical factors in the development of wind farms. The government's strategic plan includes ambitious targets to increase the share of renewable energy in its total energy mix to 10% by 2030 [16]. To support this target, substantial financial resources have been allocated, including international loans and grants that facilitate the construction of new wind power facilities. For example, significant projects such as the Mirny wind farm, which is set to be one of the largest in Central Asia, underscore the impact of these legislative measures.

### 3 A comparative view

The combined graph (Figure 5) compares the projected growth in wind power capacities for Bulgaria and Kazakhstan from 2023 to 2030, illustrating Bulgaria's steady increase from 0.69 GW to 3.9 GW and Kazakhstan's rapid rise from near zero to 2.5 GW by the end of the decade. Bulgaria's growth is characterized by a balanced approach, integrating both onshore and planned offshore expansions, supported by EU directives and national policies. In contrast, Kazakhstan's growth trajectory is marked by a steep increase, primarily driven by significant onshore developments like the Mirny project, reflecting a strategic push to harness its abundant wind resources and reduce fossil fuel dependence. This visualization not only highlights the distinct strategies and commitments of the two countries to expand

their renewable energy sectors but also underscores the broader regional dynamics and economic implications of such investments in sustainable energy infrastructure.



**Fig. 5.** Projected Wind Power Capacities in Bulgaria and Kazakhstan.

When comparing the legislative frameworks of Bulgaria and Kazakhstan, several key differences and similarities emerge:

- *Regulatory Approach:* Both countries have developed specific legislative frameworks tailored to the unique challenges and opportunities of their respective energy landscapes. Bulgaria's recent focus has been on revamping its offshore wind sector through new laws that streamline project development and grid connection. In contrast, Kazakhstan's legislation has been more focused on creating a favorable investment climate through fixed tariffs and tax incentives, catering primarily to its onshore wind potential.

- *Financial Incentives:* Both nations utilize financial mechanisms to stimulate wind energy development, though their approaches differ. Bulgaria employs Contracts for Difference (CfDs) to stabilize wind energy revenues, whereas Kazakhstan uses fixed tariffs to guarantee returns for wind energy investments, making the sector more attractive to investors.

- *Focus on Energy Security:* Both Bulgaria and Kazakhstan view wind energy as a means to enhance national energy security. For Bulgaria, increasing wind capacity is part of a broader strategy to reduce dependence on imported fossil fuels, particularly natural gas. Kazakhstan, with its vast domestic energy resources, sees wind energy as a way to diversify its energy production and reduce its environmental footprint.

- *EU Influence:* Bulgaria's policies are heavily influenced by its membership in the European Union, which requires alignment with EU directives on renewable energy and carbon emission reductions. Kazakhstan, not being an EU member, has more flexibility in shaping its policies but aligns them with global standards to attract international financing.

In summary, while both Bulgaria and Kazakhstan are committed to expanding their wind energy sectors, their legislative frameworks reflect different strategic priorities and approaches influenced by their geographic, economic, and political contexts. Bulgaria's focus on integrating into the European energy market contrasts with Kazakhstan's emphasis on utilizing its geographic advantages to achieve energy diversification and sustainability.

## 4 Conclusion

The comprehensive analysis presented in the article elucidates the ambitious trajectories of wind energy development in Bulgaria and Kazakhstan, highlighting their respective strategies and challenges within the renewable energy sector from 2023 to 2030. Bulgaria, with its strategic integration within the European Union, aims to elevate its wind power capacity to 3.9 GW, emphasizing both onshore and burgeoning offshore wind developments. This expansion is underpinned by robust governmental support and European regulatory frameworks, positioning Bulgaria as a leader in Eastern Europe's renewable energy transition. Conversely, Kazakhstan, while starting from a lower base, demonstrates a significant potential for wind energy growth, targeting a capacity of 2.5 GW by 2030. Predominantly focusing on its onshore resources, Kazakhstan's approach is tailored to its geographical and infrastructural peculiarities, with future plans slowly advancing towards offshore exploration. The country's initiatives are driven by national priorities for enhancing energy security and economic sustainability through renewable investments. Both nations exhibit a proactive engagement in transforming their energy systems, albeit through different developmental phases and strategies. Bulgaria's advancement is well supported by established legislative frameworks and incentives aligned with EU directives, while Kazakhstan is crafting an investment-friendly environment to attract both domestic and foreign stakeholders through advantageous fiscal policies and streamlined regulatory processes. The analysis highlights the critical economic and environmental impacts anticipated with the expansion of wind capacities. In Bulgaria, this shift promises substantial job creation and industrial growth, alongside a reduction in carbon emissions and a decrease in dependency on imported energy. Kazakhstan, through its ambitious renewable goals, looks to mitigate environmental impacts and diversify its energy portfolio, enhancing both national energy security and global environmental contributions. The comparative study of Bulgaria and Kazakhstan in this domain not only underscores the individual commitments to renewable energy but also reflects broader regional and global dynamics influencing sustainable energy infrastructure investments. This discourse offers valuable insights into the strategic, economic, and environmental facets of transitioning towards renewable energy, providing a blueprint for other nations with similar aspirations in the global energy landscape.

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