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BARRIERS TO THE IMPLEMENTATION OF WIND POWER IN THE ENERGY SYSTEM OF UKRAINE

Bachelor Thesis

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I have written this Bachelor Thesis independently. Any ideas or data taken from other authors or other sources have been fully referenced.

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Introduction

Renewable energy production significantly boosts economic growth in developed and developing countries (Singh et al., 2019). Renewable energy sources, including wind energy, are domestic, clean, and can decrease reliance on fossil fuels (Demirbaş, 2006). Adopting renewable energy sources, such as wind power, offers the dual benefits of enhancing national energy security and mitigating the adverse effects of climate change. Wind energy offers national energy security and a flexible, eco-friendly alternative at a time when the world's diminishing fossil fuel sources pose a threat to the long-term viability of the global economy (Joselin Herbert et al., 2007). Investing in turbines can be profitable due to technological advancements, which may also improve a country's overall GDP (Mohtasham, 2015). Additionally, it can open new markets, allowing a country to export domestically produced energy (Steffen et al., 2018). This change is not only economically necessary but also morally significant for the global community. Therefore, countries should consider implementing renewable energy solutions to enhance economic growth, reduce dependence on fossil fuels, and increase energy security.

Fossil fuels, such as oil, coal, and natural gas, are the primary sources of energy worldwide; however, they have significant environmental impacts (Balat, 2007). The main problem with using these resources is their limited availability and the high demand for them, which makes their extraction expensive and environmentally damaging (Mohtasham, 2015). Additionally, reliance on fossil fuels can make one country dependent on others and serve as a tool for establishing authoritarian regimes and manipulating global politics. On the other hand, transitioning to renewable energy creates opportunities to rethink democracy and global justice. (Mitchell, 2009) The energy sector is not only a crucial component of daily activities but also a powerful instrument of political influence. On the other hand, renewable energy offers the potential for energy independence, democratic governance, and global equality.

Wind energy is considered one of the most sustainable renewable energy sources because it requires minimal water consumption, produces low greenhouse gas emissions, has favorable social impacts, and lowers electricity costs (Kumar, 2020; Yousefi et al., 2019). On the other hand, the disadvantages include landscape constraints, such as forests and protected areas (Hajto et al., 2017). Society may also reject this form of energy due to the noise and connectivity issues it causes (Caporale et al., 2020). Regarding environmental impact, wind turbines can harm or disrupt migratory birds (Kumar et al., 2012).

Wind energy is suitable for Ukraine due to the country's significant wind energy potential (Antoniuk et al., 2022). Ukraine borders the Black Sea and the Sea of Azov and has

a coastline with a length of 2,700 km. According to Onea & Rusu (2014), this gives the country the potential to implement wind energy installations, as wind speeds are more substantial, consistent, and significant in coastal regions, with shallow water depths suitable for installations. For the country, wind energy represents a unique chance to increase energy sustainability while lowering reliance on foreign fuels.

Ukraine has made significant progress in the field of renewable energy in recent years, including decentralized energy solutions disconnected from the central grid, the deployment of biomass and solar energy, and regulatory improvements such as green tariffs and simplified permitting processes (Bashynska, 2020; Shahini et al., 2024). The government prioritizes the development of renewable energy sources (RES) due to their potential to reduce dependency on natural gas and enhance energy security (International Energy Agency, n.d.).

Despite Ukraine's favorable environment and advantages for implementing renewable energy solutions, the country faces some challenges. Several barriers hinder the growth of wind energy in Ukraine, including a misalignment between commitments to renewable energy and ongoing support for outdated nuclear infrastructure (Trachuk, 2023). Despite wind energy contributing the largest share of new renewable capacities in 2022, its overall share in the country's energy system remains small (Trachuk, 2023). In 2020, renewable energy sources (RES) accounted for 11% of final energy consumption in Ukraine, an increase of almost 7% from 2014 (Statista, 2021). Notably, in 2020, the share of wind and solar energy sources in electricity production in Ukraine was 3.1%, compared to 1% in 2015, showing a significant increase. However, this capacity is still four times lower than Poland's share. (Kuzior et al., 2021) Slow development of wind projects, a lack of a stable legal framework, and inadequate financial and policy support further complicate progress (Nykyruy et al., 2020; Trachuk, 2023; Wisz et al., 2018). Additionally, integration into the energy grid, the need for improved infrastructure such as energy storage and hybrid renewable solutions (Trachuk, 2023) and the gap between research and implementation create further obstacles (Nykyruy et al., 2020; Wisz et al., 2018).

Although there are studies on wind energy barriers in other countries, there are no studies on the Ukrainian context. By conducting a qualitative analysis of stakeholder viewpoints in Ukraine's wind energy sector, this study aims to fill these gaps. Understanding these barriers in more detail can help identify solutions for implementing wind power, which has the potential to improve both the country’s environmental and economic sustainability.

Therefore, this thesis aims to identify the barriers that impede wind energy development in Ukraine.

The research tasks necessary to achieve the thesis's aim were outlined:

- to present the theoretical framework for increasing renewable energy use, discuss the disadvantages and advantages of fossil fuels and wind energy;
- to analyze previous literature done on the barriers to wind energy implementation in Poland, Serbia, and Kazakhstan using the PESTEL technique;
- to conduct interviews with experts on wind energy in Ukraine, and identify the barriers to the implementation of wind energy in Ukraine;
- to compare the results of empirical analysis with the findings of previous studies on barriers to the implementation of wind power in developing countries.

Poland, Serbia, and Kazakhstan are relevant for research on the barriers to wind power implementation in Ukraine's energy system due to their historical, geographical, and energy-related similarities. According to Nykyruy et al. (2020) and (Brkić, 2024), Poland and Serbia, both Eastern European countries with a history of Soviet influence, share similar starting positions to Ukraine, including centralized energy systems and reliance on fossil fuels. Despite their potential for renewable energy development, these countries have encountered similar barriers to widespread wind energy adoption (Hakala & Bjelic, 2016; Piwowar et al., 2023). Like Ukraine, Poland, Serbia, and Kazakhstan have only recently started exploring the integration of renewable energy sources, and their wind energy sectors remain relatively underdeveloped (Dragović et al., 2019; Karatayev et al., 2021). These factors make these countries useful for comparing the barriers to wind power adoption, as their experiences may shed light on common issues similar to Ukraine's. The PESTEL technique will be applied to identify the barriers in these countries. The PESTLE technique is a strategic management tool used to identify external risks. Such risks are external and beyond control due to the limited availability of data, making construction projects more prone to failure or financial losses. (Rastogi & Trivedi, 2016) This tool will be used to identify barriers to implementing wind energy in Poland, Serbia, Kazakhstan and, later, in the empirical research for the Ukrainian environment.

Since Ukraine is considered a developing country (IMF, 2023), it will be valuable to compare its barriers to wind energy implementation with those of other developing countries. A comparison of the analysis results for Ukraine with those of developing countries can offer valuable insights and potential pathways for solutions.

Therefore, in the theoretical part, previous studies on the barriers to implementing wind energy in Poland, Kazakhstan, Serbia, and other developing countries will be analyzed. In the empirical part, the barriers will be examined in the Ukrainian context using a qualitative method in the form of interviews. Finally, the findings will be compared with the previously conducted studies on barriers to the implementation of wind power in analyzed countries.

Keywords: wind energy, renewable energy, PESTEL, barriers, energy transition.

