Renewable Energy and Energy Security in Ukraine:

A Strategic Response to Energy Vulnerability and Conflict Resilience During Wartime and Postwar Reconstruction.

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ABSTRACT

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For the degree of Master of Science and entitled: Renewable Energy and Energy Security in Ukraine: A Strategic Response to Energy Vulnerability and Conflict Resilience During Wartime and Postwar Reconstruction.

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The research aims to provide a comprehensive understanding of the unique advantages of renewable energy sources (RES) in the context of Ukraine, highlighting their potential to address energy disruptions and contribute to the country's energy security and independence. It also considers possible factors that can hinder the implementation of these technologies, including economic, financial, technological, and safety barriers. By addressing these obstacles, the research seeks to identify practical strategies to overcome them and foster the adoption of renewable energy solutions in Ukraine.

In this research energy security is analyzed through the Three Perspectives of Energy Security theoretical framework by Aleh Cherp and Jessica Jewell (2011a). These perspectives are sovereignty, resilience, and robustness, which cover three main dimensions that influence energy security: economics, political science, and engineering. Within this framework, the thesis identifies the most effective pathways and recommendations for Ukraine to follow in order to ensure energy security.

Renewable energy offers a fast, flexible, and sustainable way to restore Ukraine's energy security in response to wartime disruptions (Doronina et al., 2024). Its decentralized nature makes it more resilient to attacks compared to traditional energy infrastructure. Ukraine has strong potential for renewables, particularly in solar and wind, due to its favorable natural conditions. This research, based on the current state of the energy system and renewable technologies in Ukraine, presents practical recommendations for advancing renewables. Beyond the war, the findings provide a foundation for Ukraine's long-term energy transition and environmental policy.

Key words: energy security, renewable energy sources, Ukraine, resilience, robustness, sovereignty, Russo-Ukraine war, interdependence, decentralization, energy crises.

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RES	Renewable energy resource
CIS	Commonwealth of Independent States
USSR	Union of Soviet Socialist Republics
DTEK	Donbas Fuel-Energy Company
ENTSO-E	European Network of Transmission System Operators for Electricity
ERDB	European Bank for Reconstruction and Development
IFC	International Finance Corporation
TPP	Thermal power plant
NPP	Nuclear power plant
NECP	National Energy and Climate Plan
NATO	North Atlantic Treaty Organization
EU	European Union

1. INTRODUCTION

The ongoing war in Ukraine has touched every part of daily life, affecting each Ukrainian and the nation as a whole. In one day, the environment, the economy, culture, and politics all became unimportant, and the only thing people were thinking about was 'When will it all end?' But now, more than three years later Ukraine is still standing, and the need for sustainable, innovative solutions and forward-looking reconstruction strategies has never been more urgent.

The Russian invasion of Ukraine on February 24th, 2022, caused widespread destruction to the whole country. Military attacks with missiles and drones happen every week all over the country bringing darkness, sadness, and death. Its consequences are immense, posing serious challenges for Ukraine, especially for the Ukrainian energy system, which has been under attack since the first day of the war. It is a Russian strategic decision to attack power plants to leave Ukrainians dealing with blackouts and cold winters without power for days. They use energy as a weapon in this bloody war to showcase how dependent Ukraine, and Europe as well, is on Russian energy.

Most of the biggest Ukrainian energy plants have been under attack since 2022. Russians attack those power plants not only to disrupt people's lives, but they use them as an environmental threat attacking the Chornobyl and Zaporizhzhya nuclear power plants. Every missile raid emphasizes how dependent Ukraine was on Russian energy by not being able to provide enough supply. This is where the question of energy security arises. Energy security is a problem that actively has been addressed in the last years, since the beginning of the Russian invasion. I believe this topic should be addressed from a Ukrainian perspective, as energy security is fundamentally tied to national security. In Ukraine's case, a reliable and independent energy system is a critical factor in ensuring territorial sovereignty and building a resilient and independent future.

One of the reasons this research is particularly relevant is that the war has not only disrupted Ukraine's energy system but also significantly impacted the global energy market. Russia is an important factor in the world energy market and the war resulted in disruptions of trade routes and had an impact on energy pricing (Maneejuk et al. 2024). It sparked Europe to phase out fossil fuels and reconsider their dependence on Russian gas, which is a positive thing, but it came with its disadvantages (European Commission 2025b).

Considering the importance of strengthening energy security, renewable energy sources (RESs) present one of the most viable and strategic solutions. RES offers a sustainable, decentralized, and increasingly cost-effective alternative (Johansson 2013). In the context of Ukraine, where energy infrastructure has been repeatedly targeted and where dependence on external energy supplies poses serious national security risks, the integration of RES into the national energy system is not only environmentally responsible but strategically essential. There is a research gap present regarding the relations between renewable energy and energy security, most papers are focused on the domestic use of RESs but do not display a broader context. This research specifically explores how renewable energy sources can be effectively incorporated into Ukraine's energy landscape, with the primary objective of enhancing the country's energy independence and long-term security.

It is important to emphasize, that before the full-scale invasion, Ukraine was one of the top countries with the rapid development of renewable energy. Thanks to the geographical factors and climate conditions solar energy is one of the main and perspective methods of generating renewable energy (Omelchenko 2022). Renewable technologies can not only provide security for the Ukrainian energy system during wartime but can contribute to the future sustainable economic development and modernization of the energy system. Currently, after the past winters of blackouts, Ukrainian companies and households are installing more and more renewable energy sources, that can help survive the cold nights and be independent

and secure in case of another missile attack (GIZ 2024). The assurance of energy security in Ukraine is considered through the three perspectives of energy security, as outlined by Aleh Cherp and Jessica Jewell (2011a), representing various fields of further development: resilience (economics), sovereignty (political science), and robustness (engineering).

Overall, this research explores the potential for establishing energy security in Ukraine through the use of renewable energy sources during a time of war and ongoing attacks. The study offers a contextual analysis of the historical energy relationship between Ukraine and Russia, examining perspectives from both the Ukrainian and broader European sides. It highlights key political events that have shaped the current situation and identifies lessons to be learned to avoid repeating past mistakes. With the help of conducted interviews with experts in the renewable energy sector, the research assesses the current state of Ukraine's energy system and evaluates prospects for renewable energy sources. Based on these insights, I propose recommendations for policy measures and financial mechanisms that could support a sustainable energy transition and contribute to a more secure and resilient energy system.

1.1. Motivation of the research

As a Ukrainian, I am deeply concerned about the future of my country. The main motivation behind this research is to contribute my perspective to Ukraine's reconstruction. I have often heard that, during an ongoing war, environmental concerns are secondary, and that there are more pressing issues to address. However, I disagree. War, despite its devastation, offers a rare opportunity to rethink and rebuild outdated systems in ways that can benefit the country in the long run. For the past three years, Ukrainians have faced frequent blackouts and power outages, which have severely affected daily life. I believe those energy system challenges, combined with the urgent need for post-war recovery, present a chance to propose sustainable solutions that not only solve current problems but also lay the groundwork for a more resilient and secure future for Ukraine.

1.2. Research questions, aim and objectives

With this thesis, I aim to answer three research questions. The main research question is: How can Ukraine implement renewables to ensure energy security during wartime and support a future sustainable energy transition? This question will uncover specific mechanisms and tools that will help the implementation of RESs. Additional sub-question is: What is the current state of Ukraine's energy system (incl. renewables) amidst the ongoing war? Which is important to consider in the context of Ukraine's energy system. The second sub-question is: How renewables can be supported (financial, political, etc.) to be integrated into Ukraine's energy system? I address these specific questions in the discussion section following the completion of the research.

This thesis aims to research possible directions for Ukrainian energy system development with the main goal of achieving energy security through the use of renewables. This thesis aims to deepen the understanding of energy security and explore the various pathways for achieving it, with a particular emphasis on the role of renewable energy sources. By examining how renewables can contribute to a more stable, resilient, and sustainable energy system, the study seeks to highlight their strategic importance in the context of national security and the country's reconstruction.

The objectives of this study are first, to analyse the state of the energy system in Ukraine before missile attacks (before 2022) and during the active military actions. It provides a contextual explanation of the current condition. Secondly, through the insights from experts and professionals comprehend the problematic aspects and possible pathways for their resolution.

1.3. Outline of the thesis

This thesis consists of six main chapters. The first part is a literature review, which provides an analysis of academic research on energy system resilience and energy system

security, outlining the definitions of those concepts for further research. The literature review is based on publications analyzing energy system security from different perspectives as the topic of energy security can be interpreted differently. Additionally, the selected literature covers the potential of renewable energy technologies with the goal of improving energy security. The literature review also includes the theoretical framework guiding this study, which forms the analysis of energy security in Ukraine. The second part outlines the methodology used in this study, providing reasoning for the use of qualitative analysis and explaining the sources of data collection. The third part of the thesis is dedicated to the contextual analysis, that covers the historical background of Russia's energy relations with the European Union and Ukraine through the connected pipeline grid. Particular attention is given to three major energy crises triggered by Russia since the collapse of the Soviet Union. The fourth chapter introduces the results of the conducted research. It presents an analysis of the approved National Energy and Climate Plan, along with findings from coded interviews with experts in the field. The fifth part includes the discussion chapter, which engages with the key findings from the analysis. It outlines the prospects for renewable energy sources in Ukraine, supported by specific mechanisms identified through analysis. Lastly, the conclusion chapter summarizes the main findings of the study.

2. LITERATURE REVIEW. DEFINING THE CONCEPTS

The following literature review is based on identifying two main concepts of this research – "(energy) system resilience" and "(energy) security", to have a clear framework and understanding of the context of this research. With the help of recent publications analyzing Ukraine's energy system, historical background, and future perspectives, along with documentation on environmental policies implemented by the government before the war, and the adjustments made in response to wartime challenges, I want to propose an overview of Ukraine's prospects and benefits. Additionally, the selected literature focuses on the potential of renewable energy technologies in Ukraine, with a particular emphasis on solar power as a viable solution for energy resilience and transition supported by a theoretical framework, which shapes the understanding of energy security in Ukraine. To support the analysis, the review examines studies on the role of renewable energy technologies in mitigating disruptions caused by attacks on energy infrastructure and works on achieving energy security.

2.1. Defining the concepts – "Energy system resilience"

It is logical to start this literature review by clarifying the definition of the main concept of this research – energy system resilience. Given the various definitions of energy system aspects, many features can be taken into account, making it difficult to capture the concept in a single definition.

Geoff O'Brien (2009) highlights the need for and importance of an appropriate framework to understand the energy objectives of any energy policy or system, but I believe it can be applicable to academic research as well. They state that energy systems are very complex in technical and geopolitical challenges, which is impossible to disagree with, and those complexities and interconnections generate and increase vulnerabilities. In Ukraine, geopolitical and technical disruptions are interconnected because of the war. Therefore, having

a clear understanding of the key concepts, at least within the context of this research, is crucial for further analysis.

In this section, I want to look at different understandings of energy system resilience in academia, so that in the end I can identify my definition based on the work done before and which captures the framework and context of this research.

Looking at the concept of "energy system resilience" I found various articles capturing the idea, but it varies from research to research. If we are looking at the commonly used word "resilience" it implies the ability of a system to come back to a regular normal state after the disruptive event (Merriam-Webster 2024). The term "resilience" has been addressed by different disciplines, like economics, psychology, business administration, ecology, etc.

When considering resilience from an environmental perspective, an insightful article by Carl Folke (2016) describes it as a concept that emerged "as a lens of inquiry," serving as a foundation for interdisciplinary collaboration. "Resilience reflects the ability of people, communities, societies, and cultures to live and develop with change, with ever-changing environments" - this definition by Folke (2016) captures the significance of the environment around us, most importantly, its influence on us, which I believe is a crucial factor in defining resilience. (Folke 2016). According to their work, resilience is about the continuity of embracing the changes, transforming, innovating, adapting, learning, improving, etc. Carl Folke (2016) highlights adaptability as a core function of resilience; the capacity of people, environments, and systems to integrate experiences and adjust solutions. As he explains, "It (adaptability) helps turn changes and surprises into opportunities and, hence, is an important part of social-ecological resilience" (Folke 2016). I find Folke's definition both philosophical and comprehensive, as it frames resilience within the context of sustainability science. In this view, the system is seen as a dynamic entity capable of transformation and adaptation, not merely a fixed set of procedures.

To continue this literature review, I examined the work of Hosseini, Barker, and Ramirez-Marquez (2016), which provides a valuable introduction to the concept of system resilience. Their review analyzes definitions across four different domains and offers a versatile explanation. They have identified four main domains of resilience: organizational, social, economic, and engineering. These represent the broad categories to which "system resilience" can be attributed, depending on the context and focus of the analysis. One of the key disciplines that apply the resilience concept is the Environmental, Social, and Ecological domain, highlighting the growing relevance and importance of system resilience in addressing environmental challenges and supporting sustainable development (Hosseini et al. 2016).

According to O'Brien (2009), mentioned earlier, the concept of resilience centers on resources and adaptive capacity rather than on needs and vulnerabilities. A resilient system functions to reduce these vulnerabilities through knowledge, skills, and physical resources; the ability to identify and respond effectively to risks; and to reorganize itself and preserve the same functions that were present before the disturbance. O'Brien (2009) reviews the resilience in energy systems from more of a holistic and wider perspective, not only from an engineering perspective, which is the first idea that comes to your mind when talking about energy system resilience, especially considering the context of war. They state that renewable energy systems are vulnerable as well; renewable energy systems are susceptible to intermittency, meaning the energy source is not always available, and they don't share the same weaknesses as traditional energy systems (O'Brien 2009, 403). So, even though renewables have their challenges, those challenges are different from the ones the current energy system faces, such as fuel supply disruptions, geopolitical dependencies, or centralized infrastructure failures, which is the main emphasis of this research.

Jasiūnas at al. (2021) identified aspects and abilities of energy systems and disruptions based on various system resilience definitions. They state that resilience depends on the type

of disruptions. Coming out of it, the main energy system abilities are survival, maintenance, quick recovery, and transformation. These are the internal capabilities that allow the system to manage disruptions and reflect how resilient systems keep functioning or improve after a challenge. Disruption abilities, which describe how the system handles disturbances directly, are the capacity to anticipate, absorb, withstand, adapt to, and learn from disruptions. This emphasizes proactive and reactive responses to external stress (Jasiūnas et al. 2021).

Resilience is frequently used interchangeably with related concepts such as robustness, flexibility, survivability, agility, resourcefulness, and recovery (Jasiūnas et al. 2021). In the context of this research, these terms may also be used, with the understanding that they imply the broader concept of "resilience."

The paper that is fundamental for this work and inspired this research by Aleh Cherp and Jessica Jewel (2011a) views resilience as one of the perspectives of energy security, which I will elaborate on a little bit later. By "resilience" perspective they address "economics and complex systems analysis." (Cherp and Jewell 2011a). It looks for more general characteristics of energy systems, that help to protect against various threats by spreading both known and unknown risks and preparing for them in advance. It views energy system resilience not only as a complex system but also as an inherently "unpredictable and uncontrollable" one with an uncertain future (Cherp and Jewell 2011a, 6). This includes regulation changes, unexpected economic crises, changes in political regimes, the emergence of disruptive technologies, and climate change consequences. And a resilient system is a system that can be flexible and adaptable to those changes, and diverse to ensure the protection against possible future threats.

The International Energy Agency (IEA) provides a clear definition: "Resilience of the energy sector refers to the capacity of the energy system or its components to cope with a hazardous event or trend, responding in ways that maintain their essential function, identity, and structure while also maintaining the capacity for adaptation, learning, and transformation."

(OECD/IEA 2015, 1). It is important to note, however, that the IEA primarily frames energy system resilience in the context of climate change threats that can have a negative impact on the energy sector. For this reason, resilience to climate-related impacts is essential for ensuring the technical feasibility of energy systems and meeting growing energy demand (OECD/IEA 2015). The IEA emphasizes that the energy sector must assess and address the risks posed by climate change, which can significantly disrupt its operations.

The main difference among the various definitions of "resilience" lies in their focus: some emphasize actions taken before a disruption, while others highlight how a system (or entity such as a community or region) responds after an event has occurred (Carlson 2012, 12). However, there is a third critical component — mediating factors. As Monie et al. (2025) argue, a comprehensive analysis of resilience must consider all three dimensions. Based on this conceptual structure, I want to summarize the mentioned definitions and offer my own interpretation of resilience.

To represent energy system resilience most effectively in this research, I chose to construct a resilience curve (see ***Figure 1***), informed by the works referenced above. In ***Figure 1***, resilience is depicted across three phases, as outlined by Monie et al. (2025, 3): *before*, *during*, and *after*. The *before* phase reflects the system's preparedness at any given time, it is crucial because some disturbances cannot be predicted (for example, unexpected Russian attacks on power plants across Ukraine). Cherp and Jewell (2011a) emphasize the fact that the future is inherently unpredictable. Preparedness, therefore, includes system analysis and assessment, planning, risk identification, and the implementation of actions to reduce vulnerabilities beforehand. The *during* phase focuses on mitigation, specifically, the system's ability to absorb the consequences of a disruption. Gradually, the system then transitions into the *after* phase, where it begins to respond through adaptation, restoration, development, and recovery. A key characteristic of a resilient system is its ability to return to a stable or regular

operational state. Moreover, systems exposed to disturbances and risks are able to operate below their expected pre-disturbance performance levels. (Monie et al. 2025).

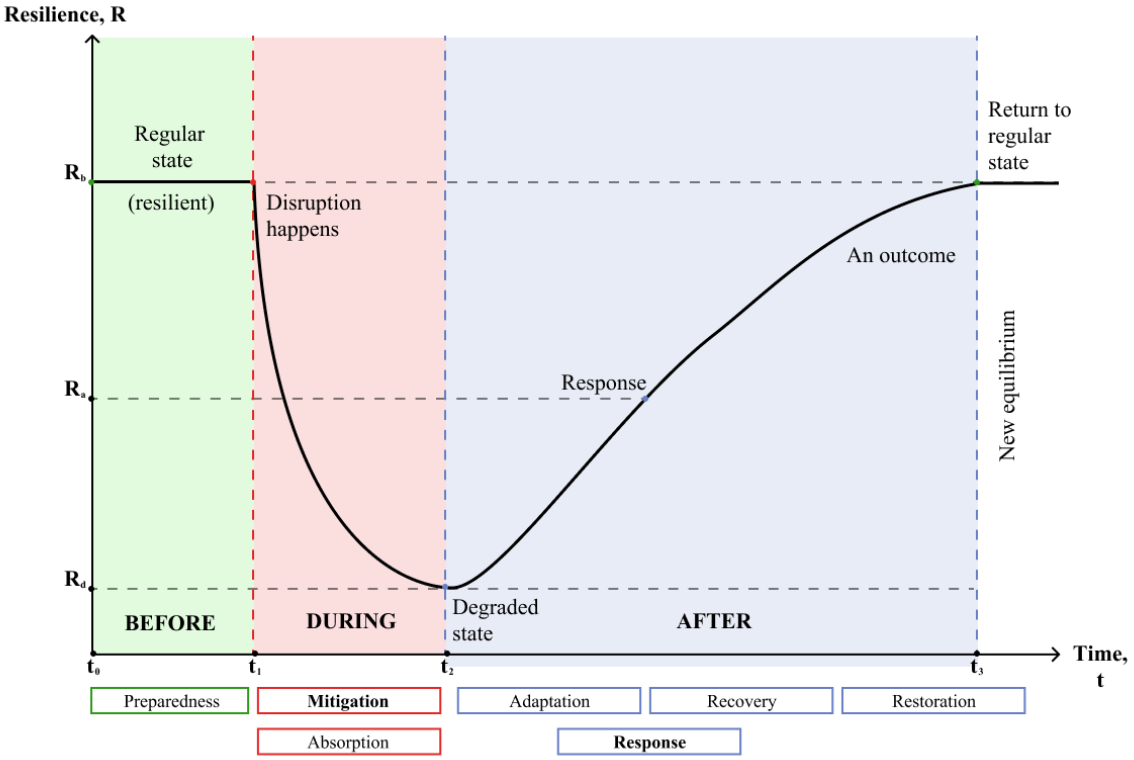

***Figure 1**. Resilience curve. An event progression with three different phases while the disturbance strikes based on Monie et al. (2025), Jasiūnas (2021), and Carlson et al. (2012).*

To conclude this section, it is important to emphasize that defining system resilience is not only essential for establishing the theoretical framework of this research (or any similar study) but also serves as a foundation for identifying measurable resilience indicators. While I found it challenging to summarize the concept of "energy system resilience" into a single sentence, I have aimed to provide a comprehensive explanation that supports a clearer understanding for readers from diverse academic and professional backgrounds. This conceptual framework will guide the subsequent stages of this thesis, informing both the analytical approach and the interpretation of findings.

2.2. Defining the concepts – "Energy security". Whose security?

To continue this literature review I want to define a broader concept of "energy security", which is one of the main topics in Ukraine and Europe as well. I will try to answer questions such as: what does it mean to secure energy, and how can energy be secured?

In some literature, energy system resilience, and energy system security are used interchangeably, but in the context of this work, I consider those terms as two different concepts that complement each other and provide a clearer foundation for this research. Often energy system resilience is considered as a part of energy security, and I agree with this idea. And I will develop and support this statement with an overview of existing literature.

In the context of this research, the concept of security extends beyond energy security alone, as it forms the foundation of the entire thesis. As previously mentioned, security is a critical consideration in the Ukrainian wartime context. Since Russia's invasion in 2022, security, across all its dimensions, has become severely compromised in Ukraine. Although my primary focus is on energy security, it is important to recognize that energy security is deeply connected with other aspects of national and human security. Energy infrastructure is both a strategic asset and a target during this war, and its disruption has cascading effects on economic stability, civilian well-being, and political sovereignty. Therefore, it is important to remember that energy resilience is not merely a technical issue but also a matter of national survival and strategic importance in times of war.

I decided to begin my research on the topic of energy security with the book Security Studies: An Applied Introduction by Rossi and Riemann (2024). This book offers a comprehensive overview of security in various contexts, including international security, state security, human security, and wartime security. Security studies started to "broaden" and "deepen" times of the Cold War by the end of the 1980s, which means that they started to pluralize. Security went over just the state and interstate security terms. One of the reasons for

that change was worldwide problems, for example, climate change and pandemics. They are changing the way we think about national security. Traditionally, security was understood as protecting a country's borders using military power. But issues like global warming or the spread of viruses don't respect borders, and military forces can't solve them. These challenges are pushing us to rethink security beyond just defense and toward cooperation, public health, environmental sustainability, and international responses (Rossi & Riemann 2024, 11).

Similar to energy system resilience, energy security does not have one specific definition that can be applied (Rossi & Riemann 2024, 14). It is important as well to clarify this concept for further research, because of the role that energy has in our lives, energy is crucial for the survival and functioning of modern society (Azzuni and Breyer 2018). Azzuni and Breyer (2018) emphasize that enhancing energy security is a central objective of sustainable energy strategies, an aim that also aligns with the goals of this research. The development of national energy security is a way to achieve freedom and sovereignty. Moreover, the definition of energy security highly affects how to measure this security. With different definitions, different perspectives and aspects arise and with that information, various tools and approaches can be used (Azzuni and Breyer 2018). The concept of energy security is highly context-dependent, shaped by national policies and evolving geopolitical issues and concerns (Azzuni and Breyer 2018). This is especially evident in the context of the war in Ukraine, where energy security concerns are deeply intertwined with Europe's dependence on Russian energy resources. The full-scale invasion sparked a re-evaluation of what constitutes secure and resilient energy systems, shifting the focus from supply reliability to broader issues like political stability and energy independence.

I find the paper by Azzuni and Breyer (2018) extremely useful when considering the concept of energy security. They provide a very comprehensive overview of how the idea of energy security has developed over time. Since the beginning of the 20th century, the question

of energy security has become very relevant to the need to supply oil for armies. Based on their work, it's clear that the definition of energy security has evolved significantly over the last 50 years because of the 1973 energy crisis, the growing focus on environmental issues, and the rise of ecology importance. Throughout this period, the term has been expanded by incorporating various new perspectives and dimensions, such as economics, politics, supply and imports, international stability, infrastructure, national power, and more recently, environment and sustainability (Azzuni and Breyer 2018). Despite these shifts, the core idea going along most of the definitions is that energy security refers to a state being free from risks and disruptions. It seems to be quite simple, but it is a definition that tries to capture the most dimensions and perspectives. Unfortunately, in my opinion, by being that simple it does not provide a full explanation and is quite shallow.

Shane Mulligan (2008) perfectly highlights the versatile definition of energy security. Traditionally, energy security was understood in terms of "the military power of states, and their capacity to respond to threats." (Mulligan 2008, 2). But, as was mentioned already, with the end of the Cold War, the energy security comprehension expanded and included environmental security as well. The concept of energy security is typically shaped by the interests and priorities of the state, particularly in terms of the military. Moreover, Mulligan (2008, 4) emphasizes the relationship between energy security and state security, energy as a power. A key historical example that Mulligan (2008) presents is British marines during World War I, who heavily relied on access to oil. Winston Churchill, who was then responsible for the Royal Navy, emphasized the need for Britain to control oil as its source to ensure a secure supply (Mulligan 2008, 4).

Mulligan (2008, 7) adds that traditional state-centered concepts of security, particularly energy security, often overlook ecological degradation, especially for Indigenous and marginalized communities. In the pursuit of national energy interests, sovereign states have

contributed to environmental harm and displaced communities (Mulligan 2008, 8). This creates security dilemmas where one state's actions to ensure its stability threaten the safety and well-being of others. This paper underlines the importance of considering energy security within different dimensions.

Renewables are the main focus of this study therefore I have tried to address the role of renewables in relation to energy security. There is not a lot of research that particularly refers to renewables, but a paper by Johansson (2013) turns to RES as an improvement of energy security. He states that energy policy is built on three pillars: competitiveness (economic and political risk factors), security of supply and demand, and the environment. RES such as wind, solar, and hydro improve energy security by eliminating the majority of the risks, particularly reducing dependency on finite and geopolitically sensitive fossil fuel supplies (Johansson 2013, 598-599). According to Johansson (2013) main advantage of RES is that they are based on energy flows available to everyone, which improves long-term energy security by being widely disturbed, less politically sensitive, and extendable. RES can affect energy security in various ways. The impact depends on the kind of energy source and the institutions and regulations in place to manage the technologies (Johansson 2013, 603).

Referring to Cherp (2012), a researcher whose work is quite relevant to this thesis, confirms the complexity of energy security: "...in complex and open energy systems where everything is connected to everything else, any little factor is likely to be at least somehow relevant to energy security." He highlights different approaches to analyse energy security, such as identifying vulnerabilities and addressing weaknesses and it requires quite comprehensive research (Cherp 2012). To simplify my research, I am going to be focusing only on the context of Ukraine, which only will help to stay focused throughout the development of this thesis. In another influential work, Cherp and Jewell (2014) explore the theoretical concept of energy security through the lens of the "four As" theory: availability,

accessibility, affordability, and acceptability. While they acknowledge that this framework has certain limitations, I believe that, when viewed from a more contextual perspective, it offers a meaningful and practical approach to understanding energy security. Its strength lies in the ability to capture a broad spectrum of concerns while remaining adaptable to different situations and policy environments. Cherp and Jewell (2011a) also propose the Three perspectives of the energy security framework, which is the basis for this study, and I will go into it deeper in the next section.

Defining energy security is quite complex, and various security studies have proposed different guiding questions to help navigate this process (Cherp and Jewell 2014) & (Rossi and Riemann 2024). Each theoretical approach highlights different dimensions of energy security and emphasizes priorities. Cherp and Jewell (2014) propose three foundational questions: *Security for whom? Security for which values?* and *Security from what threats?* These questions provide a critical lens through which to evaluate energy security in specific contexts. In contrast, Rossi and Riemann (2024) propose only one single question, but it's equally important: *Whose security?* Underscoring the subjective and political nature of energy-related risks and protections. Additionally, Jewell, Cherp, and Riahi (2014) offer a concise and non-restrictive definition of energy security as the "low vulnerability of vital energy systems." While this definition is valuable in its simplicity and flexibility, it avoids tying energy security to any single resource, system, or geopolitical stance. I want to develop a more concrete interpretation in this research. To achieve that, I attempt to answer the three fundamental questions posed by Cherp and Jewell (2014) with the support of the four As framework. This combination allows for a more nuanced and structured analysis, helping to have a clearer understanding of what energy security means within the specific focus of this thesis.

Security for whom? Typically answer to this question is the state, which is understandable. But if we look at this question from the perspective of the four As framework,

specifically affordability and accessibility – "consumers" is the answer as well. The energy should have an affordable and acceptable price both for the state and consumers, as well as it should be accessible and available, which will ensure security. *Security for which values?* In relation to Ukraine energy security advocates for independence and sovereignty values. "Protecting values of different nations means protecting distinct energy systems of those nations, not 'energy in general." (Cherp and Jewell 2014, 418). Ukraine's most important value is the protection of its territorial sovereignty and independence, so accessible and affordable energy is the factor that can strengthen national security. *Security from what threats?* Well, the answer to this question is quite obvious – Russian attacks and influence. These are major threats not only to energy security but to national security as well. And lastly, *whose security?* Energy security of an independent country. Those questions outline the main objectives and goals of this research.

To conclude, energy security is the security concern about the future of a state. This is why examining energy security is important in the context of Ukraine's present and future sovereignty, it is a way to achieve independence. It is a complex subject, which is highly context-dependent, but for this research, I have identified the main referent objects of energy security in Ukraine with the help of Cherp and Jewell (2014), specifically their foundational questions. They indicated the main priorities of this research and helped to figure out the concept of energy security from an availability, accessibility, affordability, and acceptability outlook.