1. Theoretical framework for barriers impeding wind energy development

1.1 Advantages and disadvantages of fossil fuels and wind energy

For more than a century, fossil fuels such as coal, oil, and natural gas have been critical to global economic and industrial progress. They are an essential component of the modern energy system due to their high energy density and reliability. (Mitchell, 2009) One of the advantages of fossil fuels, in contrast to some renewable energy sources, is their consistent and stable power supply, which is not affected by weather conditions (Seitter, 2024). Furthermore, the current infrastructure for extraction, refining, and delivery is well-developed, making fossil fuels easily accessible and affordable in many countries (Lazarus & van Asselt, 2018). The fossil fuel industry also provides considerable economic benefits by creating job opportunities, stimulating economic growth, and contributing to national energy security (Sasana & Ghozali, 2017; Ishida, 2013). Furthermore, many countries rely on fossil fuels for energy independence, which reduces their reliance on foreign energy sources (Mitchell, 2009). Additionally, technical improvements have enhanced the efficiency of fossil fuel extraction and combustion, contributing to maximizing energy output while reducing waste (Lanzi et al., 2011).

Despite the mentioned advantages, fossil fuels have some critical disadvantages related to environmental impact and sustainability. One of the most notable concerns is the impact on greenhouse gas emissions. The combustion of coal, oil, and natural gas emits significant volumes of carbon dioxide (CO_2) into the atmosphere, influencing global warming and climate change. (Ryemshak & Ihom, 2015) This has led to an increased number of incidents and severity of natural disasters, rising sea levels, and ecosystem changes (Mimura, 2013). In addition to CO_2 emissions, the combustion of fossil fuels emits pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter, all of which cause air pollution and health issues such as respiratory diseases and cardiovascular problems (Ryemshak & Ihom, 2015).

The finite nature of fossil fuels is another disadvantage. Fossil fuel reserves are decreasing rapidly due to their non-renewable nature. It must also be mentioned that the rising complexity and cost of extracting fossil fuels pose significant challenges to future energy security, which is a driver for moving to renewable energy. (Armaroli & Balzani, 2007) Furthermore, the geopolitical influence of fossil fuel dependency is significant, as countries with large reserves often retain economic and political power over those that rely on imports. This dynamic has historically impacted international relations, influenced political decisions, and escalated conflicts over resource ownership and allocation. (Mitchell, 2009) The extraction and transportation of fossil fuels involve environmental and ecological dangers. Oil spills, pipeline leaks, and mining operations have all caused significant environmental damage to natural habitats, water sources, and biodiversity. (Gleick et al., 2012) In conclusion, although fossil fuels have played an important role in global industrialization and economic expansion, their long-term usage is being questioned due to their environmental, economic, and geopolitical disadvantages.

Considering these serious disadvantages, the global shift to renewable energy sources has become essential. Many countries are investing in solar, wind, hydroelectric, and geothermal energy to reduce their reliance on fossil fuels and lower their environmental impact (Katoch & Bhat, 2010). Under the United Nations Framework Convention on Climate Change (UNFCCC), governments and international organizations have implemented agreements and regulations, such as the Paris Agreement, to encourage the use of renewable energy sources and reduce carbon emissions (Baruch-Mordo et al., 2019). As a global framework for climate action, the UNFCCC encourages countries to move away from fossil fuels in order to slow global warming and mitigate climate change (United Nations Framework Convention on Climate Change, 2025). However, there are some challenges in implementing renewable energy. For example, Asante et al. (2020) note that developing countries face significant challenges in adopting wind energy. For instance, political and regulatory barriers are mostly caused by inconsistent policies and bureaucratic delays. Weak legal frameworks and corruption deter investment in wind farms even further (Asante et al., 2020). Among the economic barriers, high initial investment costs, limited financial incentives, and competition with subsidized fossil fuels can be highlighted. Furthermore, high risks and weak financial mechanisms are additional difficulties many investors face when securing funds. Technical barriers include inadequate infrastructure, weak grid systems, and a shortage of skilled labor. Additionally, many countries experience grid instability in their energy systems and lack wind energy installation and maintenance expertise. (Siraj et al.,

2022) Concerns about land use, noise, and environmental impact cause public resistance and contribute to social barriers. Environmental barriers include insufficient wind resources in some locations and potential impacts on wildlife. (Diógenes et al., 2020)

Wind is considered one of the most promising renewable energy sources because of its sustainability, environmental benefits, and potential for universal adoption. Sustainability is one of the most significant advantages of wind energy. In contrast to fossil fuels, wind energy relies on limitless resources in the form of wind, positioning it as a sustainable, long-term solution for energy production. Furthermore, wind power is a clean energy source that emits no greenhouse gases during operation, considerably lowering its ecological impact. Another significant advantage of wind energy is its potential for cost-effectiveness. Although wind farms require significant initial investment costs, long-term operational costs are minimal because wind is a free resource. Advances in wind turbine technology have also increased efficiency and reduced maintenance costs, making wind energy more competitive with traditional energy sources. Furthermore, wind power installations create jobs, which promotes economic growth. (Asghar et al., 2023).

Despite these advantages, wind energy has some drawbacks. One of the most significant issues is its reliance on weather conditions. This variability can lead to fluctuations in energy supply, necessitating backup storage solutions or integration with other energy sources to maintain a stable power grid. Another disadvantage of wind energy is its impact on wildlife and the environment. Wind turbines can endanger birds and bats, which may collide with the blades. Furthermore, the development and operation of wind farms can lead to habitat destruction. Another problem is noise pollution, as the operation of turbines and the sound of spinning blades can impact nearby communities. Furthermore, wind energy projects require significant amounts of land and space, particularly for large-scale wind farms. While offshore wind farms help alleviate land use concerns, they also present additional challenges, such as higher installation and maintenance costs, as well as potential impacts on marine ecosystems. Communities opposed to wind turbines have also raised aesthetic concerns regarding their visual impact on landscapes. (Ahmed et al., 2020)

Table 1

Comparison table summarizing the advantages and disadvantages of fossil fuels and wind energy

Aspect	Fossil fuels	Wind energy
Sustainability	Non-renewable, depleting reserves	Renewable, relies on limitless wind resources
Environmental impact	High CO_2 emissions, air pollution, oil spills, habitat destruction	Low emissions, but an impact on wildlife and noise pollution
Energy reliability	Stable power supply	Weather-dependent, requires storage or backup sources
Infrastructure	Well-developed extraction and distribution systems	Requires investment in and grid integration
Economic impact	Creates jobs, contributes to economic growth	Creates jobs, high initial investment costs
Geopolitical influence	Countries with large reserves hold power over import-dependent nations	Reduces dependence on countries with large fossil fuel reserves
Cost	Low initial cost, but long-term costs are rising	High initial investment, but low long-term operational costs
Technological advancements	Advances in the extraction and combustion	Advances in turbine technology, improved energy storage solutions
Land use	The need for land for extraction and combustion.	Large land requirements for wind farms
Public perception	Familiar and widely used, but facing criticism due to climate concerns	Some local communities' resistance due to aesthetics and noise

Source: compiled by the author

To summarize, wind energy is a sustainable and environmentally friendly alternative to fossil fuels, offering benefits such as long-term cost savings and economic advantages. However, its dependency on variable wind conditions, impact on wildlife, and land use constraints pose concerns that must be addressed. Improvements in energy storage, turbine efficiency, and regulatory policies can help improve wind power's utilization as an important component of the global transition to renewable energy.

1.2 Comparative analysis of barriers to wind energy implementation in Poland, Serbia, and Kazakhstan based on previous studies

Due to similar energy, economic, and environmental circumstances, previous research on Poland, Serbia, and Kazakhstan will be used to conduct a comparative analysis of barriers to wind energy implementation.

The study will examine barriers to wind energy implementation in Poland based on six scholarly articles. The articles were selected for their diverse methodologies and detailed insights. Methodologies vary widely among the authors of the six analyzed articles. One of the most used methodologies is qualitative interviews, employed by Talarek et al. (2022) and Mrozowska et al. (2021). Another frequently applied methodology, used by Mrozowska et al. (2021) and Kryszk et al. (2023), is policy review and analysis. Additionally, other approaches include a SWOT analysis by Igliński et al. (2016), a data analysis and literature review by Dolega (2016), and a quantitative analysis by Aydin et al. (2022). These articles provide a comprehensive overview of the political, economic, social, technological, environmental, and legal barriers associated with wind energy in Poland, making them well-suited for applying a PESTEL analysis. Finally, the findings from the analyzed articles on barriers to wind energy implementation in Poland will be summarized in Table 2.