2.3. Theoretical framework

Energy security is a very complex subject, that can be interpreted differently by different people, but it does not make it meaningless. However, these variations don't imply multiple concepts of energy security, they reflect how one concept adapts to different contexts. Current energy security concerns extend far beyond just oil supply but cover a range of issues

(Cherp & Jewell 2014). A specific framework can help to cover necessary aspects and provide a clear understanding of energy security. For this research, I chose to look at Aleh Chep's and Jessica Jewell's framework of Three Perspectives on Energy Security (2011a). They emphasize that in developing energy security theories it is important to include different perspectives, in particular economics, political science, and engineering (Cherp & Jewell 2011a). Those perspectives were developed based on the historical evolution of energy security.

It all started during World War II with the supply of fuels for the military. Ensuring access to energy wasn't just about economics, it was tied to national power, geopolitical influence, and survival. Both military force and diplomatic engagement could be used to protect or expand access to energy resources. So, energy security became part of a bigger strategic vision, where energy policy and foreign policy are closely intertwined (Cherp & Jewell 2011a).

The discourse of energy security was brought up because of two factors, as Cherp and Jewell indicate (2011a): globally limited resources and the vulnerability of complex systems. The first one is quite clear, but the vulnerability factor was a major concern. Most energy systems are vulnerable because they rely on technologies fueled by imported energy sources. Accidents like Chornobyl and Fukushima only raised further concerns. Even short-term disruptions, such as technical failures or terrorist attacks, can sabotage the consistent energy supply. This is why it is important to identify a unified energy security theory, which includes different perspectives and disciplines. The integration of different 'perspectives', like economics and political science helps to overcome the difference in theories. "Viewing energy as a market commodity rather than a public good has increased the relevance of economic rather than political analysis." (Cherp & Jewell 2011a, 3-4).

One effective strategy for enhancing energy security is to approach the policymaking process through three distinct perspectives, a multidimensional approach, which enables a more

targeted focus on specific threats, risks, and strategies. The Three Perspectives are: 'sovereignty', 'robustness' and 'resilience' (Cherp & Jewell 2011a). First, the perspective of 'sovereignty', which comes from political science, highlights security threats posed by major exporters and terrorist nations. In the context of this research, it can help identify potential future threats from Russia, allowing for more resilient and risk-minimization energy strategies. Risk-minimization strategies include switching to more trusted suppliers or diversifying and substituting imported resources with domestic ones, which will support military, political, and economic control over the energy system (Cherp & Jewell 2011a, 5). Second, the 'robustness' perspective, comes from natural science and engineering that considers largely measurable objective factors such as increasing demand, resource depletion, technical failures, and extreme natural events. The strategies to minimize risks involve upgrading the infrastructure, adopting safer technologies, balance out the energy system with different energy sources. The solutions are quite technical, for example, implementing renewable technologies (Cherp & Jewell 2011a, 6). Third, 'resilience', which considers economic factors, implies that the future is highly unpredictable, so it involves the need for certain flexibility and diversity in the energy system. As possible solutions it involves change of political regimes, establishing new policies with the consideration of climate change goals. It looks for general features of energy systems, like flexibility, adaptability, and diversity, that help protect them from all kinds of threats by being prepared for unexpected events. (Cherp & Jewell 2011a, 7) (See ***Fig.2***).

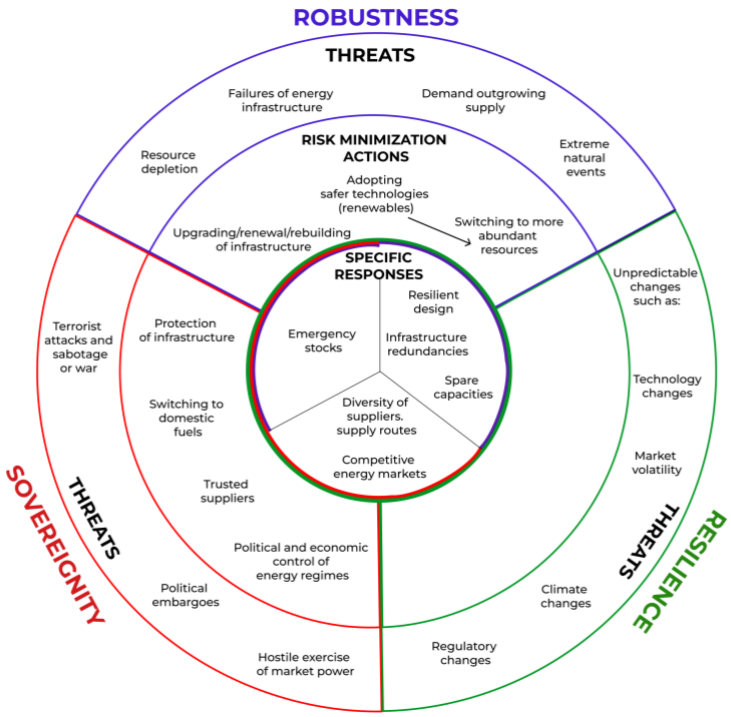

Figure 2. *The Three Perspectives on Energy Security. Energy security threats, risk minimization strategies, and specific responses (Cherp & Jewell 2011, 6).*

To support this theoretical framework, it is important to mention Aleh Cherp and Jessica Jewell's (2011b) work on measuring energy security. They emphasize the temporality of energy systems; they can change and transform. And as I am looking at the future of Ukraine's energy system security, according to Cherp and Jewell (2011b) there are different ways of representing the future. They differentiate three mindsets for the future: 'deterministic', 'sovereignty', and 'resilience' (Cherp and Jewell 2011b, 332). Based on the names of these mindsets alone, it is possible to see the connection to the three perspectives I covered earlier. It explains how we can look at the process of analyzing the energy system. 'Deterministic' mindsets consider the future as consequences of the present. It accounts for resources, stocks, infrastructure, technologies, etc. We can clearly see the connection with the 'robustness' perspective, where future threats and risks caused by natural or technological factors can often be predicted or estimated based on the present features of the system. 'Sovereignty' looks at how energy systems depend on the actions, goals, intentions, and influence of the people

involved. The future is uncertain and shaped by the choices of people pursuing their plans and goals – the 'sovereignty' perspective. Lastly, 'resilience' emphasizes how energy systems can organize themselves without outside control. The future is seen as something that emerges from self-organization, not just as a continuation of the present or a result of some plans – a 'resilience' perspective (Cherp and Jewell 2011b, 332-333).

Coming out of that, it is possible to state that approach to measuring and identifying the energy security system can be different and this theoretical framework is a great way to analyse and categorize the findings. The Three Perspective theoretical framework brings out the energy security theory outside just as the geopolitical problem. Moreover, Cherp and Jewell emphasize that "energy security challenges have to be resolved simultaneously rather than one by one." (Cherp & Jewell 2011a, 7). By including the Three Perspectives on energy security theory and identifying the focus and goal of this research it will be possible to distinguish the main future sustainable energy policy points for Ukraine, which in perspective can ensure Ukrainian energy security after the war and possibly even during it.

3. METHODOLOGY

3.1. Research design

This research covers different methodological approaches to understanding the economic and political complexities and obstacles to achieving energy security in Ukraine with the help of renewables. This methodology explores the political background and current policies within Ukrainian governance regarding RES and examines and tries to predict future reforms for the development of RES. Energy security is a very contextual framework, which requires a thorough analysis from different perspectives (Azzuni and Breyer 2018).

A literature review discovers that energy system resilience and energy security an important aspect of any energy system. What are the main indicators of a resilient and secure energy system? The literature review examines the definition of energy security through the lens of different international outlooks. Although, it covers the theoretical framework of Aleh Cherp and Jessica Jewell (2011a) – Three perspectives of energy security. Based on this theoretical framework I will analyze obtained data and categorize my findings into three main sections, based on those three perspectives – 'sovereignty', 'robustness', and 'resilience', trying to cover the most important aspects of energy security (Cherp and Jewell 2011a).

Further, I am providing a contextual analysis of Russia's energy dominance and power over the EU. As well as the relationship between Ukraine and Russia, particularly in the context of natural gas transit through Ukrainian territory and the disputes that have arisen as a result. Analysis of Ukraine's current energy situation, with a particular focus on its vulnerability and energy security.

Interviews were conducted with Ukrainian experts in the field of solar power and renewable technologies, which helped to gain insights into the effectiveness of the technology, current sector state, and perspectives of renewables in Ukraine during the war and postwar

recovery. Interviews are going to be analyzed with the help of systematic coding, and category based on the theoretical framework mentioned earlier.

3.2. Data analysis

This thesis researches the support of energy security in Ukraine with the help of renewable energy sources, specifically solar power. Moreover, it looks at prospects of future sustainable energy transition with the help of RES. The data analysis includes contextual analysis, qualitative research methods (thematic coding of interviews), and policy review.

3.2.1. Contextual analysis

Contextual analysis in this research is used to look at the historical events that resulted in the present energy dependence of Ukraine. In the context of this research, it is significant to cover the events of the last three decades of Ukraine's independence, specifically the energy crises that appeared at the beginning of the century. The contextual analyses of energy dependence on Russia will provide information about the factors that influenced this dependence and, most importantly, it will give insights for future policy developments. The Russo-Ukrainian war did not start out of nowhere, there were signs and prerequisites for that, and energy transit and export are some of the main indications. Based on previous experience it is possible to avoid the same mistakes and have another perspective on what could have been done differently. It will allow me to have a better understanding of my suggestions and will broaden my discussion.

Moreover, Russia's relations with Europe have a direct impact on Ukraine, because Ukraine is a country that separates, and at the same time, connects Russia with the European Union. Contextual analysis of the development of energy relations is a significant input to have while covering the establishment of energy security in Ukraine.

3.2.2. Interviews

The conducted interviews are used for gathering qualitative data for analysis from the perspective of experienced professionals who work in the field of renewable energy sources and can provide their outlook on the development of this sector within the framework of supporting energy security. A list of questions for semi-structured interviews was structured to cover all the topics needed for this research: current state and prospects, energy security and renewables, support from the EU partners, the role of the state and state policies, social attitudes towards renewables, and future reforms.

Interviews were conducted with the help of Zoom and lasted between 40 minutes and one hour. Every interviewee was provided with the short abstract of the research, and the main goals of the research and was asked to sign a consent form. The consent form included all the information about the conditions the interview was conducted and my further steps using the data. All interviews were video, and audio recorded. For the analysis and coding part, the interviews were transcribed and proof-checked for the accuracy of the information. The interviews were conducted in Ukrainian so the information would be clear and accurate, and it would not create any language barrier. The proof-read transcripts were uploaded to the data analysis software for systematic coding (NVivo).

The interviews were coded based on key themes mentioned before, identifying the patterns and common topics in interviewees' answers. Common topics and perspectives provide an outlook on the state of solar power in Ukraine in the context of energy security. Those semi-structured interviews provide insights from experts who work within the solar power sector and are able to give their professional points of view for a more realistic analysis.

3.2.3. Policy review

For a thorough analysis, a key policy documents review was conducted, which outlines governmental goals related to RES, with a particular focus on solar power. One document that

stood out, frequently referenced during interviews, was the National Energy and Climate Plan (NECP) for the period up to 2030. Given its significance, it became essential not only to examine the NECP itself but also to analyze the official progress report on its implementation.

These documents provide valuable insights into Ukraine's strategic direction for energy transition, outlining targets for renewable integration, investment priorities, and alignment with European Union regulations. By reviewing both the plan and the implementation report, I was able to assess not only the intended policies but also the extent to which these goals have been realized in practice. This approach allowed for a more grounded and realistic evaluation of the current state and prospects of the solar energy sector in Ukraine.

4. CONTEXTUAL ANALYSIS

In this contextual analysis, I am investigating the roots of how Russia obtained this energy dominance and power over the EU. I focused on the key factors that shaped this dynamic, as they are essential for a deeper understanding of the relationship between Russia and Ukraine, particularly given Ukraine's role as a geopolitical and energy mediator between Europe and Russia. This part, also, dives into the relationship between Ukraine and Russia particularly in the context of natural gas transit through Ukrainian territory and the disputes that have arisen as a result.

This section provides an overview of Ukraine's current energy situation, with a particular focus on its vulnerability, energy security, and the need for energy independence. It examines the impact of the ongoing war on the country's energy transition efforts, as well as the policies and projects currently in place to address these challenges. Finally, this part explores how these developments not only support national resilience but also align with broader goals of environmental sustainability.

4.1. Russia's energy dominance and influence on Europe. The power.

The country's energy security is a key aspect of the nationwide economic security system (Sabadash 2011). Energy security in Ukraine is under extreme pressure and faces a wide range of serious risks. As a result, developing effective strategies to improve it has become more urgent than ever. The Russo-Ukrainian war has further intensified these challenges, particularly due to Ukraine's historical energy dependence on Russia, a dominant player in the global energy market. To continue this research, I want to look into the history of how this dependence on Russia was acquired because it can provide answers to how to stop it and how to avoid it in the future.

Nowadays, we can observe not only energy differentiation in the modern world but also the formation of energy connections between countries and regions. These connections are

beginning to replace traditional geopolitical borders or, on the other hand, unite large and small territories, which are becoming zones of strategic partnership. This is why the issue of energy security plays the role of an important regulator of international stability. Russia, recognized by the international community as one of the leading energy powers, is actively participating in shaping a new global energy paradigm, where geopolitics often plays a significant role (Magda 2010, 146).

Historically, Russia has held a significant advantage due to its geographical, economic, and environmental resources, most notably, its access to reserves of oil, gas, coal, and other natural resources. This resource wealth has enabled Moscow to gain political leverage, influence energy pricing, and employ considerable pressure on foreign policy decisions. However, beyond these natural advantages, various other factors have contributed to the situation we see today, specifically, how Russia became so deeply interconnected with Europe and acquired such power in the energy sphere. So, the next section will analyze the key factors that have contributed to Russia's energy power and, more broadly, its overall influence within the European Union.

Firstly, an important (and quite obvious) aspect that established Russia's power in Europe was the construction of a pipeline system, which was transporting Russian (Soviet) oil and gas to Europe. In the 1960s, the Druzhba pipeline initiated this connection, followed by other projects like Bratstvo, Soyuz, and Progress (Perovic 2017). These pipelines were only developing and expanded to improve transportation abilities. In the 1960s-70s Russia was handling intense negotiations regarding energy supplies with Austria, Italy, Germany, France, Sweden, and Finland. Those negotiations resulted in various agreements connecting them to a pipeline grid (Hogselius 2013). With that Soviet Union became committed to its partners, which became even more dependent on Soviet Union energy. The construction of a pipeline was carried through the territory of Ukraine, and Ukraine was an important transit country, a

way for Russian supply into the EU. Exactly during the 90s the idea of a single energy market started to be taken seriously and was becoming a reality (Buchan & Keay 2015). An interconnected energy market was seen as a positive thing that can reduce each state's energy vulnerability to any possible shocks or crises, which makes sense (Andersen et al. 2017). But unfortunately, everything was not that easy and nice.

Secondly, the factor that is very important to mention is the dissolution of The Union of Soviet Socialist Republics (USSR) and the establishment of the Commonwealth of Independent States (CIS) in 1991, which led to complex integrational and geopolitical changes in Europe. The CIS was found to help post-soviet countries to overcome those changes and problems together. In CIS Russia was the most active participant. Strengthening Russia as a leading force in the formation of a new system of interstate political and economic relations in the post-soviet countries was one of the main goals of the Russian Federation (Shcherbyna 2012). External economic and geopolitical relations for Russia were and are the instrument of power. In the 1990s the energy policy was not seen as controversial or "unsafe", because of relatively low prices and abundant supply of resources. Dependence on Russian gas and concerns about supply security were raised in the 2000s, as Russo-Ukrainian relations became increasingly complicated and unstable, especially during the gas disputes of 2006 and 2009, and the annexation of Crimea in 2014 (Andersen et al. 2017). Moreover, with the collapse of the Soviet Union, which brought a complete geopolitical change, the EU saw an opportunity to broaden Europe's energy cooperation with Russia (Buchan & Keay 2015).

Thirdly, in the period from 1991 to 1993 Russia was mostly interested in establishing relations with Eastern and Central European countries (Poland, Bulgaria, Slovakia, and Ukraine), they were afraid that Eastern Europe would move towards the West and isolate Russia (Orban 2008, 35). As Anita Orban (2008) indicates Russian diplomatic relations after the dissolution of the Soviet Union and lost Cold War, were strategically calculated to show

the West and the United States that Russia is a “mature country” that was hoping to build strong and secure relations. During those years Russia had the plan to make Central European countries sign the treaties with “security clauses”, which prohibited joining any security organization or any other party that Russia would consider “counter to its interest”. This way they tried to establish their power, which was already high level, even more, but fortunately this attempt failed. In the end, in 1991-1992 Russia signed bilateral treaties with Poland, Czech Republic, Slovakia, and Hungary by changing their foreign policies (Orban 2008, 36-37).

Fourthly, Russia was quite afraid of NATO enlargement with the fear of being isolated from Europe if the Central European countries would join and the West’s increasing their influence, “Russia viewed NATO enlargement as the embodiment of the changing balance of power” (Orban 2008, 38). And from that point on, the same pattern can be seen continuing to this day, this NATO-Russia battle, if it can be called that. When the Russian invasion of Ukraine happened, one of Russia’s concerns was that Ukraine might join NATO, which, in their view, would essentially mean a direct war between Russia and NATO. At the same time, NATO hasn’t been particularly eager to accept Ukraine either, partly due to the same fear, that doing so could trigger a world war. So, in the end, Ukraine finds itself stuck in between, used as a buffer zone in a much bigger geopolitical game, where neither side is willing to fully commit, yet neither is willing to back off. Moreover, this only shows the amount of power that Russia had and has up until this day in the world arena.

To conclude, as mentioned earlier, Europe’s initial reliance on Russia appeared to be a practical solution for securing natural gas supplies. However, granting Russia too much control and power over this critical resource ultimately proved to be a strategic mistake. Concerns about Europe’s dependence on Russian natural gas began to surface after the supply disruptions or “gas crises” of 2006, 2009, and 2014, which were early warning signs. Yet the European Union failed to properly address the issue until the full-scale invasion of Ukraine in 2022 when

dependence on Russia shifted from being a topic of discussion to an urgent problem. With this leverage, Russian natural gas effectively became an “energy weapon”, used not only against Ukraine but also to pressure other European countries (Hogselius 2013).

4.2. Russia and Ukraine energy (gas) relations

I am approaching an important of this research — Ukraine and Russia’s energy relationships. While their shared history is rich and eventful, I will focus specifically on their gas relations to keep the discussion brief and concise. For this research, it's crucial to examine this factor, as understanding the origins of Ukraine's energy system is essential for supporting a sustainable energy transition and building a secure and resilient energy future. Just to give the reader some context — Russia had an enormous political, economic, and social impact on Ukraine since the beginning of Ukraine’s independence and even before that. It was framed as a “friendly support” and “brotherhood”, but we can see that it was a complete lie. So, keep this in mind before diving into how those energy relations began and how they developed.

4.2.1. Soviet Union and its collapse (1960s-1991)

It all started with the beginning of construction of pipelines connecting Europe and Russia, and Austria was an important factor in this situation. Russia had sufficient capacity to supply gas to Austria, but transportation limitations posed a significant challenge. Much of Russia’s energy resources were in remote regions of the Soviet Union, such as Siberia and Central Asia, making it difficult to transport gas to the western parts of the country and beyond. Therefore, Ukrainian gas from the Galician region, near the border to Czechoslovakia, was a great solution to meet the demand. Galician gas played a key role in the Soviet gas system in Belarus, Lithuania, Latvia, and Russia as well (Hogselius 2013, 95). By 1965-1967 the fields were exploited, and it was obvious that it was not possible to meet a set goal of energy supply to Austria and support Galicia as well. To overcome this challenge new long-distance pipelines

connecting Ukrainian cities like Rivne, Ivano-Frankivsk, Kalush, and Kam'yanets'-Podil's'kyi were constructed (Hogselius 2013, 97). With that in the 1960s-1970s Ukraine became the main exporter of gas from the Soviet Union to Eastern Europe, about 48% of the total Soviet gas production was produced in western Ukraine. Despite this gas pipeline network, many industrial centers, especially Kyiv, Dnipro, Zaporizhzhia, Kryvyi Rih, Lviv, and other western cities, faced serious gas shortages during the winter. After the resource depletion, Ukraine shifted from being a gas exporter to being a transit country (Voytyuk 2021, 215).

The collapse of the Soviet Union in 1992 was the possibility for Ukraine to become independent from Russia, but in some sense, it never happened, unfortunately, they were bound with the energy infrastructure. Nevertheless, after gaining independence, Ukraine strived for freedom from Russian influence while also aiming to maintain good relations with Russia. (Kappeler 2014). In the 1990s, Ukraine struggled to pay for the large volumes of gas it imported from Russia, leading to a debt. In response, Russia periodically cut supplies to enforce payment (cut-offs in 1992 and 1993), prompting Ukraine to divert gas meant for Europe. These disputes over debt, supply cuts, and unauthorized diversions created only more tensions and controversies (Stern 2006).

4.2.2. 2000s and independent Ukraine. Energy crises.

At the beginning of the 21st century, the pipeline grid in Ukraine extended for almost 37 km^2 transiting the Soviet gas to Germany, the Czech Republic, Slovakia, Romania, and Poland. In the 2000s Ukraine was transiting more than 80% of Russian gas exports to Europe. But everything quickly changed after 2004 — the Orange Revolution. I am coming now to the most important timeframe in Ukraine-Russia energy relations (2004-present), which brought up the energy security concerns. The Orange Revolution brought political instability and raised issues that continue to affect Ukraine to this day. The country was divided into the Western part, where people were heading towards Europe and supporting Ukrainian identity and

language, and Eastern, which was more pro-Russian (Torres et al. 2009). Following the Orange Revolution, three main energy crises took place between Russia and Ukraine in 2006, 2009, and 2014.

On January 1st, 2006, Russia cut-off of Turkmen gas supplies to Ukraine, it was the first big energy crisis, that took place between Russia and Ukraine. The reason why this cut-off happened was that Ukraine rejected Gazprom's condition (Russian energy corporation) of paying "European prices" of between $160-$230/mcm for gas. The problem with this cut-off was that allegedly Russia was not delivering agreed volumes of Turkmen gas to Europe. This action had an immediate consequence not only in Ukraine but in Europe as well. In the meantime, Gazprom was insisting that they were supplying the right volumes of gas, and Ukraine was insisting that they did not take any additional gas from the transit. Ukrainian representatives stated that Ukraine took the amount of gas they were entitled to, but unfortunately in the contract signed beforehand with Turkmenistan was no mention of the volume of gas Ukraine was entitled to. So, this dispute left Hungary losing up to 40% of supplies, and Austria, Slovakia, Romania, France, Poland, and Italy losing between 14% and 33%. In response, Gazprom announced it would increase gas flow by 95 million cubic meters per day. By January 4th, most countries had their supplies restored to normal levels, and Ukraine and Russia signed a 5-year agreement (Stern et al. 2006, 43-44).

This gas cut-off was seen as a political move, with Russia trying to intervene in the upcoming elections by putting political pressure. At that time, during the elections, Ukrainians chose Viktor Yushchenko, a president who was heading Ukraine towards the EU and NATO. Russia was trying to "blackmail" Ukraine by raising gas prices and cutting off supply. This energy crisis raised the first signs of energy security concerns in Europe, the question if Russia can be trusted (Stern et al. 2006, 46-47).

The beginning of the 2009 gas energy crisis is considered to be the most serious one, because Russia cut off the gas supply completely, which never happened before. It affected drastically European countries, as well as Ukraine. It all started the same as in 2006, Russia accused Ukraine of stealing gas, while Ukraine was claiming that they only were using technical gas, which is gas that is needed to run the compressor stations. The roots of this conflict were similar to the 2006 crisis: Russia demanded that Ukraine repay its gas debt and warned that failure to do so would result in supply cuts and increased gas prices. As an attempt to fully tie Ukraine to Russia, an offer was made for Ukraine to follow the "Belarusian model", meaning it would sell its stake in the pipeline system in exchange for Russia resolving the crisis (Lee 2017).

With the 2009 energy crisis, the EU became very concerned with the issue that energy security has been disturbed. Energy security is one of the pillars of the EU's energy policy, and this energy shock from Russia's side disrupted more than 15 European countries. The long cut-off in gas supplies pushed the EU to reduce its energy dependence on Russia. The EU revived plans for a Southern Energy Corridor to bring in gas from other sources and supported Ukraine's gas transit system (Stulberg 2015).

One of the main issues was the agreement on gas prices. Ukraine pushed for a gas price of $201 and a transit fee of $2, while Russia demanded $250 per 1,000 cubic meters without raising the transit tariff (Torres et al. 2009). Another issue, as mentioned before, was unpaid debt from the previous year, which Ukraine did not pay fully and was not within negotiated deadlines. On January 7th, 2009, Russia cut off the gas supply completely and Europe entered the negotiations as a mediator because it was evident that Ukraine and Russia could not find a common ground about the gas price. After the negotiations with the European Commission's help on the 19th of January, both sides signed an agreement and on the 20th of January, the gas

flow resumed. The agreement indicated that Ukraine would keep transit fees unchanged and pay a European gas price with a 20% discount in 2009 (Lee 2017).

4.2.3. Beginning of Russia's war against Ukraine in 2014

An important phase in this contextual overview of Ukraine-Russia energy relations is 2014 — the year, when Russia's war against Ukraine started, a tragic year for every Ukrainian. It all started in 2013 with a peaceful demonstration against at that time Ukrainian government — Viktor Yanukovych. People were protesting his decision to reject the Association Agreement with the European Union, and by January 2014 it transformed into a full-on national revolution between Western (pro-European) and Eastern (pro-Russian) views (Stulberg 2015). Concerning the state of gas transit, during the revolution, in April 2014, Russia withdrew the gas price discount it had given Ukraine in December 2013, canceled the reduced gas-export duties tied to the Black Sea Fleet's presence in Crimea, and once again demanded repayment of Ukraine's large gas debt (Łoskot-Strachota and Zachmann 2014).

Russian gas deliveries to Ukraine stopped in June but resumed later in the fall. Ukraine, despite the conflict, allowed Russian gas to transit through its territory to European countries. Both sides acted quite aggressively — Gazprom issued threats and halted deliveries, while Ukraine changed contract terms and build up debts similar to the 2009 dispute. By the early fall of 2014, no agreement had been reached, and the risk of a complete breakdown in gas trade remained high, threatening energy supplies across Eastern and Central Europe. Military tensions between Russia and NATO also intensified during this time. Still, despite the political and military pressures, neither side escalated the gas dispute further. In October 2014, they reached a temporary deal to settle Ukraine's debts and secure gas deliveries through the winter, the so-called 'winter package' to restore gas deliveries to Ukraine from November 2014 to March 2015 (Stulberg 2015).

The transit through Ukraine during 2014 was quite fragile because of the beginning of the war. The first phase of Russia's war was the annexation of Crimea in February 2014. The referendum took place in March of 2014, and there are no exact numbers of the turnout, only the ones that Russia provided. And is important to highlight as well, a referendum took place while Russian armed forces were present in Crimea. So, the legitimacy of this referendum has been widely questioned. The second phase was the war in the East of Ukraine, Donbas region (Luhansk and Donetsk). These two events are closely linked; without the annexation of Crimea, the war in Donbas likely would not have occurred (Sasse 2022). As a result of military actions, Europe imposed economic sanctions limiting Russia's financial and trading operations. All these events raised serious concerns about energy security and the possible Russian future actions (Martinez et al. 2015).

4.3. Russian gas (energy) as a weapon

Building on the previous section, it's helpful to organize these events for clarity. Torres et al. (2009) presented three different stages of development of gas infrastructure in Ukraine, and they are identified by three crisis points, based on Youngblood's (2010) theory: *Pre-Crises, Crisis,* and *Post-Crises*. But as this paper was written in 2009 it does not include the energy crises of 2014, for this reason, I want to propose my understanding. The *Pre-Crises* phase indicated the signs before the upcoming *Crises* — 1991-2014. The *Crisis* period is the year of 2014, the most intense point. And *Post-Crises*, when the gas supply was restored, and an agreement was reached (Torres et al. 2009). All those critical points were leading toward the full-scale invasion in 2022, which I will cover later.

When it comes to energy security, every point of crisis only deepened existing concerns. Each disruption and cut-off served as a reminder of a strong connection and dependence on Russian energy and the vulnerabilities that come with it. Rather than mitigating tensions, these

repeated crises reinforced fears about supply reliability, potential manipulation of energy flows for political leverage, and the need for alternative sources and routes.

Many European countries, especially those that rely heavily on gas are working on diversifying the ways they get their gas. This includes building new supply routes and passing EU laws to encourage competitive gas markets. Some Russian officials admitted that they need to modernize and compete more fairly to stay relevant. Meanwhile, President Putin, still believes Russia has strong advantages, such as existing pipelines, and new deals in Asia, that allow Russia to compete effectively and maintain influence (Stulberg 2015).

There's debate among experts on how energy affects global politics. Realists think countries use gas as a weapon for power. Others say that market rules, global trade, and business interests make it harder for countries to act aggressively. Some argue domestic politics, national culture, and internal goals shape a country's energy policy more than pure strategy (Stulberg 2015).