A political dependence on coal is a significant barrier across all sources. Mrozowska et al. (2021) state that political dependence on coal is a significant barrier, as it ties the government to the coal industry and fosters resistance to renewable energy initiatives. Similarly, Talarek et al. (2022) argue that prioritizing coal reduces investment potential for renewables and that shifting priorities and regulations create instability in the growth of wind energy. Igliński et al. (2016) highlight the Act on Renewable Energy Sources as an example of regulatory changes that increase investor uncertainty, showing that wind energy projects face significant barriers in the absence of a stable policy framework, where political instability is the main cause of inconsistent regulatory changes that hinder long-term investment decisions.

Financial difficulties and high investment costs are widely recognized as significant economic barriers. According to Kryszk et al. (2023), wind energy projects face additional financial obstacles due to the recent energy crisis, which has increased operating costs for renewable energy sources. Similarly, the costs of renewable energy systems, influenced by local and market factors, pose substantial barriers to expanding wind energy projects in Poland (Dolega, 2016). According to Talarek et al. (2022), government-backed loans could support wind projects by facilitating grid connections and infrastructure.

Across studies, social resistance is also common due to concerns about the effects of noise and visual impact. According to Dolega (2016) and Talarek et al. (2022), local opposition is commonly observed in residential and rural areas where residents are concerned about the aesthetic and noise disturbances caused by wind turbines. Furthermore, Aydin et al. (2022) point out that people are generally unaware of the advantages of wind energy.

Table 2

PESTEL analysis of barriers to wind energy in Poland

Authors and year	Political	Economical	Social	Technological	Environmental	Legal
Aydin et al. (2022)	Government dependency on coal	High initial investment costs	Limited public awareness	Lack of infrastructure and data	Spatial constraints in urban areas	Complex regulatory process; long-lasting investment planning
Dolega (2016)	Political preference for fossil fuels	High investment costs	Resistance of local communities	Lack of sufficient grid infrastructure	Environmental concerns over land use	Difficulties in permitting processes
Igliński et al. (2016)	Policy instability	Long and complex investment process; high investment cost	Local community resistance	Outdated grid technology	Space and environmental constraints	The long adaptation of legislation; shifting policies
Kryszk et al. (2023)	Long and complex investment procedure; delays incentives	Increase in operational costs	Low public awareness	Insufficient grid capacity and outdated infrastructure; limited grid hosting capacity	Space and environmental constraints	Lack of consistent legal framework across regions
Mrozowska et al. (2021)	Resistance to EU climate policies focused on coal phase-out	High costs for transitioning from coal to renewable energy	Potential impact on energy costs and employment	Need for modernization of coal-dependent technology	Environmental protection measures	Misalignment between local and national policies
Talarek et al. (2022)	Heavy reliance on coal	High investment costs	Local community resistance	Outdated grid capacity	Environmental protection standards	Complex permitting and zoning laws

Source: compiled by the author, with sources from Subchapter 1.2

Most studies agree that Poland's outdated infrastructure poses a significant technological barrier to wind energy. Aydin et al. (2022) and Kryszk et al. (2023) highlight the limitations of Poland's existing grid in accommodating renewable energy and recommend rapid upgrades to increase wind integration capacity. Beyond basic infrastructure requirements, Aydin et al. (2022) emphasize the need for urban-specific wind data and infrastructure, as current systems are not equipped to meet the unique needs of urban wind projects.

Environmental constraints, such as site availability and ecological impacts, are considered environmental barriers. According to Talarek et al. (2022), environmental regulations restrict available land, particularly in protected areas, making it challenging to expand wind farms. Igliński et al. (2016) highlight issues with environmental standards, which impede the building of new wind farms. Analyzed studies state that balancing wind energy projects with conservation initiatives is essential for addressing the environmental risks associated with renewable energy.

Legal and regulatory delays complicate wind energy implementation. Permitting processes vary among locations, leading to delays in project deadlines (Igliński et al., 2016; Dolega, 2016). Similarly, Talarek et al. (2022) claim that complex zoning restrictions impede the efficient deployment of wind farms and promote simpler approaches to improve regulatory efficiency.

The methodologies applied by the authors of the five analyzed articles about Serbia differ but share some common approaches. The most used methodology is policy analysis employed by Komarov et al. (2012), Ljubojev et al. (2018), Micić et al. (2014), and Stojilovska & Kolovrat (2024). Another methodology used in studies done by Vučić & Radović Vučić (2020) and Komarov et al. (2012) is case study analysis. Vučić & Radović Vučić (2020) use this approach to compare Serbia to the Nordic countries in renewable energy implementation, while Komarov et al. (2012) focus on the current state of wind energy in Serbia, such as policies and projects. Additionally, Ljubojev et al. (2018) applied legal analysis to examine how Serbia's laws are harmonized with European Union legislation.

The findings from the analyzed articles on barriers to wind energy implementation in Serbia will be summarized in Table 3.

Table 3

PESTEL analysis of barriers to wind energy in Serbia

Authors and year	Political	Economic	Social	Technological	Environmental	Legal
Komarov et al. (2012)	Slow policy adaptation	High financial risk	Low public awareness about the benefits of RES	Insufficient grid capacity; outdated infrastructure	Environmental protection measures	Lack of a consistent legal framework
Ljubojev et al. (2018)	Slow harmonization with EU policies	High operational costs for wind farms	Low public awareness	Insufficient resource assessment	Environmental impact assessments	Ambiguity in licensing processes
Micić et al. (2014)	Limited government prioritization; dependence on fossil fuels	High initial costs	Limited public awareness	Lack of infrastructure and data	Land use conflicts	Inconsistent permitting processes
Stojilovska & Kolovrat (2024)	Energy policies prioritizing coal	Lack of funding mechanisms	Low community involvement in decision-making	Lack of skilled workforce	Biodiversity protection	Bureaucratic delays in project approvals
Vučić & Radović Vučić (2020)	Conflicts between centralized and localized policy approaches	Investment uncertainty	Low public awareness	Infrastructure development challenges	Concerns over protected biodiversity areas	Overlapping jurisdictions

Source: compiled by the author, with sources from Subchapter 1.2

Political barriers include Serbia's low prioritization of renewable energy by the government and a reliance on fossil fuels that impedes wind energy progress (Micić et al., 2014; Stojilovska & Kolovrat, 2024). Komarov et al. (2012) and Vučić & Radović Vučić (2024) agree that slow policy adaptation, complex regulatory frameworks, and conflicts

between centralized and local policy approaches are significant barriers to the implementation of wind power. Furthermore, energy policies that favor coal and the slow alignment with EU renewable energy policies hinder the expansion of wind energy (Ljubojev et al., 2018; Micić et al., 2014).

Economic barriers include high initial costs for wind turbine development (Micić et al., 2014) and a lack of funding mechanisms (Stojilovska & Kolovrat, 2024). These financial issues are compounded by uncertainty and significant financial risks (Komarov et al., 2012; Vučić & Radović Vučić, 2024) and the lack of appropriate financial support for large-scale wind farms (Ljubojev et al., 2018).

Social barriers include poor public awareness of the benefits of wind energy (Micić et al., 2014; Komarov et al., 2012) and low community participation in decision-making processes (Stojilovska & Kolovrat, 2024). The widespread resistance and lack of public awareness of wind energy's benefits are key difficulties.

Technological barriers include inadequate infrastructure, such as insufficient grid capacity and outdated technologies, which hinder the integration of wind energy (Komarov et al., 2012; Vučić & Radović Vučić, 2024; Micić et al., 2014). Furthermore, the insufficient resource assessment, and limited capacity for grid modernization (Ljubojev et al., 2018) make it more difficult to build new wind farms.

Environmental barriers include land use conflicts in agricultural areas (Micić et al., 2014) and restrictions due to environmental conservation laws that limit the availability of land for wind farms (Komarov et al., 2012). Another concern is the balance between wind projects and biodiversity protection (Stojilovska & Kolovrat, 2024).

Legal barriers are focused on inconsistent permitting processes and overlapping jurisdictions, which are reasons for delays (Micić et al., 2014; Vučić & Radović Vučić, 2024), as well as a lack of a consistent legal framework for renewable energy (Komarov et al., 2012). Bureaucratic delays in project approvals further impede wind energy development in Serbia (Stojilovska & Kolovrat, 2024).

Another country whose previous studies will be analyzed is Kazakhstan. The methodologies differ across the five studies reviewed, reflecting various approaches to analyzing wind energy development in Kazakhstan. Policy analysis is one of the most used methodologies, as demonstrated by Dadabaev & Naurzbaeva (2014) and Jianzhong et al., (2018) in their analyses of legislative and institutional frameworks. Data analysis methods, such as wind resource assessments and infrastructure evaluations, are also commonly used by Akhmetov et al. (2011) and Lettice (2011). SWOT analysis and expert surveys are other

approaches used in the study of (Xenarios et al., 2024), examining specific wind energy projects and initiatives in Kazakhstan. Akhmetov et al. (2011) and Lettice (2011) used data analysis methods, such as wind resource assessments and infrastructure evaluations. Together, these techniques offer a comprehensive picture of the political, economic, social, technological, environmental, and legal variables driving wind energy growth in Kazakhstan.

The findings from the analyzed articles on barriers to wind energy implementation in Kazakhstan will be summarized in Table 4.

Table 4

PESTEL analysis of barriers to wind energy in Kazakhstan

Authors and year	Political	Economic	Social	Technological	Environmental	Legal
Akhmetov et al. (2011)	Dependence on fossil fuels	High operational and maintenance costs	Risk for workforce	Outdated infrastructure	Ecological impacts of wind farms	Unclear investment policies
Dadabaev & Naurzbaeva (2022)	Weak institutional capacity; slow policy adoption	High capital costs	Limited public awareness	Lack of integration with existing systems	Land use conflicts	Overlapping regulatory jurisdictions
Jianzhong et al. (2018)	Policy inconsistencies	Dependence on government subsidies	Limited public awareness	Low technological competitiveness	Environmental concerns	Inefficient investor protections
Lettice (2011)	Limited state support; reliance on international aid	Inadequate funding mechanisms	Limited public awareness	Complex grid connection of renewable energy projects	Environmental concerns	Long permitting processes
Xenarios et al. (2024)	Immature business environment; lack of political incentives	Low retail energy prices; high investment risks	Skilled labor shortages	Outdated electricity grids and transmission systems	Heavy reliance on fossil fuels	Lack of consistent legal frameworks

Source: compiled by the author, with sources from Subchapter 1.2

Several political barriers in Kazakhstan hinder the country's wind energy development. Xenarios et al. (2024) concluded that an immature business environment for renewable energy and the lack of sufficient government incentives slow down the growth of the alternative energy sector. Similarly, as Dadabaev and Naurzbaeva (2022) point out, the country's reliance on fossil fuels impedes the transition to renewable energy. Jianzhong et al. (2018) claim that inconsistencies in renewable energy policies exacerbate the instability, limiting long-term investments in wind energy.

Economic barriers are a major obstacle to wind power projects in Kazakhstan. According to Xenarios et al. (2024), low retail energy prices restrict profitability, while high investment risks discourage private sector engagement. Lettice (2011) highlights that insufficient funding mechanisms for wind power development limit access to capital, making it challenging for projects to be scaled. Dadabaev and Naurzbaeva (2022) also point this out by mentioning the large upfront capital requirements, which act as a barrier to entry for new projects.

Another significant barrier to wind energy is a lack of awareness. According to Jianzhong et al. (2018), there is limited public awareness, which has an impact on number of wind energy projects. Lettice (2011) highlights the public's lack of awareness of the benefits of wind energy, which exacerbates this reluctance. Additionally, Xenarios et al. (2024) point out the scarcity of a skilled workforce in renewable energy technologies, which limits the effectiveness with which wind energy infrastructure can be deployed and maintained.

Kazakhstan's technology landscape presents another significant challenge. According to Dadabaev and Naurzbaeva (2022), the country's outdated electricity grids and transmission systems are unsuitable for renewable energy integration. Lettice (2011) mentioned the complex grid connection of renewable energy projects, complicating wind farm development and placement. Furthermore, Xenarios et al. (2024) argue that outdated electricity grids and transmission systems affect the efficient distribution of wind power.

The environmental challenges are also substantial. Dadabaev and Naurzbaeva (2022) note land use disputes that limit the availability of suitable wind farm locations. Jianzhong et al. (2018) also mention ecological concerns, which make accelerating wind energy projects difficult. Balancing environmental preservation with the demand for renewable energy production remains a significant concern (Akhmetov et al., 2011).

Kazakhstan's legal system is another impediment to wind energy development. Lettice (2011) emphasizes the lengthy and complex permitting processes that cause project delays. According to Dadabaev and Naurzbaeva (2022), overlapping jurisdictions and inconsistent

regulations complicate the process of obtaining permissions for wind energy projects. Additionally, Jianzhong et al. (2018) contend that ineffective legislative mechanisms for investor protection discourage private-sector investment.

Based on the analysis, we can see that wind power implementation faces a variety of barriers across countries, with Poland, Serbia, and Kazakhstan presenting particular obstacles.

In all three countries, strong reliance on coal is the primary political barrier. This leads to political resistance to renewable energy, as coal holds significant economic and political importance. In Poland, Serbia and Kazakhstan this reliance contributes to delays in the implementation of wind energy projects. Another political barrier in Serbia is the slow adaptation of policies to align with EU standards, which also hinders the process of implementing wind energy. In Kazakhstan, one of the biggest political barriers is a weak business environment for renewable energy, limited government incentives, as well as policy inconsistencies and slow legislative reforms.

Economic barriers to the deployment of wind energy are evident in all three countries. High initial investment costs and insufficient financial support are common barriers. Economic barriers are particularly challenging in Poland, where high initial investment costs and insufficient financial incentives impede wind energy development. Similarly, Serbia faces significant financial risks due to a lack of funding mechanisms for wind projects, along with high operational and initial costs. Additionally, in Kazakhstan, economic barriers include low retail energy prices, coupled with high initial capital costs. The lack of effective funding mechanisms and financial support for wind power projects further limits the scalability of wind energy projects.

In all three countries social barriers are present in the form of local communities' resistance. Residents are concerned about the visual, noise, and environmental impacts of wind turbines. Another reason for resistance is the disruption to rural landscapes. This opposition is primarily caused by a lack of public awareness regarding the benefits of wind power.

All three countries face substantial technological barriers due to outdated infrastructure and a lack of technological capabilities. Poland, Serbia, and Kazakhstan all have limited grid capacity and outdated infrastructure, which makes it difficult to integrate wind energy. Poland has insufficient grid capacity and outdated infrastructure, whereas Serbia also has insufficient grid capacity and poor wind resource mapping. Kazakhstan confronts similar technological barriers, including outdated electricity grids and a lack of connectivity with other energy systems.

Poland, Serbia, and Kazakhstan share environmental barriers, particularly those related to land use and ecological issues. In Poland, land constraints in rural areas and environmental regulations in sensitive areas impede wind farm construction. Serbia and Kazakhstan also face land-use conflicts, particularly in agricultural areas, and concerns about biodiversity protection.