Concerning Ukraine's dependence on Russian gas it is possible to say that their dependence is asymmetrical. This means that prolonged gas cut-offs would have had a "devastating impact" on the Ukrainian economy. Moreover, it is possible to identify the key issues that were the basis of disputes in the gas relations between Russia and Ukraine: debt, gas prices, transit fees, and a pipeline system (Lee 2017, 202). As was mentioned previously, financial issues were the underlying cause of the energy cut-offs. Those monetary issues allowed Russia to advance its political pressure. The debt held by Ukraine was a tool to maintain the influence of Russia over Ukraine by offering subsidized gas. When the Ukrainian government and public began pursuing more openly anti-Russian policies, such as the desire to join the EU and aspiring to become a NATO member, Russia was unwilling to overlook Ukraine's outstanding debt. Instead, it began using Ukraine's financial struggles as a tool to pressure and punish its pro-Western leadership (Lee 2017, 204). The pipeline issue was that

Russia was always trying to gain control over Ukraine's pipeline system. But Ukraine understood the value of the system and that the loss of their control would "lessen their autonomy from Russia" (Lee 2017, 205).

To conclude, within Europe, interdependence with Russian energy resources, including oil and gas, gradually deepened, resulting in different levels of integration and dependence among EU members. This reliance grew more pronounced as domestic oil and gas production across Europe declined. Since the 2000s, the revenues from selling fossil fuels have helped Russia reclaim its influence in former soviet countries (LaBelle 2023). Regarding Ukraine, as it has been an important part of Russian energy transit, over the years the political tension only intensified. This geopolitical realignment, coupled with disputes over gas pricing and debt, strained the energy relationship between the two countries. As a result, Ukraine's role as a key transit state for Russian gas exports to Europe, became both a strategic asset and a vulnerability, putting the energy security at risk.

5. RESULTS

In this part, I will cover an overview of the Ukrainian current energy system during the times of the ongoing full-scale invasion that happened in February 2022. The war has placed immense pressure on Ukraine's energy infrastructure, raising urgent questions about energy security and resilience. Despite these challenges, Ukraine is actively advancing its energy transition, with renewable energy playing an increasingly important role.

I begin by examining the structure of Ukraine's energy system and the impact of ongoing war on its stability and functionality. The chapter then turns to the role of renewable energy sources within Ukraine's broader energy landscape, highlighting both existing projects and future ambitions. Key government policies and current initiatives aimed at promoting green energy will be reviewed, along with the technologies and natural advantages that position Ukraine as a strong candidate for renewable expansion. Further, I will consider the sustainability benefits of transitioning to cleaner energy and assess Ukraine's long-term energy prospects. Finally, the chapter discusses how closer integration with the European Union could support Ukraine's energy goals, enhance security, and unlock new opportunities for cooperation and investment in the green energy sector.

5.1.The full-scale invasion in Ukraine in 2022 and the effects on the energy system.

Early in the morning on February 24th, 2022, Russia invaded Ukraine, and this news shocked the whole world. The signs of upcoming danger were there, but people did not want to believe that a full-scale invasion could happen in the middle of Europe in the 21st century. Unfortunately, it did happen, and now Ukraine, Europe, and the entire world are left to confront the consequences. These consequences are evident across every sector of the economy. Safety concerns are more pressing than ever, and the credibility of international law and the effectiveness of global agreements are under intense scrutiny. And, of course, energy security

has escalated from a concern to a full-blown crisis. Russia's imperialistic ideology is at the root of it all, and the world must find ways to prevent a nuclear catastrophe.

In this part, I will focus on the impact and changes the full-scale Russian invasion has brought to the energy system. As was already mentioned before, at first, this economic and energy interdependence between Europe and Ukraine was seen as a positive aspect, and even that "economic interdependence fosters peace" (Skalamera 2023, 14). Nevertheless, the dependence only left the EU vulnerable. 2022 is the year that changed the European energy order. Russia's invasion of Ukraine caused the EU to diversify the structure of its energy imports (Kravchenko et al. 2023).

To maintain a clear focus, this chapter will examine the impact on Ukraine's energy system. Energy resources are one of the aspects of energy security for Ukraine, which identifies the country's ability to maintain and ensure its energy supply (Lisoviy 2024). With the beginning of military actions, the exports and the extraction of electricity decreased drastically. It all happened because of constant attacks on energy plants all over Ukraine. In February 2022, the work of the Kharkiv thermal power plant (TPP), Pavlogradsk TPP in the Dnipropetrovsk region, and Kremenchuk TPP in the Poltava region was stopped. 27 power plants are based in the occupied territories of Ukraine, which means there is no access. Zaporizhzhia nuclear power plant (NPP) and Chornobyl NPP have been occupied and under attack since March of 2022. Firstly, the Zaporizhzhia Nuclear Power Plant consists of six power units with a total capacity of 6,000 MW. Secondly, it is the largest nuclear power plant in Europe (Tkach 2023). Their occupation has been an enormous nuclear threat to Europe (Chornii 2022). So based on this information it is possible to state that supporting energy security in Ukraine is hard and even sometimes impossible. Moreover, it all leads to negative effects on the economy, GDP decrease, which affects the quality of life. The energy sector occupies an important role in ensuring the welfare of the Ukrainian people (Tkach 2023, 53).

Therefore, there are significant losses in Ukraine's renewable energy sector that are the results of terrorist actions of Russian attacks, particularly affecting solar power infrastructure. To begin with, around 60% of Ukraine's industrial solar power plants are located in the southern and southeastern regions, that have seen the most intense attacks. As a result, these regions have suffered substantial destruction. Approximately 40% of the solar power plants in these areas have been destroyed, amounting to a loss of approximately 1,400 MW in capacity. The solar park in Mykolaiv region with a capacity of 22 MW was partially destroyed by Russian artillery. Furthermore, the operational capacity is unusable due to the destruction of 5.5 km of power lines that once supplied electricity to Mykolaiv (Tkach 2023, 54).

During the fall of 2022, right before the winter season, the attacks on energy infrastructure became more often and strategic with an explicit aim to destroy power plants that generate electricity and the infrastructure for its supply. Almost 40% of critical energy infrastructure was damaged. As a result of missile and drone attacks targeting Kyiv, Kharkiv, Zaporizhzhia, Cherkasy, Chernivtsi, Lviv, Sumy, and Dnipro, significant disruptions to electricity supply have occurred (Tkach 2023). Approximately, Ukraine lost around 40% of its nuclear generation and 75% of its thermal power capacity (Kubatko et. al 2023).

In 2022 Ukraine was synchronized with the European Network of Transmission System Operators for Electricity — ENTSO-E. More specifically, Ukraine was synchronized with Moldova's electricity grid. Because of growing concerns about energy security and supply caused by the Russian invasion, the synchronization process was completed in just three weeks, far ahead of the originally planned one-year timeline. Zbynek Boldis, president of ENTSO-E said: "Synchronization is an act of solidarity from the European Transmission System Operators. It was important for Ukraine and Moldova as it helped them keep their electricity systems stable under extremely difficult circumstances." (ENTSO-E 2024).

To conclude, Ukraine's energy system has suffered significant destruction since the beginning of Russia's full-scale invasion. Critical infrastructure has been severely damaged or destroyed, leading to a substantial decrease in energy capacity and the ability to meet the demand. Even the renewable energy resources located in the East of Ukraine were destroyed and were not able to support the energy system. Nevertheless, thanks to the support of European partners, much of the ability to supply enough energy was restored in a relatively short period.

5.2. Energy security and renewables in Ukraine's energy system.

Energy security is an opportunity not only to protect national interests but also to prevent negative influence and to guarantee the future well-being of a country (Kubatko et. al 2023). As we saw previously, Ukraine's energy system suffered a lot with the beginning of a full-scale invasion. Achieving energy security involves the consideration of different factors: resource availability, technical, economic, regulations, environmental, social, innovative, political, geopolitical, etc. Since the Russian invasion, Ukraine's energy security has faced severe challenges, including a deepening energy crisis, economic recession, and uncertainty about future development (Shchurov 2022). Moreover, the study by Oleksii Lyulyov (2022) that calculated Ukraine's energy security index for 2000–2020 showed uneven changes in 2004-2008 and 2014-2018, periods of energy crises and political instability, Orange Revolutions and the Revolution of Dignity. Those political crises, which were provoked by Russia's involvement slowed down Ukraine's "transition to resource-innovation models, as well as reforms to ensure a green structure of energy consumption" (Lyulyov 2022, 248). Therefore, the need to address and support Ukraine's energy security is evident.

The main problems that Ukraine's energy security is facing are (Lisoviy 2024):

- ➔ Dependence on imported energy resources poses significant risks to energy security, especially in light of ongoing war and potential future political conflicts.

- ➔ Ukraine's energy infrastructure is outdated, originating from the Soviet times, and requires investments in modernization and reconstruction. Instability in the workflow of the present infrastructure can cause even more disruptions.
- ➔ Ukraine has high energy consumption per unit of GDP, which indicates low energy efficiency. Moreover, the ineffective use of energy resources only increases dependence on imports.
- ➔ Ongoing war and geopolitical conflicts disrupt the energy supply.
- ➔ Inadequate investments in the development of alternative energy resources. It slows down the advancement of the renewable energy sector
- ➔ Attacks and bombings. It relates to the factor of war, but attacks on energy infrastructure have been one of the Russian war strategies to disrupt energy security.

Based on these six factors, it is possible to outline the direction and scope for enhancing energy security. Achieving progress in this area will require a comprehensive approach that includes strategic planning, policy reforms, infrastructure investment, and the adoption of modern technologies. Equally important is the coordination of efforts among the government, the private sector, and international partners to ensure effective implementation and long-term sustainability.

Paper by Seyed Ehsan Hossein (2022) suggests that the Russo-Ukrainian war can be seen as a driver for a future sustainable transition, and an opportunity to speed up the renewable implementation. He brings up a great perspective considering the fact that Russia is the largest natural gas and oil exporter and producer, and around 40% of Russian gas is imported in Europe, and with an invasion, they are extremely unreliable. Those two options are: renewables and nuclear. Nuclear is not affordable and very costly to rebuild (Hossein 2022).

As was established before, energy security is the ability to access energy resources at an affordable price without disruptions. Renewable energy sources seem to be a great solution

that fits this description. RES in Ukraine has great potential to support the energy system during times of war and future sustainable transition. I will examine the prospects of renewable energy later in my analysis, based on the interviews I conducted. However, even at this stage of my research, it is evident that renewables, especially solar power, have a strong potential to serve as a valuable energy source for Ukraine and contribute to strengthening its energy security.

The papers that I examined on Ukraine's energy security consistently highlight the critical role that renewable energy sources play within the national energy system. These studies argue that integrating renewables, particularly solar and wind, offers a reliable way to secure sufficient domestic energy supply while simultaneously reducing dependence on imported fuels. In addition to strengthening energy self-sufficiency, renewables are highlighted as a strategic tool for mitigating a range of risks, like geopolitical tensions and supply disruptions caused by conflict. (Hlushko 2024; Kubatko et. al 2023 & Lisovyi 2024).

According to national statistics, by the end of the first half of 2021, Ukraine had a total of 9225 MW of installed capacity generating electricity from renewable sources, and total investments exceeded $12 billion. Of this total, 6351 MW was generated by solar power stations and 1594 MW by wind power stations. The most renewable energy installed was in 2019 with the amount of 4669 MW (Government Portal 2021). Unfortunately, this was the most recent official data available in national registers. Since the start of the full-scale invasion, official statistics about the state of RES have no longer been publicly accessible, and only approximate estimates are available. At the beginning of 2024, renewable energy capacity amounted around to 8.7 GW. Despite the constant attacks on the energy system in 2023, Donbas Fuel-Energy Company (DTEK) connected more than 1400 new renewable energy facilities to the system. According to data from UkraineInvest, a total of 1,823 MW of wind power capacity and approximately 500 MW of solar power capacity were commissioned (UkraineInvest 2025).

5.3. Policy review

In this section I look at the main document that establishes Ukraine's goals in the development of renewable energy sources - the National Energy and Climate Plan (NECP). This document has been mentioned in various papers. And, most importantly, it was mentioned in conducted interviews by experts in the renewables sector. Moreover, this document includes the Report on the progress of implementing the NECP, which will hopefully provide a clearer understanding of the current state of renewables in the country, with a specific focus on the solar energy sector.

5.3.1. Energy transition in Ukraine's policy

Ukraine is implementing an ambitious and long-term energy system transition plan, guided by the strategic vision of becoming a climate-neutral by 2070. This transition is not only a response to global climate challenges but also a fundamental restructuring of the country's energy policy. The document that outlines the main goals is the Concept for Ukraine's Green Energy Transition to 2050, a policy framework developed by the Cabinet of Ministers, in alignment with the Paris Agreement and the European Union's Green Deal. The Concept sets out a clear approach to reduce greenhouse gas emissions to a level that ensures a just transition to climate neutrality (Cabinet of Ministers 2020).

The Ukrainian government recognizes that climate change poses serious threats to health, food security, water supply, and critical infrastructure. The transition to clean energy is therefore not just an environmental necessity, but also a matter of national security and economic growth. According to the Ministry of Environmental Protection and Natural Resources, Ukraine sees the energy transition as part of its post-war recovery, helping to build a more reliable, local, and sustainable energy system, while creating new opportunities across all sectors (Ministry of Environmental Protection, 2024).

At the core of the transition is the goal to increase the share of renewable energy sources to 70% of electricity production by 2050, including a significant role for solar and wind, as well as bioenergy. Decentralized energy systems are strongly emphasized, encouraging households and communities to produce and manage their own energy through rooftop solar installations and energy cooperatives (EITI Ukriane n.d.).

The transition will also require significant investments. Ukraine's financial strategy includes moving away from fixed-price support schemes toward competitive auctions, green bonds, and incentives for storage and grid flexibility. Financing from the Energy Efficiency Fund and Ukraine Facility will also play an important role, especially for the residential sector. At the same time, Ukraine is also focusing on energy efficiency, particularly in the building sector, which consumes nearly 40% of the nation's energy. The industrial sector, responsible for a third of energy use, is planned to undergo electrification and wide implementation of circular economy principles. Ukraine's industrial competitiveness depends on reducing energy intensity to levels seen in European economies (Cabinet of Ministers 2020).

Finally, innovation, research, and international collaboration form the foundation of the transition as well. Ukraine is integrating into the EU research programs, fostering climate-oriented and sustainable startups, and supporting partnerships between academia, industry, and government to accelerate technological deployment (Cabinet of Ministers 2020).

In conclusion, Ukraine's green energy transition is more than just a climate strategy, it is a national development plan. It reimagines the country's energy system as clean and decentralized. Despite the challenges of war, Ukraine views the transition as a necessary and transformative step toward energy independence, economic modernization and integration with the European Union. Nevertheless, it is important to note that this Concept looks very promising on paper, but in reality, a few changes have been introduced.

5.3.2. Analysis and review of the NECP for Ukraine

Almost a year ago (on the 25th of June) Cabinet of Ministers of Ukraine approved the National Energy and Climate Plan (NECP) for the period up to 2030. "The NECP is a strategic document, which is directed for a coordination of energy and climate policies to provide sustainable development and economic recovery of Ukraine" – the description provided by the Cabinet of Ministers of Ukraine. The preparation and adoption of the NECP is an obligation of Ukraine under the Energy Community Treaty, in accordance with the requirements of Regulation of the European Parliament. In addition, the development and approval of the NECP is a condition for the allocation of EU financial assistance under the Ukraine Facility instrument. This document was developed with the help of the Institute of Economics and Forecasting of the National Academy of Sciences of Ukraine, with the support of the British and the US initiative Net Zero World. According to the National Economic Strategy until 2030 and the Energy Strategy until 2050, Ukraine aims to reach 27% of renewable energy in final energy consumption by 2030 and 70% in total primary energy supply by 2050.