Legal barriers, including inconsistent or complex permitting processes, are present in all three countries. In Poland, delays in permits and zoning laws impede the expansion of wind energy. Serbia also faces inconsistent permitting processes and overlapping jurisdictions, contributing to delays. Kazakhstan, like Serbia, experiences delays due to lengthy permitting processes and overlapping regulatory jurisdictions, while inconsistent legal frameworks further discourage investment.

While Poland, Serbia, and Kazakhstan each face unique challenges in integrating wind energy, they share several common barriers, as outlined in Table 5. These include political dependence on fossil fuels, economic difficulties in securing funding, social resistance, outdated technological infrastructure, environmental concerns related to land use, and complex legal processes.

Table 5

Key barriers overview across countries

Barrier category	Common barriers across countries
Political	Reliance on fossil fuels; limited government support for renewables
Economic	High investment costs; high initial costs; insufficient financial support
Social	Public resistance due to visual and noise impact; lack of public awareness
Technological	Outdated infrastructure; insufficient wind resource data
Environmental	Land use conflicts; biodiversity concerns
Legal	Complex permitting processes; inconsistent regulations

Source: compiled by the author

Key findings about barriers to wind energy implementation in previous studies are summarized in Table 5. The main barriers include outdated infrastructure, reliance on fossil fuels, and complex permitting processes.

2. Barriers to the implementation of wind power in the energy system of Ukraine

2.1 Methodology and data

Since Ukraine gained independence in 1991, the energy sector has experienced significant changes. With a large portion of its energy infrastructure passed down from the Soviet Union, Ukraine has historically been mostly dependent on fossil fuels, especially coal and natural gas. Energy production and delivery were inefficient, and it was heavily reliant on Russian gas imports. Ukraine initiated several market-oriented reforms in the post-Soviet period to liberalize its energy industry. Among these measures were the restructuring of the electrical industry and the privatization of energy businesses. However, because of political instability and corruption, development remained slow. The country continued to rely mostly on imports of natural gas from Russia. (Bacon 2021)

An important turning point for Ukraine's energy industry was the Russian annexation of Crimea in 2014 and the subsequent conflict in Eastern Ukraine (Johannesson & Clowes, 2020). Ukraine accelerated its energy diversification efforts due to the crisis, highlighting the risks of over-reliance on Russian energy (Cebotari, 2022). Increased imports from Europe through reverse-flow systems and improvements in local production aimed to reduce dependency on Russian gas (Johannesson & Clowes, 2020).

Ukraine has made significant progress in increasing its capacity for renewable energy in recent years. To encourage investment in wind and solar energy projects, the government implemented Green Tariff and other incentives. This development reflects Ukraine's aim to conform to EU norms as part of its larger integration objectives and global support for green energy programs (Kharlamova, Nate, & Chernyak, 2016).

To delve deeper into the barriers to wind energy implementation in Ukraine, a qualitative empirical analysis using interviews with key stakeholders in the wind energy sector was conducted. Qualitative analysis in the form of semi-structured interviews was used due to its applicability to the studied topic, as demonstrated by Talarek et al. (2022) and Mrozowska et al. (2021) in their studies on wind energy development in Poland. These interviews were designed to get insights from a wide range of stakeholders involved in the planning and execution of wind energy projects. The author conducted five online interviews and received one written response (see Table 6) with 6 stakeholders, including a lawyer working at a wind development company, a representative from the Ministry of Energy of Ukraine, an energy analyst, a lawyer with a technological background, a business

development manager at a wind farm development company, and an energy department specialist at an environmental NGO.

Table 6
Summary of interviewee information

Interviewee	Position	Interview format	Interview minutes	Pages of transcribed interview	Interview date
1	Lawyer	Online	72	16	22.03.2025
2	Lawyer (with technological background)	Online	69	17	12.04.2025
3	Energy analyst	Online	36	8	16.04.2025
4	Representative from the Ministry of Energy of Ukraine	Online	42	8	16.04.2025
5	Business development manager	Online	52	14	23.04.2025
6	Energy department specialist at an environmental NGO	Written response	-	3	28.04.2025

Source: compiled by the author

All participants were contacted via the LinkedIn platform. Each respondent was provided with the questions in advance, and consent forms were signed. The consent form contained details about using information from interviews anonymously. The example of the consent form is provided in Appendix B. The interviews were recorded with the consent of interviewees, transcribed, coded, and analyzed using a thematic approach with the PESTEL technique. Inductive coding was used to analyze and interpret data collected from interviews, identifying themes, patterns, and categories. To summarize, the methodological process was as follows: designing the interview questions based on theoretical findings, conducting the interviews, coding responses into PESTEL categories, highlighting the main barriers, and comparing the results with previous studies (see Figure 1).

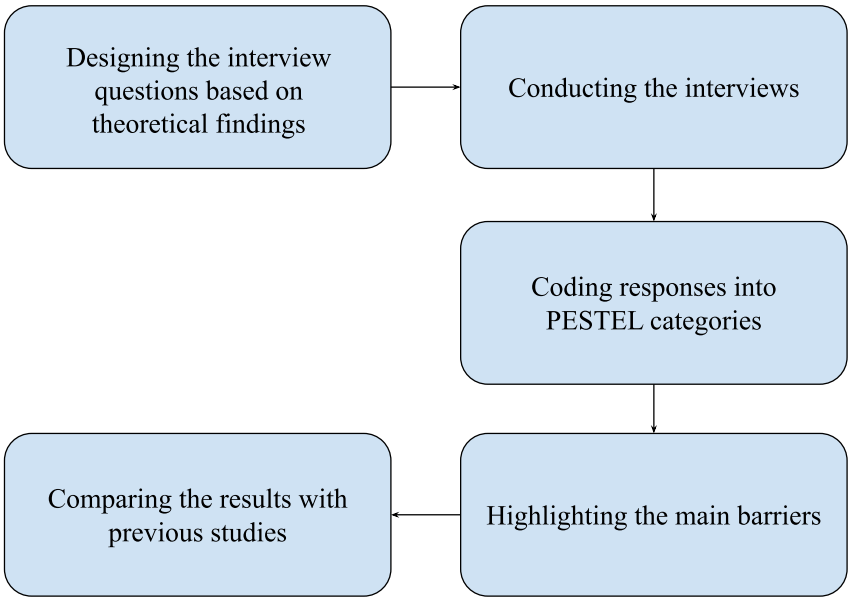

Figure 1. The methodological process of the empirical part

Source: compiled by the author

The interview questions (see Appendix A) are based on the key barriers identified in previous studies and summarized in Chapter 1.2. The questions were designed to understand how these identified barriers emerge in the Ukrainian context. They address the political and economic climate for wind energy, challenges in obtaining funding, public perceptions of wind energy, technological constraints, environmental factors, and legal and regulatory issues. A detailed table with the PESTEL analysis of the conducted interviews (see Appendix C) was compiled to show how representatives from different institutions and organizations perceive barriers similarly or differently.

Using the respondents' experiences and perspectives, a comprehensive view of the barriers to wind energy implementation in Ukraine was developed through the PESTEL technique applied throughout this work. The findings from the interviews will be compared with those from other countries and previous studies. Finally, the findings will be summarized, and opportunities and recommendations will be provided.

2.2 Analysis of interviews with wind energy experts

The interviews with various stakeholders in Ukraine's wind energy sector provide a comprehensive overview of the challenges and opportunities for implementing wind energy projects. Each perspective offers a unique insight into the PESTEL factors affecting the sector. By analyzing these interviews, recurring themes, differing viewpoints, and potential areas for development emerge.

The political climate in Ukraine presents significant obstacles to the growth of wind energy. Investor trust has been weakened by frequent legislative changes and inconsistent policy implementation. Frequent modifications to the legislative framework, such as the repeal of the Green Tariff, have created uncertainty for investors. According to a legal expert interviewed, "*When the Green Tariff was reduced and transitioned, it created financial instability for many projects*" (Interview 1). Additionally, war-related risks have shifted the government's priorities, delaying necessary reforms to align with EU regulations. As noted by a representative from the Ministry of Energy, "*The ongoing war undermines investor confidence and disrupts energy policy reforms*" (Interview 4).