The NECP emphasizes the vulnerability of the Ukrainian energy system in times of war and stresses the number of destructions that have happened. It identifies the main goals to achieve by 2030 (Ministry of Economy of Ukraine 2024):

- The share of renewable energy sources in the gross final energy consumption structure should be at least 27%.
- Reduction of import dependency (gross imports in total primary energy supply) to 33%. Sufficient balance and flexibility of the power system.
- Further diversification of energy supply sources and routes – no more than 30% from a single supplier.
- Full and comprehensive integration of Ukraine's electricity and natural gas markets with the European market. Specifically, at least 10% integration with ENTSO-E.

- Development and financing of innovation and research in the sectors of clean technologies, renewable energy, and low-carbon production.
- Enhancement of competitiveness.

It covers several dimensions, like: decarbonization, energy efficiency, energy security, domestic energy market, research of innovations, and competitiveness (Ministry of Economy of Ukraine 2024). The main laws that form the legal framework for the development of renewable energy in Ukraine are the laws "On Alternative Energy Sources" and "On Alternative Types of Fuels". These laws partially incorporate the provisions of the EU Directive RED II, which promotes the use of renewable energy.

Since 2009, the growth of renewable energy in Ukraine has been supported by the "green" tariff, a special incentive that guarantees high prices for electricity generated from renewable sources. However, this system had several weaknesses. Rapid growth, more than tripling between 2019 and 2021, led to financial and technical challenges, such as unstable payments for producers and the limited capacity of Ukraine's energy grid to integrate all renewable energy. To address these issues, in 2019 the Government initiated public discussions with all stakeholders. A memorandum was signed, where investors agreed to reduce "green" tariffs, and the state committed to making regular payments, settling debts, and supporting the sector's development on competitive terms. Since then, Ukraine has partially repaid its debts to investors in renewable energy. However, new challenges have emerged with the Russian full-scale invasion. In 2021, Ukraine committed to implementing the EU's "Clean Energy for All Europeans" package. In 2023, the EU adopted a revised version of RED III, which introduces stricter requirements. If Ukraine joins the EU, it will also have to comply with RED III. The Ukrainian government is currently working on legislation to implement these rules.

Within the NECP it is mentioned that renewable energy development is a key focus of Ukraine's energy policy. It helps reduce the use of traditional energy sources, lessen

environmental impact, and combat climate change. Increasing the share of renewables will also reduce import dependency and help Ukraine meet its international climate commitments.

5.3.3. Report on the progress of implementing the NECP

Unfortunately, the analysis of this report will be quite brief and short, because a lot of the data is not public and/or is not available due to the inability to measure data. The report on the progress of implementing the NEPC for the period up to 2030, prepared in accordance with the requirements of the EU Commission Implementing Regulation. The data that was available and is relevant for this research briefly explains the electricity generation from RES and installed capacity from solar power (see ***Table 1***), which does not give a lot of input.

Table 1. *Available data from the report on the progress of implementing the NEPC*

Report item	Unit of measurement	Years	
		2022	2023
Renewable electricity generation (with normalization)	GW	15 319	21 441
Share of electricity generation from renewable energy sources	%	13,5	20,3
Total installed capacity from solar renewable energy technology	MW	7175	7327
Electricity produced by photoelectric panels (solar)	GW per hour	5390,878	6145,588

Source: *Ministry of Economy of Ukraine 2025*

The projected development trajectories for RES were designed based on the total RES capacities across the entire territory of Ukraine. However, the actual data on RES capacity for 2022–2023 includes only the territories under Ukrainian control, excluding the occupied territories. As a result, there is a noticeable deviation from the projected trajectory. It is important to note that due to the invasion of Ukraine by Russia, approximately 25% of the installed RES capacity was located in occupied territories as of 2022. The situation is particularly critical for wind power plants where 75%, or around 1.25 GW of their capacity, is situated in the occupied territories of the Kherson and Zaporizhzhia regions.

"Additionally, approximately 14% of Ukraine's solar power plants, representing over 0.6 gigawatts (GW) of capacity, are currently located in territories under occupation, significantly limiting their operational contribution to the national energy grid. Despite these severe challenges stemming from the ongoing war, Ukraine demonstrated notable resilience and commitment to its renewable energy goals. In the period between 2022 and 2023, more than 650 megawatts (MW) of new renewable energy capacity were successfully installed across the country. This includes 371 MW generated by newly built solar power plants, a substantial portion of which 287 MW originated from private households, highlighting a growing trend of decentralized and citizen-led energy production. (Ministry of Economy of Ukraine 2025, 17).

This report also provides additional insights into other types of RESs utilized within Ukraine's energy system, such as hydropower, wind energy, and biogas. It outlines their installed capacities, and general trends in development, and mentions a few strategic objectives related to their future use. However, the depth of the data remains quite limited. As a result, while the report offers a broader overview of Ukraine's renewable energy strategies and goals, it does not fully capture the current situation. Unfortunately, this is the case with many government documents and reports, while they are technically 'available' the actual data they reference is often inaccessible or missing.

5.4. Interview analysis. RES in Ukraine.

In this section, I analyze the qualitative data gathered through interviews conducted with experts working in Ukraine's renewable energy sector. These interviews serve as a critical empirical foundation for this research, providing firsthand insights into the current challenges, developments, and strategic priorities. Drawing on the responses of the interviewees, I categorize their perspectives according to the thematic structure outlined in my theoretical framework – The Three Perspectives of Energy Security. This framework allows for a

structured interpretation of the data and enables a comparative analysis across different expert viewpoints. Notably, the interview questions were designed in alignment with specific criteria and key factors derived from the literature and theoretical framework of this research. This approach ensures that the responses are relevant to the research objectives and contribute to the conclusions and proposals presented later in the thesis.

To analyze the interviews, I have assigned each expert a pseudonym that has no connection to their real identity. These pseudonyms are used for clarity and consistency throughout the analysis. In addition, I provide a brief, general description of each expert's professional background (see ***Table 2***). These descriptions are intentionally non-specific and do not include any personal information to ensure the anonymity and confidentiality of the participants.

Table 2. *Assigned pseudonyms to interviewees with a short description of their field of work*

The interviews №	**Short description**	**Name**
№ 1	Independent investment policy consultant	IR1
№ 2	Representative of a Ukrainian solar panel company	IR2
№ 3	Investment advisor between Germany and Ukraine	IR3
№ 4	Representative of a company that works on developing and supporting policies between Ukraine and Europe	IR4
№ 5	Renewables construction advisor and educational consultant	IR5

The purpose of including these short profiles is to give the reader a sense of the professional context and areas of expertise represented in the interviews. This background information helps to frame the responses and offers insight into how each expert's role and experience may shape their perspective on issues related to energy security and renewable energy development in Ukraine.

5.4.1. Assessing Ukraine's Energy System: Status, Security, and Outlook. Resilience.

The main idea that followed through all the interviews considering the state of the renewable energy sector in Ukraine is that currently it goes through a development stage and is getting close to reaching its peak. However, I want to dive deeper to present more perspective and understanding of the nuances of Ukraine's energy system in times of war. Moreover, this part of the interview analysis will provide an outlook on the resilience of the Ukrainian energy system. One of the perspectives, that covers the capacity to recover from disruptions is the adaptability of a system. There were a couple of points made about the fact why even during the war the renewable sector, specifically solar and wind, is expanding and developing.

First, it was noted by IR1, IR2, and IR3 that investors see great potential in investing in solar because of its natural advantages. Ukraine is a large country with a large amount of available land suitable for renewable energy installations. Geographic and climatic conditions make solar energy one of the most promising and effective methods for generating renewable power (Onyshchenko 2022). More importantly, investors are willing to finance and develop projects due to the support provided by the government and the European Bank for Reconstruction and Development (EBRD), particularly through insurance guarantees. In the case of Ukraine, guarantees play a crucial role in ensuring the resilience perspective by trying to adapt to unpredictable factors and changes. The exact targets of future attacks are unpredictable and guarantees from the government and international partners help provide flexibility and adaptability in response to ongoing events. It is important to note, that the war has been active for more than three years and it does not mean that the development and energy transition should be halted. IR3 working on foreign investments stated that: "I think there's still quite a lot of uncertainties related to it (perspectives), but people are ready, and the pure potential is great." Solar panels are usually installed with two main objectives: first, to contribute to and integrate with the general energy system by supplying clean energy. And

second, to provide a financial return on investment through mechanisms such as energy savings or feed-in tariffs. So foreign investors as well as state ones currently are very interested in investing more in Ukraine's renewable market due to favorable terms.

Second, with Ukraine's aim to get into the EU, it is essential to follow all the standards and requirements for the energy system to achieve a future sustainable transition. IR4 mentions: "We don't have a lot of other options except renewables. We need to meet European standards. There is no other alternative." The progress in the renewable energy sector may have been driven by necessity, but it could prove beneficial in the long term. The interviewee IR4 named it a "forced decarbonization". For Ukraine, this inevitability can serve as a driver for advancing energy policy. Additionally, it demands a more adaptable energy system, ultimately enhancing the country's overall resilience.

And lastly, the constant attacks had an effect on critical infrastructure. As mentioned before a very big part of energy infrastructure was either damaged or destroyed. But, from the perspective of renewables development, IR2 and IR4 mentioned that war is an opportunity for change and reconstruction. IR2 working specifically in solar panel distribution highlighted that there is an enormous need for additional energy resources to support constant and stable energy supply and solar and wind energy are a great additional source. Devastating and important events like war are indeed awful, but it is smart to use this as an opportunity for innovation. Renewables offer a resilient response to the challenges posed by war; challenges that, in turn, are reframing the conditions and priorities of the energy sector.

To conclude this section on the resilience of Ukraine's energy system, the factors mentioned earlier are key drivers of renewable energy development in the country. These same factors also play a crucial role in strengthening the resilience of Ukraine's overall energy infrastructure. It is possible to say that Ukraine is moving towards a more resilient energy system and prospects are quite promising.

5.4.2. The role of international support. Sovereignty.

Sovereignty is the perspective that probably is the most undeveloped one in Ukraine and requires a lot of additional work. Especially it is hard to achieve energy sovereignty while there are active military attacks on the territorial sovereignty of a country. While Ukraine works to strengthen its independence from Russia, this progress is possible through close cooperation with European (and not only) allies. Beforehand, it is important to emphasize that Ukraine receives substantial financial and military aid and support from partners around the world. This support is both deeply appreciated and absolutely essential, and without it, Ukraine would not have been able to remain as resilient and strong as it is today.

Right after starting the interview block about sovereignty and international aid every interviewee with no hesitation said that the EU provides immense help in the development and support of RES in Ukraine. IR2 emphasized very clearly that: "Europe really helps. As a consolidated body of the European Union, through its various institutions, and many individual European countries. Either for the state, or for communities separately, or for cities, regions." Several projects and initiatives were discussed, and I will highlight the most impactful ones to better understand the scope of Ukraine's energy sovereignty.

Considering financial aid, the project Ukraine Facility was mentioned as an important European instrument to help Ukraine address Russian aggression (European Commission 2024). This is a tool created by the European Commission to provide financial support to Ukraine, which provides up to €50 billion in stable financial payments. IR4 mentioned that: "…nothing like that was done before and it is amazing." It is probably the most impactful instrument with an aim to support Ukraine's recovery and reconstruction, the political reforms on the way to the EU, and "facilitating investment flows to catalyze rapid economic recovery and sustainable growth" (European Commission 2024). Pillar I (Ukraine Plan) provides €38.27 billion in financial aid to Ukraine — €5.27 billion in grants and €33 billion in loans to support

macro-financial stability, reforms, and reconstruction. Pillar II (Ukraine Investment Framework) provides €9.3 billion to attract public and private investments for Ukraine's recovery, including €7.8 billion in loan guarantees and €1.5 billion in grants. It supports a range of financial tools and prioritizes sectors like energy and social impact. Finally, Pilar III (Assistance programs) amounts to €4.76 billion and supports Ukraine's alignment with EU laws through technical assistance and reform implementation (European Commission 2024). IR1 mentioned that "…this initiative is expected to mobilize up to 40 billion euros in public and private investment over the coming years." Ukraine Facility is a very needed tool that supports and develops Ukraine's energy system to become more independent after cutting off the energy relations with Russia. This European initiative represents a significant push toward Ukraine's integration into the EU.

Considering the energy system support the synchronization with ENTSO-E was mentioned multiple times by IR1, IR4, and IR5. I already briefly touched upon the ENTSO-E, but it is important to capture the significance of this truly historic event. On March 16, 2022, less than a month after the start of the full-scale invasion, the national power grid was integrated with the European Network. By joining ENTSO-E, Ukraine boosted regional energy stability and contributed to Europe's shift away from Russian energy by supplying electricity that reduced the need for gas-powered generation (Ministry of Energy of Ukraine 2023). "When there were blackouts and significant destruction and shortages, energy system used imports from neighboring countries thanks to a synchronized system" — said IR1 while mentioning awful blackouts that lasted hours and even days. For the future of integration into the EU, IR4 said: "Now our task is to unite with them (Europe) on trade terms. We need to create, in fact, a common market with them. More precisely, to add us to their common market."

Those two events, the Ukraine Facility, and ENTSO-E were and are the main aspects from the EU side that promote national control over the energy, thereby the country's energy

sovereignty. Moreover, many more projects were mentioned during the interviews, like the International Finance Corporation, the EU4U fund, Germany's support in the RES sector, and different opportunities from international banks, funds, auctions, and projects. As already mentioned before about the guarantees provided by the EBRD, IR1 emphasized that: "European Bank for Reconstruction and Development in Ukraine is the organization that is actively involved in financing renewable energy."

The sovereignty perspective in Ukraine is on the way to development with the help of European partners. Achieving energy sovereignty in Ukraine is not possible without the support of international allies. This cooperation is crucial because Ukraine's continued dependence on Russian energy threatens not only its own stability but also the broader energy security of the entire European Union. Reducing this reliance is essential to safeguarding the EU from potential political and economic vulnerabilities tied to Russian influence.