One of the biggest obstacles to Ukraine's wind energy development is economic. The absence of accessible project financing and high initial costs negatively affect smaller developers (Interview 5). Economic challenges are further exacerbated by logistical issues. Due to security concerns, turbine deliveries are restricted to regional ports, resulting in higher transportation expenses for developers. As noted by the business development manager, *"The high costs of logistics…especially due to insurance issues for transporting turbines, significantly raise expenses."* The lack of easily accessible financing instruments worsens these logistical difficulties, impeding the sector's expansion even further. Furthermore, international financial institutions (IFIs), such as the IFC and EBRD, provide little assistance due to their strict criteria.

Public opposition to renewable energy is still a noticeable problem, frequently stemming from a lack of awareness and false information. Noise, health effects, and aesthetic landscape alterations were among the most commonly mentioned concerns. According to the Energy Department specialist at an environmental NGO, there is a common misconception that wind farms are harmful to wildlife and human health; however, this perception is often unsupported by data. Campaigns for education and the involvement of local stakeholders were identified as crucial remedies. Developers have been able to overcome opposition by providing social investments, such as financing regional healthcare or infrastructure initiatives. As the Energy Department specialist at an environmental NGO highlighted, *"It is necessary to transparently communicate benefits and risks and have communities participate in project revenues through joint ownership or social funds."* (Interview 6).

Logistical difficulties and inadequate infrastructure are related to technological barriers. The outdated infrastructure cannot handle the intermittent nature of wind electricity. Furthermore, grid balancing problems are exacerbated by the lack of necessary energy

storage technologies. An interviewee stated, *"The lack of mandatory energy storage systems hinders the reliability of wind energy and its ability to meet peak demand"* (Interview 2). Projects are frequently delayed by logistical challenges associated with the war. For instance, transporting turbine parts under low-clearance bridges and along narrow roadways can be quite difficult, especially since Ukrainian ports cannot be used for delivery.

The complicated procedures for environmental evaluations and disputes over land use in environmentally sensitive locations are examples of environmental barriers. In protected regions where biodiversity is a major concern, such as Emerald Network sites, these conflicts are particularly significant. Environmental impact evaluations are essential, but the existing process is complex and unclear, according to the interviewed lawyer (Interview 1). Developers are addressing these issues by implementing biodiversity studies and avoiding migratory bird paths. These initiatives demonstrate how wind energy projects can support ecological preservation objectives, which could be further enhanced if regulatory procedures were made more efficient.

Table 7
PESTEL factors, barriers, and key themes in Ukraine

Factor	Barriers identified	Key themes
Political	Inconsistent policies, war risks, retrospective tariff changes	Policy instability, lack of alignment with EU directives
Economic	High costs, lack of project finance, logistical challenges	Financing gaps, logistical constraints, debt crises
Social	Misinformation, resistance from communities	Public education, local stakeholder engagement
Technological	Outdated grid infrastructure, inadequate energy storage, war-related delivery delays	Infrastructure modernization, storage solutions
Environmental	Land use conflicts, biodiversity concerns	Balancing ecological impacts and project feasibility
Legal	Complex permitting processes, lack of regulatory clarity	Need for legal reforms, centralization of approvals

Source: compiled by the author

Legal barriers also impede the development of wind energy projects. With overlapping responsibilities among regulatory agencies, the permitting process is lengthy and inconsistent. The lawyer and energy analyst emphasized that developers must navigate a complex and time-consuming process due to the lack of a centralized mechanism for permits

(Interview 1; Interview 3). Reforms, such as establishing a "one-stop shop" for approvals and introducing more precise rules for land use and grid connections, were strongly supported by stakeholders. Aligning Ukraine's regulatory framework with EU norms through such actions could attract international investment.

Despite these barriers, several opportunities to overcome the barriers could drive the development of wind energy in Ukraine. For example, international cooperation, including partnerships with IFIs like the IFC and EBRD, could provide financial support and technical expertise to mitigate risks (Interview 6). Another opportunity for community involvement is through educational initiatives and revenue-sharing schemes, which can increase public support and reduce opposition (Interview 5). To improve wind energy integration and reliability, some respondents also emphasized the need for technological advancements, such as investments in energy storage systems and grid upgrades (Interview 2; Interview 4). Regulatory reforms are another crucial step in streamlining permitting procedures and establishing robust regulations to improve the investment climate (Interview 4; Interview 6). Access to capital, particularly for smaller developers, could be enhanced through the development of financial mechanisms, such as expanding corporate PPAs and creating project finance options (Interview 5; Interview 3). The business development manager and a representative from the Ministry of Energy emphasized the development of decentralized energy systems as an opportunity to mitigate war risks and provide energy to regions with deficiencies. Additionally, decentralization can offer some degree of independence and create opportunities to introduce new revenue streams to the regions where plants are developed.

As can be mentioned, different players from the sector have emphasized various barriers. For instance, the business development manager highlighted the practical difficulties associated with funding and logistics, the energy department specialist at an environmental NGO focused on environmental concerns and the importance of public awareness, and the lawyers emphasized the need for legal reforms and regulatory alignment with EU standards.

These variations underscore the significance of a holistic approach that balances social participation, environmental sustainability, and financial prosperity.

Table 8

Opportunities and recommendations for wind energy development in Ukraine

Category	Key Points
Opportunities for growth	Support from international financial institutions, risk guarantees, and decentralized wind energy projects for regions with energy deficiency.
Community involvement	Educating local communities about the long-term advantages of wind energy.
Technological improvements	Investment in energy storage systems, grid upgrades, and flexible generation technologies to overcome integration and intermittency issues.
Decentralized projects	Encouraging decentralized wind energy installations in areas experiencing energy shortages in order to guarantee a steady supply of electricity.

Source: compiled by the author

According to the analysis, the interviewees' overall viewpoints on the main obstacles to wind energy deployment in Ukraine are consistent, despite differences in emphasis. A multifaceted strategy, including policy stability, financial improvements, community involvement, technical improvement, and expedited legal procedures, is needed to address these obstacles. Ukraine can overcome its barriers and clear the path for a sustainable energy future by making use of the mentioned opportunities.

2.3 Comparative analysis of findings with previous literature

The results of interviews with key players in Ukraine's wind energy industry reveal both substantial prospects and challenges that are quite similar to those experienced by developing countries worldwide. However, Ukraine's unique circumstances, shaped by the war and its alignment with EU norms, bring new opportunities and complications.

The issue of political instability is present in both the context of developing countries and Ukraine. Stakeholders in Ukraine point to unpredictable legislative changes, inconsistent political support, and retrospective policy changes as the main challenges. Calls for stable and predictable regulatory frameworks stem from the ongoing loss of investor trust caused by auction delays, short-term political objectives, and war-related risks. Similar issues in developing countries discourage investment in wind energy projects, such as unpredictable regulations, lengthy bureaucracy, weak legal systems, and corruption (Asante et al., 2020; Dadabaev & Naurzbaeva, 2022). Another political obstacle is the reliance on fossil fuels. For instance, the adoption of renewable energy can be hampered by this reliance and opposition to EU climate mandates (Mrozowska et al., 2021; Hakala & Bjelic, 2016). Policy instability, which is less common in other contexts, has been made worse by Ukraine's particular circumstances, which are formed by the ongoing war. Ukraine is trying to address these difficulties, as seen in its ongoing legal reforms to align with EU norms.

In both contexts, economic obstacles pose serious challenges, but some unique barriers related to Ukraine were identified. High upfront capital costs, accumulated debt in the renewable energy sector, and financing difficulties are the main issues in Ukraine. Price limitations, high equipment import tariffs, and underdeveloped corporate power purchase agreements (PPAs) further constrain profitability. These problems are exacerbated by war-related risks, which increase the cost of turbine deliveries and hinder off-taker agreements. Other countries also face challenges with subsidized fossil fuels, large upfront investment costs, and a lack of financial incentives (Komarov et al., 2012; Igliński et al., 2016). Similar to Ukraine's financial instability, investors find it difficult to obtain capital due to weak financial mechanisms and significant risks. Ukraine's findings do not specifically address competition with subsidized fossil fuels, although developing countries place strong emphasis on this issue.

Another common issue is social opposition. Misinformation, perceived health risks, environmental concerns, and a preference for economic gains over sustainability are the main causes of social opposition in Ukraine. Public opinion is divided; some areas support projects because they could lead to increased tax revenue and job opportunities. Opposition in other countries is also driven by concerns about environmental impacts, noise pollution, and land use (Jianzhong et al., 2018; Igliński et al., 2016). In both cases, social barriers are exacerbated by a lack of understanding of the benefits of wind energy. The results from Ukraine, however, delve deeper into community-specific factors that can reduce opposition and foster acceptance, such as tax revenue and job creation.

Both Ukraine and other countries frequently cite technological constraints (Akhmetov et al., 2011; Igliński et al., 2016; Komarov et al., 2012). Significant issues in Ukraine include insufficient balancing capacities, grid integration challenges, and outdated infrastructure. Improvements in storage technology and grid modernization are essential to address intermittency issues and reliance on monopolistic grid operators. Similarly, developing countries face challenges with poor grid systems, inadequate infrastructure, a lack of skilled workers, unstable grids, and insufficient installation and maintenance expertise.

Concerns about the environment are present in both Ukraine and developing countries. For instance, issues such as biodiversity and land-use disputes restrict the size of wind energy installations (Akhmetov et al., 2011; Dadabaev & Naurzbaeva, 2022). Restrictions on environmentally sensitive areas and comprehensive environmental impact assessments are necessary in Ukraine, where resistance is fueled by misinformation about ecosystem damage. Other countries also face potential impacts on wildlife and limited wind

resources in certain regions. While environmental issues must be addressed in both contexts, Ukraine's findings highlight the role of misinformation in shaping public opinion.

Another area of convergence is legal restrictions. Complex permitting procedures, unclear land use laws, and delays in dispute resolution are significant obstacles in Ukraine. These challenges are also mentioned in the context of other countries, including complex permitting procedures, unclear land-use laws, and delays in approvals (Stojilovska & Kolovrat, 2024; Igliński et al., 2016). The goal of ongoing legal reforms is to align regulations with EU standards. In contrast, corruption and weak legal frameworks in developing countries discourage investment in wind farms. While complicated legal structures are identified as obstacles in both contexts, corruption is emphasized more explicitly in the context of developing nations.

Some new findings, distinct from those in previous studies, were identified. For instance, some of Ukraine’s barriers differ from those of other developing countries due to war-related logistical bottlenecks, such as higher turbine delivery costs, postponed project schedules, and increased financial risks. Stakeholders also noted indirect consequences of the war specific to Ukraine's geopolitical context, such as a decline in investor confidence and delays in policy reforms.

Another important conclusion is that, although social opposition to wind energy is widespread globally, this study shows that emphasizing tangible economic benefits, such as job creation, local tax revenue, and infrastructure investments, can foster community acceptance. This research underscores the importance of adapting communication strategies to highlight the local benefits of wind projects, particularly in areas resistant to renewable energy initiatives.

Additionally, it was emphasized that financial models for wind energy projects in Ukraine must account for war-related risks. Stakeholders suggested decentralized wind energy systems as a means to enhance energy security in areas impacted by war, one of the most frequently discussed themes across all interviews. This localized approach addresses grid reliability issues and ensures electricity delivery to areas vulnerable to disruptions.

Furthermore, price caps and debts in the sector limit profitability and discourage investments. The massive debt owed to energy project developers in the sector further hampers the expansion of wind energy integration. Price limitations also restrict profitability and deter investment.

In summary, the challenges faced by Ukraine's wind energy industry closely mirror those encountered by developing countries worldwide, particularly in terms of public

resistance, financial instability, political inconsistency, technological limitations, environmental concerns, and legal complications. However, Ukraine's unique context, shaped by war threats and alignment with EU standards, adds further complexity and potential.

Conclusion

This thesis used a PESTEL framework and insights from Poland, Serbia, and Kazakhstan to examine the obstacles to wind energy implementation in Ukraine. The advantages and disadvantages of wind energy and fossil fuels were discussed, highlighting the sustainability advantages of wind energy despite challenges such as intermittency and ecological concerns, as well as the environmental and geopolitical risks associated with fossil fuels.

In the theoretical part, a comparison of the barriers in Kazakhstan, Serbia, and Poland is provided. Despite differences among these countries, all face common issues, including reliance on fossil fuels, high investment costs, outdated infrastructure, public opposition, environmental constraints, and legal complexity. These findings formed the basis for analyzing the Ukrainian context.

The empirical part focused on Ukraine. A qualitative method based on six expert interviews was described. The key barriers were then identified as unstable policies, war-related risks, high capital costs, inadequate financing channels, outdated grid infrastructure, legal uncertainty, and social opposition driven by misinformation. The findings were compared with those of other developing countries, confirming shared challenges while emphasizing Ukraine’s specific conditions, particularly the impacts of war and monopolistic grid operations.

Although Ukraine has strong potential for wind energy, a combination of political, economic, and technical barriers continues to hinder progress. Despite these challenges, the study identified opportunities in international cooperation, regulatory reform, decentralized energy systems, and public engagement.

There are some limitations to this study. The diversity of viewpoints within Ukraine's wind energy industry may not be adequately represented by the limited sample size of six expert interviews. Furthermore, the generalizability of the findings is limited by their focus on Ukraine, and the results could change due to the current economic and political environment. Due to the scope of the study, certain aspects, such as community perceptions, were not thoroughly examined. Future research could address these limitations. By addressing these constraints and advancing research in these areas, a better understanding of

the barriers to wind energy adoption in Ukraine can be gained, leading to the development of more effective policy recommendations.

This study provides a platform for policymakers, developers, and researchers to further explore and develop wind energy.

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APPENDIX A

Interview Questions

Barrier Category	Questions	Source
Political barrier	• How would you describe the current political support for renewable energy, particularly wind power, in Ukraine? • Are there any specific policy gaps or delays in aligning Ukraine's renewable energy goals with international or EU standards? If so, what are they? • What role does the government play in incentivizing or disincentivizing wind energy development in Ukraine?	Antoniuk et al. (2022); Bashynska (2020); Allen et al. (2012); Balat (2007); Lazarus & van Asselt (2018); Kuzior et al. (2021); Baruch-Mordo et al. (2019); Igliński et al. (2016)
Economic barriers	• What are the main economic challenges for initiating and scaling wind energy projects in Ukraine? • Are there sufficient funding mechanisms or financial incentives available to wind energy developers? If not, what improvements are needed? • What role can international financial institutions play in addressing these economic barriers?	Bashynska (2020); Kuzior et al. (2021); Piwowar et al. (2023)
Social barriers	• How do local communities perceive wind energy projects in Ukraine? Are there concerns about land use, noise, or environmental impacts? • How can developers better engage with local communities to address their concerns and promote acceptance of wind energy?	Caporale et al. (2020); Kumar (2020)
Technological barriers	• What are the main technological challenges hindering the integration of wind energy into Ukraine's energy grid? • What technological advancements or investments are required to improve grid connectivity and integration for wind energy in Ukraine?	Ahmed et al. (2020); Joselin Herbert et al. (2007)
Environmental barriers	• What environmental challenges, such as land-use conflicts or biodiversity concerns, arise during the development of wind energy projects in Ukraine? • Are there specific regulations or land constraints that limit the construction of wind farms in rural or environmentally sensitive areas?	Baruch-Mordo et al. (2019)
Legal barriers	• How would you describe the permitting process for wind energy projects in	Komarov et al. (2012); Kuzior et al. (2021);

	Ukraine? Are there delays or inconsistencies? • What legal reforms are necessary to simplify the approval and permitting processes for wind energy projects in Ukraine? • Do you think the existing legal framework in Ukraine sufficiently protects investors in renewable energy? If not, what changes are needed?	Piwowar et al. (2023); Bashynska (2020)

Source: compiled by author

APPENDIX B

Consent form

Форма згоди

Бакалаврська дипломна робота: *Перешкоди на шляху впровадження вітрової енергетики в Україні*

Шановний(а) учасник(ця),

Вас запрошують взяти участь у науковому дослідженні, присвяченому аналізу перешкод на шляху впровадження вітрової енергетики в Україні. Це дослідження проводиться в межах моєї бакалаврської дипломної роботи в Тартуському університеті.