Nevertheless, I also considered the role of the national government in assessing sovereignty, and unfortunately, the outcome is less positive compared to international efforts. The main problem that really became an obstacle to the implementation of RES in Ukraine came from the government's side — the green tariff. All interviewees emphasized this critical issue: while the government introduced green tariffs, that allowed the installation for private households and the sale of surplus electricity in 2015 to encourage the installation of renewable energy sources. In 2019-2020 ultimately, they were unable to meet its payment obligations, resulting in substantial debt. In 2020, investment in renewable energy sources (RES) fell by 68%. It led to imbalances in the electricity market, technical problems with the operation of renewable energy plants in the power grid, and non-payment to companies under the "green" tariff (Babayev 2021). IR4 mentions that: "In fact, this tool (green tariff) in general, gave a great push to the development of renewable energy in Ukraine in general. That is, if it were not for it, we would not have everything that we have now." As IR4 highlights as well, the problem

with green tariff was: “It was a crisis moment for the entire sector. Many investors were extremely dissatisfied, especially international ones because you take out loans, you agree with banks about a certain level of income, and then they simply reduce it administratively.” This opinion about the Ukrainian government’s incompetence and disappointment was seen throughout every interview. Some of the opinions were even quite negatively strong towards the government’s actions: “This was stopped intentionally and with international scandals, because, before that, many international investors had come to Ukraine, built solar power plants, large industrial ones, and invested hundreds of millions of dollars under this law for a green tariff for industrial solar power plants. And at the end got nothing.” (IR2).

The main idea behind all the interviews about the governmental influence on RES was mostly negative, unfortunately, but IR5 highlighted a positive influence as well: “They do not interfere and it’s good enough. If it is not possible to help financially, the state can still help implement it through regulations.”

Therefore, considering these two factors (international partnerships and government influence) it is possible to conclude that supporting the sovereignty of Ukraine’s energy system requires strengthening relations with Europe while simultaneously pushing national policies toward a sustainable energy transition.

5.4.3. The need for decentralization. Robustness.

The robustness perspective concerns the ability of the energy system to withdraw shocks, specifically, the technical ability to do that, infrastructure durability, and availability of energy. I think it is one of the hardest perspectives to assess as I am not an engineer and, unfortunately, I was not able to get a hold of the Ukrainian engineers. In any case, it was not my focus from the beginning, and still, I was able to receive some insights on how to assist the robustness of Ukrainian energy system from the experts I conducted interviews with.

A very important factor in establishing the energy system's robustness that was mentioned by IR3, IR4, and IR5 is decentralization. Decentralization is the condition of war that Ukraine must follow to support the technical robustness of the energy system. The IR4 says: "...the construction of even large RES stations will work for the energy security of the entire country and the energy system as a whole. Simply from the point of view of the fact that it will still be distributed throughout the country, and it will not all be in one place." It was mentioned that decentralization is happening now on two levels. The first level is decentralization on the part of consumers, meaning that consumers place generation sources closer to themselves. This is beneficial because it guarantees that, no matter what happens to the grid, they will still have access to electricity. The second level is the construction of industrial plants, which are also decentralized. "So, on the other hand, the more such plants we have, even if they're 100 MW or 200 MW across the country, we can imagine the scale and number of transmission infrastructure points that would need to be attacked in order to cause any real disruption to the energy system" - concludes IR4. IR3 supports this statement: "I would say that any future system that is expected to provide energy security, energy access, constant supply of energy will necessarily be more decentralized than what we have at the moment." So, a decentralized system is much stronger in terms of robustness, than one, two, or three nuclear power stations, that can always be attacked militarily. Overall, decentralization emerges as the primary factor in establishing robustness, which is to be expected due to its critical role in enhancing safety.

5.4.4. Future of RES in Ukraine.

For the last part of my interview questionnaire, I left a block about the future of RES in Ukraine, what should be changed, and what reforms should be implemented. I will go through each point to bring all the interviews together into a clear and coherent outlook. First, the obstacles that could stand in the way of developing a strategy were identified, and the main one

of course is war. Military attacks are highly unpredictable, and the future outcomes are as well. Moreover, safety is a factor that cannot be guaranteed in Ukraine at the moment: "…constant shelling and people leaving Ukraine are two big problems. So, it's very difficult to plan now and I understand why the state can't do it either." (IR4).

Nevertheless, as I mentioned before, war should not hinder development, so we should at least try. The National Energy and Climate Plan (NECP) that was already mentioned is a great referring point for national and international businesses, potential investors, and even households to understand the future trajectory that the government is going to follow. It has its nuances and drawbacks, but it can be used positively. "We have the Energy and Climate Plan, but it is not super good to rely on in planning the energy system. But it is good for us to have an energy strategy and a vision from the Ukrainian government of how we want to move forward, how we will develop, considering all the experience that we already have and all the trends that we have seen now" says IR4. Unfortunately, another barrier that hinders strategic planning, and is evident in governmental documents, including the NECP, is the unavailability of data. Three out of five (IR1, IR2, and IR4) interviewees mentioned the lack of data and therefore, is it hard to analyze and predict any possible events: "Therefore, it is impossible to say right now how many nuclear power plants, renewable energy sources, and gas there should be, because this is a process with nuances. And in reality, we simply do not have the data for this." (IR4). Of course, Ukraine can rely on the goals it has set and is obliged to follow because of its intention to align with the EU. The abandonment of coal, which means minus a large part of the generation, must be replaced with cogeneration plants on biofuel, which is what many investors are already interested in. Plus, Ukraine has some prospects for the decommissioning of nuclear units, this must also be considered. Plus, climate targets for decarbonization, which also include an increase in the share of renewables. Focusing on this it is possible to forecast some kind of vision for the prospects of the energy system. Of course, again, all this is very

much dependent on reality, the security situation, which can change everything, therefore, it is difficult to answer precisely.

Nevertheless, the interviews included possible prognoses, as well as solutions and suggestions. Circling back to the previous part, the EU programs implemented like the Ukraine Facility and support from the EBRD in action Ukraine will see much more RES installations in upcoming years. “The EBRD will use funds from the Ukraine Facility to provide investor insurance, which could help unblock projects and attract more international investors starting next year,” says IR5. “Within the framework of the Ukraine Facility program, it is planned to purchase equipment for the construction of at least 1.4 GW of high-maneuverability power plants, 1.1 GW of biofuel plants, 0.8 GW of electricity storage systems, 4.5 GW of wind and 3.8 GW of photovoltaic plants” provides information IR1. Therefore, the prospects for the future are promising. It was stated by the IR4 that even now we can see positive trends of batteries for solar systems getting more popular and, therefore, cheaper: “Batteries will become cheaper, as we can already see, they will be installed more and more, consumers and big players consider them more. We can already see that Ukrainian operators of wind and solar stations are installing batteries right next to the stations to test more, these are still pilot projects. But this is another completely new segment for the business in renewable energy.”

Following the interview analysis, three key reform goals for transforming the energy system were outlined. The first and most frequently mentioned proposal was that the government should address the debt caused by the green tariff problem. Ukraine faces a significant problem with debts in the renewable energy sector, primarily caused by an imbalance between the high “green” tariff rates and the insufficient funds collected through electricity transmission tariffs. It is the problem that has been following Ukraine’s energy system for at least the last five years. The debt has been paid partially but it is something that has not been addressed properly, IR1 states that: “In order for everything to be generally good

with renewable energy and in particular solar power plants, this situation of debt that has arisen in this market must be overcome." As of June 2024, Ukrenergo (Ukrainian electricity transmission system operator) owed around 20.5 billion UAH to renewable energy. The root of this issue lies in chronic underfunding: the transmission tariff set for Ukrenergo does not fully cover the cost of supporting renewable generation, and market participants have also fallen behind on payments. Nevertheless, Ukrenergo has already paid nearly 19.4 billion UAH this year (Bodenchuk and Savytska 2024).

The second suggested reform is coming from the previous point — reform the current tariff system. The IR3 commented that: "The reform of the tariff system should be done, and it must really show market prices. It will be a big reform for Ukraine, and it will help renewables." I will go into more detail and suggestions in the recommendations part, covering possible tools and mechanisms for the reform.

And lastly, continuing market liberalization and integration with the European energy market should be among the main goals for a sustainable energy transition and to ensure energy security. IR4 highlights that: "Market liberalization, fulfillment of all our commitments on the path to European integration - that's what we should be doing because we have a lot of tasks in the energy sector. We need to do all this, because a liberalized market, normal market mechanisms - that's what business is most interested in." Market liberalization is a key reform that brings Ukraine closer to the European Union, and the country has been pursuing this goal since 2019 (European Commission 2025a).

To sum up, on a positive note, I want to bring up the IR2 conclusion that Ukraine is only starting the sustainable energy transition with the help of renewables. It will not only support energy security but promote the European integration of Ukraine. Implementing and promoting renewables is something that Ukraine has to do, IR2 clearly emphasizes it: "This is the only alternative path."

6. DISCUSSION

The discussion part covers the interpretation and explanation of the results presented in the previous chapter, furthermore, I aim to outline the main findings and provide answers to my research questions that were posed at the beginning of this thesis.

6.1. Energy system resilience and security.

The main problem that Europe, as well as Ukraine, is trying to combat right now is the reliance on Russia, specifically Russian gas, that developed through decades of interconnected relations and agreements. Since February 2022, this reliance has revealed just how vulnerable it can make the country's energy system, and its impact extends far beyond the context of the Russian invasion (Viñuales 2023). The energy crises from 1991 to 2014 raised concerns about energy security all over Europe, but the full-scale invasion had to happen to finally start the phase-out. Ukraine, the country was mostly bound to Russia because of the geographical closeness, specifically the pipeline grid. Based on the results of the research it can be concluded that the RESs are the solution needed for establishing energy security in Ukraine. Tulchinskiy et al. (2020, 103) stated as well that: "The use of renewable energy sources contributes to improving the country's energy security and greening economic development."

Nevertheless, this reliance made Ukraine's energy system extremely exposed and unprotected at the beginning of the invasion. Russia used and still uses energy as a weapon to disturb people's lives, devastate the environment, and destroy any sign of sovereign Ukraine. Energy dependence and vulnerability are the challenges we face today, and their presence is no longer in question. Coming back to the literature review, after the conducted research, it is possible to state that Ukraine's energy system, unfortunately, is not resilient based on the definition I provided referencing works of Cherp and Jewell (2011a), Monie et al. (2025), Jasiūnas (2021) and Carlson et al. (2012). This question can be looked at from two different

perspectives: the beginning of the war and the current energy system state. On one hand, with the beginning of the war Ukraine's energy system was not prepared for the possible military attacks. The unpreparedness of the system was the main issue that made the energy system so vulnerable. On the other hand, it is most of the time impossible to predict this kind of event. So, it is hard to say how Ukraine's energy system could have been prepared for the beginning of the war. If we look at the next step of improving the system's resilience — mitigation — the process, meaning the system's capacity to absorb the consequences of a disruption, is currently well developed. After more than three years of constant military actions, Ukraine's energy system adapted to unpredictable attacks and the blackouts that lasted weeks at first, right now only lasted a couple of days. If an attack destroys a power plant, the system compensates by redistributing supply from other regions of Ukraine. So, in this regard, the system improved its resilience. However, the blackouts still happen, and this supply redistribution and balance can be supported by the RES, which is my main argument in this research. Coming from the results of the interviews, RES is a solution that has to be implemented, Ukraine does not have any other choice but to support the energy system's resilience. In the meantime, the adaptation and restoration process will be easier and faster, which, again, will only strengthen the system's resilience.

The energy system's resilience is one of the perspectives that I covered when considering energy security. Moreover, the main findings to advance the resilience were providing guarantees and insurance from the government to the investors and following the European requirements. All those aspects promote the installment of RES, which only supports my argument about the need to promote RES to ensure resilience.

To conclude, because of the historical long-term reliance on Russia's energy, it is a complex and difficult process to establish energy security in Ukraine. Nevertheless, according to the research results, this is something that must happen for Ukraine to integrate with the

European Union and establish its full independence; and energy security can be achieved with the help of RES.

6.2. Key future developments and recommendations

Based on the analyses I conducted; I have identified two key implications that I believe are feasible for future development and will support the energy system security supported by the RES. The first one is the reform of the current tariff system. Based on European and even just international experience it can be achieved in various options: “green” auctions, net metering, corporate power purchase agreements, and feed-in premiums (Babayev 2021, 19-36). Those are mechanisms that can be executed in Ukraine.

➔ **“Green” auctions**

Green auctions are a competitive tool many countries use to support renewable energy development as clean energy markets mature and equipment costs fall. The government announces the required capacity for new renewable projects, and companies submit bids indicating how much power they will produce and the price at which they will sell electricity. The winners are those offering the lowest prices while meeting other criteria and securing long-term contracts with state support. In Ukraine, since 2019, new large solar (over 1 MW) and wind (over 5 MW) projects have participated in auctions instead of receiving the former fixed “green tariff.” These auctions guarantee a stable electricity price for 20 years and offer state-backed purchase commitments even before construction begins. This model helps lower the cost of renewable energy and ensures transparent, competitive project development (Babayev 2021, 20-23). Unfortunately, currently the actions are not being successful because of the lack of participants and, there is still a significant debt to renewable energy producers under the "green" tariff (Demyanik 2025).

➔ **Net metering**

Net metering is a system that allows homeowners with solar panels to send excess energy they produce back to the grid in exchange for credits. These credits can then be used to offset the electricity they draw from the grid when their panels don't produce enough electricity. This mechanism can be used in households as well as in industrial enterprises (Babayev 2021, 24-27). In 2022 Cabinet of Ministers of Ukraine proposed net metering as an improved green tariff mechanism, "which will be focused on covering consumer's consumption and will not lead to an increase in the number of subsidies at the expense of other consumers, which is in line with the goal of energy security" (Ministry of Energy of Ukraine 2022).

➔ **Corporate PPAs (power purchase agreements)**

Corporate PPAs are more of a competitive mechanism that supports the RES. These are long-term contracts for the purchase and sale of electricity from renewable sources, according to which the buyer of electricity is not an enterprise designated by the state, but a private company. Corporate PPAs help renewable energy producers reduce financial risks by enabling direct sales to consumers, ensuring faster and more stable payments. These long-term contracts provide price stability for buyers and steady income for producers. PPAs also support companies' sustainability goals, as many businesses seek green energy to meet decarbonization targets and strengthen their brand image (Babayev 2021, 28-27). There are now available agreements that can be signed with Ukrainian private companies, like: Renergy or DTEK.

➔ **Feed-in premiums**

This mechanism lets renewable energy producers sell electricity on the market and earn an extra premium per kW. The premium can be fixed or dynamic and helps support certain technologies. Fixed premiums are simple but risk over- or under-compensation, so limits

are often set to balance payments (Babayev 2021, 33-35). This tool is an additional payment to a “green” tariff for meeting the required level of use of Ukrainian-made equipment and applies for the entire term of the "green" tariff (Diia Government Services Portal n.d.).

Those are the main mechanisms that have been introduced into the tariff system to deal with the accumulated debt from unsuccessful “green” tariffs and to promote RES in Ukraine. They have just been implemented in recent years, but the results are not very affirmative. The government should work on the promotion of those programs because one of the problems is that organisations and consumers are not aware of those possibilities. The government’s involvement can make a difference in RES promotion.