Ця угода покликана гарантувати, що ваша участь у зазначеному дослідженні є добровільною та відповідає вашим побажанням.

- Я даю згоду на використання інтерв'ю, яке я збираюся дати/вже дав(ла), виключно в дослідницьких цілях (зокрема для наукових публікацій і звітів) із суворим дотриманням моєї анонімності.

Контактні дані дослідника:

Софія Гальченко

g * * * * * * *6@gmail.com

University of Tartu

Підпис учасника: _____

Дата: _____

Адреса: _____

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APPENDIX C

Comparative PESTEL analysis

Interviewee	Political	Economic	Social	Technological	Environmental	Legal
Interviewee 1	Lack of consistent political support; frequent legislative changes.	Difficulty finding off-takers; high turbine delivery costs due to war risks.	Local communities prioritize economic benefits; resistance from landowners; lack of awareness.	Outdated infrastructure; limited local expertise; technical challenges related to terrain.	Restrictions in ecologically sensitive zones; required impact assesment.	Complex permitting processes; ambiguities in land use regulations.
Interviewee 2	Inconsistent regulatory framework; delayed auctions; short-term political priorities over sustainability.	Accumulated debts in the renewable energy sector; price caps limiting profitability.	Public resistance due to health risks and environmental concerns; lack of awareness about benefits.	Grid integration challenges; insufficient balancing capacities; lack of mandatory energy storage systems.	Land use restrictions in protected areas; ecological impacts on wildlife.	Complex bureaucratic procedures; ambiguities in renewable energy incentives.
Interviewee 3	Unpredictable regulatory policies; retrospective changes in legislation.	High import taxes on equipment; underdeveloped corporate PPAs; debt crisis in the energy sector.	Local resistance due to misinformation; perception of fewer jobs compared to other industries.	Bureaucratic hurdles in grid connection; dependence on monopolistic grid operators.	Misinformation about harm to ecosystems; lack of focus on sustainability in policymaking.	Complex legal frameworks for project approvals; delays in dispute resolution by antitrust bodies.
Interviewee 4	Inconsistent government support; delays in auctions due to market debt and war risks.	Existing debts under the green tariff scheme; high upfront capital costs; challenges in securing financing.	Mixed public perception; resistance in scenic areas, but positive reception due to tax revenues and jobs.	Intermittency requires balancing capacities.	Environmental conflicts in scenic areas; comprehensive environmental impact assessments.	Time-consuming permitting processes; ongoing legal reforms to streamline regulations with EU standards.

Interviewee	Political	Economic	Social	Technological	Environmental	Legal
Interviewee 5	Lack of long-term policies, unreliable government-backed auctions (CFDs), and political instability.	Absence of Project Finance, reliance on Corporate Finance, and delayed payments under the Green Tariff.	Mixed community perceptions, with concerns about noise, visual, and environmental impacts.	War-related logistics issues, lack of cranes and insurance, and transport challenges.	Complex ESIA process, unclear protected area rules, and biodiversity concerns.	Complicated permits, slow approvals from state bodies, and legal uncertainties in land use and planning.
Interviewee 6	Bureaucratic delays, a lack of investor guarantees, and an absence of clear mechanisms.	High costs of credit resources, a lack of long-term financial mechanisms, and war-related risks.	Support of communities due to economic benefits, but concerns about noise, health impacts, and landscape changes.	Insufficient grid capacity and a lack of system flexibility for variable generation.	Land use in ecologically sensitive areas; complex and non-transparent environmental assessment procedures.	Delays and inconsistencies in permitting processes and inadequate investor protection.

Source: compiled by the author

Resümee

TUULEENERGIA RAKENDAMISE TÕKKED UKRAINA ENERGIAAHJEL

Sofiia Halchenko

Tuuleenergia on üks jätkusuutlikumaid taastuvenergia allikaid, mis pakub keskkonnasõbralikku ja majanduslikult kasulikku alternatiivi fossiilkütuste kasutamisele. Käesoleva bakalaureusetöö eesmärk on tuvastada Ukraina tuuleenergia arengu takistused. Uurimus tugineb teoreetilisele raamistikule, võrdlevatele analüüsidele Poola, Serbia ja Kazaakhstani olukorrast ning empiirilisele analüüsile, mis põhineb Ukraina kontekstis läbi viidud ekspertide intervjuudel.

Ukraine on suurepärane kandidaat tuuleenergia kasutuselevõtuks, arvestades selle geograafilist asukohta Musta mere ja Aasovi mere ääres. Samuti on Ukrainas ulatuslikud rannikualas, mis annavad võimaluse rakendada tuulepargi projekte. Samuti on riigil potentsiaali tuuleenergiat kasutades vähendada oma sõltuvust välisenergiast ja edendada energiajulgeolekut. Siiski seisab Ukraina silmitsi mitmete takistustega. Nende hulka kuuluvad poliitiline ebastabiilsus, majanduslikud probleemid, ühiskonna vastuseis, vananenud infrastruktuur, keskkonnamõjud ja keerulised õiguslikud protsessid. Näiteks roheenergia tariifi (*Green Tariff*) tühistamine ja retrospektiivsed poliitilised muudatused on vähendanud investorite usku. Majanduslikud tõkked hõlmavad kõrgeid alginvesteeringute makse, akumuleerunud võlga taastuvenergia sektoris ning rahastamisprobleeme. Ühiskondlik vastuseis tuleneb tihti ekslikest teadmistest, terviseohtudest ja keskkonnamõjudest.

Poola, Serbia ja Kasahstani vaheline võrdlus näitab, et paljud takistused on sarnased, sealhulgas fossiilkütuseid ümbritsev poliitika, majanduslikud kitsaskohad ja vananenud tehnoloogiad. Siiski on Ukraina olukord eriline, arvestades selle geopoliitilisi konflikte ja Euroopa Liidu nõudmistele vastamist. Intervjuuded Ukraina ekspertidega rõhutati, et stabiilne ja ennustatav seadusandlik raamistik on esmatähtis investorite usalduse taastamiseks. Finantsmehhanismide loomine, ühiskonna kaasamine, teadlikkuse tõstmine ja tehnoloogilised uuendused võivad aidata neid probleeme lahendada.

Kokkuvõttes on tuuleenergia rakendamiseks Ukrainas vajalik integreeritud lähenemisviis, mis arvestab poliitilisi, majanduslikke, sotsiaalseid, tehnoloogilisi, keskkonna- ja seadusandlikke tegureid. Rahvusvahelise koostöö ja detsentraliseeritud energiasüsteemide rakendamise kaudu saab Ukraina ületada praegused takistused ja liikuda jätkusuutlikuma energia tuleviku suunas.

See uurimus pakub aluse poliitikutele, tööstusharudele ja teadlastele edasiseks uurimiseks ning keskkonnasõbraliku energia arendamisele.

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