The second implication is market liberalization. On July 1, 2019, a new electricity market was officially launched in Ukraine, marking a significant milestone in the development of the country’s energy sector. The introduction of a liberalized market model was based on European principles and in line with the requirements of the EU’s Third Energy Package. The move aimed to create a competitive environment that meets European standards and ensures transparency and efficiency in electricity supply (Ukrhydroenergo 2025). Liberalization of the market is a political and regulatory process aimed at replacing monopoly with competition. Its main goal is to improve market efficiency through competitive conditions, which helps to reduce costs and prices, ultimately making market players more competitive. This approach has been implemented across almost all EU countries (Hryshina 2019). Ukraine needs full liberalization of its energy market to successfully integrate into the European Union’s energy system. Liberalization will not only support integration with the EU market but also help protect against shortages and outages while ensuring a predictable cost of energy (Sklyarenko 2024).

The unification of the Ukrainian power system with the ENTSO-E provided new opportunities for the energy sector and influenced future energy goals, which now are directed

towards European objectives for sustainable development and energy efficiency. Ukraine's aims are the modernization of its energy sector, protection of stakeholders, energy mix optimization, boosting energy independence, reducing losses, efficiency improvement, ensuring market transparency, and importantly expansion of renewable energy use (Tulchinskiy et al. 2020, 101). "More renewable energy and full energy markets integration will bring to greater energy security both for Ukraine and the European Union" states Ursula von der Leyen talking about support for Ukraine's energy security and full market integration (European Commission 2025a).

These are the two key implications that can strengthen Ukraine's energy security through the use of renewables. The reforms enhance the resilience of the energy system, making it more adaptable to unforeseen events by promoting renewable energy sources (RES) that can back up the grid system. They also support the sovereignty of the energy system by integrating Ukraine's energy market into the European system, ensuring greater liberalization and external support in the event of attacks or blackouts. Additionally, the reforms contribute to the robustness of the system by encouraging the development of decentralized RES, which further strengthens energy security and ensures safety.

6.3. Answering the research questions

At this point of my research, I want to go back to the research questions that I have posed in the beginning to reflect on my results. The primary question of my research was — how can Ukraine implement renewables to ensure energy security during wartime and support a future sustainable energy transition? The answer has been presented in my recommendations chapter. The implementation of renewables can be assisted in various ways through governmental influence or international support. In any case, throughout my research, I have been indicating the importance of RES in ensuring energy security, especially during wartime. The RES implementation (solar and wind power) is extremely advantageous for the Ukrainian

energy system and an energy transition towards more sustainable and clean energy resources. Renewables are the solution for the damaged Ukrainian energy system and with the reformed tariff system and international help, it is possible to keep pushing the sector for further development. The advantages of implementing RES significantly exceed the potential challenges, as they enhance energy security, reduce dependence on imports, and support sustainable economic development.

My second question was — what is the current state of Ukraine's energy system (incl. renewables) amidst the ongoing war? This question was the first question that actually sparked my interest in this topic. This was something I was eager to explore in my interviews with the experts I reached out to. For this research, it was important to look at the current state of the energy system because, with the start of the invasion, everything changed drastically. After looking at the contextual context, conducting interviews, and getting the results it is possible to say that the Ukrainian energy system needs additional energy resources to maintain the required energy supply, and those additional resources are renewables (mostly solar and wind energy, potentially hydro and biogas). Currently energy system cannot handle the necessary level of energy supply all over Ukraine, and specifically, the rejection from Russian gas hit hard on the energy system which is something that must be addressed in the foreseeable future.

The third question concerned the ways of support for renewables through financial and political outlets for better integration. This question was addressed in the previous part of my thesis. Firstly, without the financial aid from international partners that support Ukraine's reconstruction, I do not think that RES would be on the same development trajectory as it is now. European financial programs are one of the main drivers for effective RES implementation. It's all unfolding like a butterfly effect: with the support of European investors, renewables gain more opportunities for development, which strengthens the energy system, drives the sustainable transition, supports Ukraine's European integration, and reduces

Europe's dependence on Russia. Secondly, the political involvement of the Ukrainian government is something that should be addressed better. The government doesn't stand in the way of RES implementation, but at the same time, it doesn't actively promote it either. There are mechanisms I mentioned earlier that could be used and encouraged more effectively.

In closing, I was able to find answers to the research questions I posed at the beginning of this work. While the answers may not have been as ambitious as I had initially hoped, they still addressed all the concerns and uncertainties I set out to explore. I believe these questions helped uncover the main objectives of this research and guided me toward a clearer understanding of the challenges and opportunities in securing the energy sector. The answers offered at least some new and valuable insights that can be further explored and applied to support Ukraine's recovery and its transition toward a greener and more resilient energy future.

6.4. Research limitations

Like any other research, this study has its own limitations. The most obvious one is that this research is heavily context and country-based. And it is evident that Ukraine's context is unique because of geopolitical relations. War has its own effect and consequences on Ukraine's energy system specifically. Moreover, the historical background is important as well considering the relations between Russia and Ukraine. I fear this study cannot be fully applied to other country-based research, but it can provide some insights into energy security studies.

Another possible restraint is the methodological limitations. First, the lack of available data is a limitation that does not allow a full understanding of the state of renewables in Ukraine. It was already mentioned earlier not even just by me but by the interviewees as well. It restricts a more thorough analysis of the state of renewables in Ukraine. Nevertheless, I have tried to provide the most recent and accurate information that was available. Second, I should indicate the lack of any prior knowledge in the energy sector, which could have affected some of the points that I have brought up. Third, the interviews were selected based on personal

experience, which may have resulted in certain perspectives being overlooked. Including stakeholders from diverse sectors could have provided additional viewpoints.

Another important limitation of the study is related to language barriers. The interviews were conducted mostly in Ukrainian, so during translation into English, some points may have been interpreted slightly differently, although I have tried to capture the main ideas accurately. The coding analysis was also carried out in Ukrainian, which might have influenced the interpretation of some of the responses.

Lastly, I should acknowledge the potential influence of researcher bias as a limitation of this work. Given the deeply personal nature of the subject, which is closely tied to my own experiences, some of the interpretations may have been shaped, consciously or not, by emotional responses. Conducting research on a war happening in my own country, while following rapidly evolving news and real-life events, has undoubtedly had an impact on my perspective. Although I have tried to maintain objectivity and distance myself from personal emotions throughout the process, it is important to recognize that moments of emotional involvement may have surfaced during the writing of this research.

6.5. Future research recommendations and contributions

This research can be improved in various ways because the context of the Russo-Ukrainian war can change any day, therefore the study can be improved by analyzing political events and new possible military attacks. The energy system is a complex system, and any additional or new modification can completely transform the future strategy and trajectory. Those changes can be supported by forecasting different possible scenarios of turn of events. It is impossible to anticipate every imaginable circumstance, but by selecting one specific policy direction, it becomes possible to outline and explore several potential scenarios that may unfold as a result. While these scenarios are speculative, they provide a structured way to

imagine future developments and assess the broader implications of the chosen course of action. It can be one of the potential future contributions.

Moreover, future studies could build upon these findings by going into greater depth about the range of energy sources available, such as solar, wind, hydro, biogas, or even nuclear power, in order to gain a more nuanced understanding of the potential of the Ukrainian energy system and renewable energy sources. In the course of my interviews, I was not able to explore in detail the diversity of renewable energy types or their specific roles within the current Ukrainian context. However, the fact that several interviewees brought up solar and wind energy suggests there is genuine interest and relevance, and that much more research remains to be done in this area. Ukraine holds significant potential for the development of a wide variety of RESs, and with the right focus, the possibilities for future exploration and study are limitless.

In addition, a more thorough and detailed study could be conducted focusing specifically on national policies and the government's role and influence within the renewable energy sector. While my research primarily concentrated on contextual analysis and broader trends, there is an opportunity for a deeper investigation into the legislative and regulatory framework that shapes the development of renewable energy in Ukraine. This could include an in-depth look at existing policies, and economic mechanisms that have been implemented, such as "green" tariffs and subsidies. Understanding how these instruments function in practice, and to what extent they have been effective or need adjustment, would provide valuable insights into the structural dynamics of the sector. Additionally, such a study could also examine policy gaps, bureaucratic challenges, or institutional limitations that may be slowing down progress in the field of renewables. Security studies are a broad topic, especially considering the Ukrainian context, it can be developed within various theoretical frameworks and methodologies. There are hundreds of ways of energy security interpretation by different academics and experts, so this research can be addressed from various perspectives.

7. CONCLUSION

The ongoing war, particularly constant Russian missile and drone attacks across Ukraine has inflicted significant damage on the country's critical infrastructure. Among the most affected sectors is the energy system, which has turned energy security into one of the most urgent and pressing national concerns. Considering these developments, this thesis has explored the potential of renewable energy sources as a means to secure Ukraine's energy future. The research goes beyond just safety considerations but also addresses the long-term environmental impact and sustainability goals. Renewables offer clear advantages, not only by contributing to a safer and cleaner energy supply but also by enabling a strategic shift away from dependence on the Russian energy grid. This transition supports Ukraine's broader goals of independence, resilience, and sustainable post-war reconstruction.

7.1. Main findings

Throughout this research, I have explored a completely new field for me – security studies. By engaging with a wide range of literature and conducting my own analysis, I uncovered findings that I believe can contribute meaningfully to Ukraine's energy system resilience and post-war recovery. One of the most important conclusions I have reached is that renewable energy sources are critical for Ukraine's wartime resilience. In particular, solar and wind energy offer a decentralized, flexible, and robust alternative to the traditional centralized power systems. This decentralization makes them significantly less vulnerable to missile and drone attacks, which have repeatedly targeted Ukraine's conventional energy infrastructure during the war. The ongoing damage to critical facilities has only further exposed the vulnerability of the current system. In this context, renewables are not merely a sustainable option, they are a strategic necessity for protecting Ukraine's energy system. Moreover, to highlight the need of establishing and ensuring energy security is that in case of Ukraine energy

security implies national state security. A reliable and independent energy system is essential for Ukraine's sovereignty.

One of the main advantages is that Ukraine has significant potential in the renewable energy sector, both in terms of natural resources and emerging financial interest. The country benefits from favorable climatic conditions, especially for solar and wind energy generation. This natural advantage gives Ukraine a chance for expanding the solar power, not only for long-term sustainability but also for energy resilience. Furthermore, through the interviews conducted as part of this research, it became evident that the private sector has demonstrated growing interest in renewable solutions. This interest has been especially strong during periods of blackout and energy instability. Both households and businesses are increasingly turning to decentralized energy solutions as a way to ensure the supply of energy.

This thesis reviews energy security through the framework of Three perspectives: sovereignty, robustness and resilience. All three dimensions are crucial for Ukraine's energy strategy. From the resilience perspective, it is essential for the government to provide guarantees and insurance mechanisms for potential investors. The sovereignty perspective highlights the importance of international support for Ukraine, particularly in reinforcing the country's efforts to disconnect from Russian energy dependence. Additionally, the role of the Ukrainian government emerged as a critical factor that requires further attention and strategic engagement. From the robustness perspective., it became clear that decentralization offers a key technological advantage in strengthening Ukraine's energy system.

Despite the promising potential of renewable energy in Ukraine, significant barriers remain. The adoption of renewable energy sources is hindered by financial, institutional, technological, and safety-related challenges. One of the most pressing issues is the lack of clear and consistent regulations, which creates uncertainty for investors and slows down project development. Additionally, insufficient state support, both in terms of policy encouragement

and funding, discourages the implementation. Technological limitations and the need for modern infrastructure also pose serious obstacles. Moreover, the ongoing war creates serious security risks, as renewable energy systems can still be targeted by missile and drone attacks. It is important to address these challenges to create a safe and supportive environment for the development of renewable energy in Ukraine.

Overall, this war provides a unique chance for a systematic change. Despite all the destruction and damage, the war offers a rare opportunity to rebuild Ukraine's energy system from the ground up, focusing on decentralization, innovation and sustainability.

7.2. Recommendations

In assessing Ukraine's energy system security, the main recommendations focused primarily on the need for stronger financial mechanisms to support renewable energy development and on comprehensive governmental reforms. These two areas are finance and governance, they are currently underdeveloped and lack sufficient support, yet they hold the utmost potential to accelerate the adoption of renewable energy sources. Strengthening these sectors is essential for creating a stable foundation for Ukraine's energy transition and enhancing the overall resilience of its energy system.

When considering potential financial mechanisms, a key area for reform is the tariff system, which plays a crucial role in shaping investor interest and market stability. Past attempts to introduce "green" tariffs in Ukraine had mixed results: while they successfully encouraged a rise in renewable energy installations, they also exposed significant weaknesses in regulation. This experience highlights the importance of ensuring strong governmental regulation and transparency if such incentives are to be reintroduced or expanded. Drawing on international best practices, there are several proven financial tools that could be adapted to the Ukrainian context. These include "green" auctions, which allow renewable energy projects to compete for state contracts; net metering, which lets households offset electricity costs with

energy they produce; corporate power purchase agreements (PPAs), enabling businesses to buy clean energy directly; and feed-in premiums, which offer fixed bonuses on top of market prices. Implementing a well-regulated and diversified mix of these mechanisms could significantly enhance investor confidence and support the broader deployment of renewable energy across the country (Babayev 2021).

Governmental reforms represent another critical area that demands attention. At present, the Ukrainian government's involvement in the renewable energy sector remains limited, with existing strategies and policies often lacking depth and long-term vision. Many of these frameworks are surface-level and insufficiently enforced, failing to provide the consistent support needed to encourage large-scale adoption of renewables. Throughout this thesis, I have emphasized the importance of international support, particularly from European partners, but such support can only be effective if the government demonstrates a stronger commitment to engaging in and promoting these initiatives. To truly advance the development of renewable energy, the government must take an active leadership role in shaping and implementing supportive policies. This includes not only improving regulatory frameworks and offering financial incentives but also promoting public awareness and stakeholder engagement. Practical steps could involve launching informational campaigns targeting households, implementing educational programs at the municipal level, and strengthening diplomatic and economic negotiations with potential partners and investors. Such efforts would not only increase public trust and understanding of renewable technologies but also build a more attractive environment for long-term investment.

7.3. Contributions to the field

This thesis contributes to the broader discussion on the future reconstruction and recovery of Ukraine after the war. Beyond the immediate focus on infrastructure and economic restoration, it highlights the strategic role of the energy sector, particularly renewable energy,

as a foundation for long-term national resilience and sustainability. Moreover, it brings forward the often-overlooked issue of energy security within the context of wartime damage, offering a unique perspective on how energy systems can be designed to withstand military disruptions. By analyzing the Ukrainian case, this research expands the discourse around energy security, traditionally seen through geopolitical or economic lenses, by grounding it in real wartime conditions and vulnerabilities.

Moreover, renewables are placed at the heart of this study, not only as a sustainable energy option but as a strategic instrument for enhancing national security and independence. The findings clearly indicate that renewable energy technologies can play a crucial role in securing a stable and decentralized energy supply, even in times of war. Furthermore, this thesis opens space for discussing how post-war energy transitions can be accelerated not only through technical and economic measures, but also through stronger political commitment and international cooperation.

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