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Developing a resilient critical energy infrastructure in Kosovo

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Executive Summary

Critical infrastructure resilience is vital for achieving national resilience and security. Given the essential role of energy in all aspects of society, the energy system's resilience is crucial. A resilient energy system is prepared to absorb the shocks or stress and ensure the provision of power to the population during and after these events. Furthermore, such a resilient energy system involves technology, a thorough policy-making process, and social capacities.

Developing a resilient critical infrastructure is even more vital and complex for developing states such as Kosovo. The key vulnerability of Kosovo's energy system is the vast reliance on the two old lignite-fired thermal power plants for generation. Thus, this high reliance on lignite power plants makes the energy system unflexible, leading to unstable security of supply, unreliable, and dependent on imports, despite the regular restorations. Furthermore, Kosovo's energy system also is prone to losses in the distribution system, lack of energy reserves, storage, and an open energy market.

Kosovo energy stakeholders grasp energy security in terms of energy security of supply, having enough energy to produce, and liquidity without relying on imports. Furthermore, to them, energy security is a national security issue that enables a state to cover the vast energy demand and attract investments while ensuring economic development and political stability. Parallel to this, as most energy sector stakeholders are unaware of the concept of resilience, a level of awareness towards energy resilience as a concept that needs to be operationalized was observed in KOSTT.

Even though Kosovo is vulnerable to summer droughts and severe floods, this study found that the stakeholders in the energy sector are more concerned regarding shocks such as new technology, equipment failure, and cyber threats than the effects of climate change on energy resilience. Furthermore, they recognize the importance of preparing for new technology, which will be introduced with the enhanced Renewable Energy Capacities, the enhanced vulnerability of the system due to cyberattacks on critical infrastructure, and the need for investments in the current capacities to prevent failure. However, as states have started preparing to mitigate the effects of climate change on the energy system to the stakeholders in the energy sector in Kosovo, such changes do not affect the existing lignite power plants nor supply and distribution.

Kosovo's energy sector faces a critical moment in updating its legal infrastructure in line with its changing priorities and EU energy policies while accommodating coal-based power plants. The government must blend development priorities with resilience imperatives to ensure a better future and a more resilient critical infrastructure. The rising influence of extreme weather events on unforeseen disruptions to electricity generation and supply requires performing a risk analysis of disorders in power systems. Furthermore, community resilience must be enhanced, and adequate protection of critical infrastructure against cyberattacks must be integrated into organizational operations.

Kosovo's energy sector faces a critical moment in updating its legal infrastructure in line with its changing priorities and EU energy policies while accommodating coal-based power plants. The government must blend development priorities with resilience imperatives to ensure a better future and a more resilient critical infrastructure.

Key recommendations include:

- The Government of Kosovo should focus on enhancing the thermal energy capacities. While it conducts feasibility studies in eight municipalities, it should focus on finding investors and securing funds to improve thermal energy capacities.

- Since Kosovo aims to rely vastly on RES and integrate them into the transmission system, the Government must enhance its current budget for incorporating such RES into the system while allowing for investments in the transmission infrastructure.

- While commercial losses are a crucial weakness of the distribution system, the Government must invest in smart meters.

- Considering the vast importance of energy storage to energy resilience, the Government of Kosovo should focus on meeting the legal conditions, and the political barriers should be removed by May 2024 before procuring 170 mW batteries.

- As the Law on Critical Infrastructure in Kosovo lists energy (production, transmission, distribution, and storage) as critical infrastructure, the Government of Kosovo should draft a document, strategy, or action plan to address the development of resilient critical energy infrastructure in Kosovo.

- Since the Government is drafting the National Plan on Energy and Climate 2025-2030- it is essential to include and address energy resilience in light of climate change, considering that climate change is a rising stress, a chronic threat to the energy systems.

- While the National Draft Strategy on Energy projects the shift to RES, the bureaucratic procedures for investment and development of private RES should be eased to enable the investments. Furthermore, clear regulations should also be developed regarding prosumers' connection since an accurate guide is currently lacking.

- With the modernization and interconnectedness of energy systems, the shift towards RES and energy security requires adequate protection of critical infrastructure, especially against cyberattacks. Thus, during this modernization and digitalization, its essential to incorporate resilience cybersecurity best practices into organizational operations, planning, and procurement; prioritize cybersecurity investment needs; and establish the basis for region-wide cybersecurity information sharing.

Resilience is especially important in the lifeline sectors—energy, communication, water, and transportation—because they underpin the most essential functions of our society. Critical Infrastructure systems operate within various political jurisdictions where some of these assets are private and public. All this requires vast public policy engagement that calls for strong coordination and cooperation among infrastructure sectors and political jurisdictions.

1 Introduction

Critical Infrastructure is the backbone of societies all over the world, as it provides the essential and crucial services that these societies cannot successfully function without. Critical infrastructure resilience is vital for achieving national resilience and security. As the threat of terrorism increased globally, many governments have begun to increase their focus on the protection and resilience of Critical Infrastructure; however, the threats and challenges that critical infrastructure face, and will face, has vastly increased. While some hazards can be foreseen with warning signs that may allow time to prepare, risks under global challenges, especially risks such as climate change and cyberattacks, are not easily forecasted. The increased interconnectedness has brought numerous benefits to our society, it has also created dependencies and interdependencies of critical infrastructure sectors. Therefore, local shocks are increasingly likely to have far-reaching and costly consequences. This hyper-connectedness of critical infrastructure systems requires designing interdependent infrastructure to be more resilient before shocks happen. Resilience is especially important in the lifeline sectors—energy, communication, water, and transportation— because they underpin the most essential functions of our society. Critical Infrastructure systems operate within various political jurisdictions where some of these assets are private and public. All this requires vast public policy engagement that calls for strong coordination and cooperation among infrastructure sectors and political jurisdictions.

Developing such resilience in these critical systems is a highly complex process that requires extensive public policy involvement combined with engineering and technical solutions. While the European Union policy focuses on protecting its critical infrastructure in its energy security[1], building resilient critical infrastructure is even more critical and complex in developing states. Many developing states do not have an advanced Critical Infrastructure to begin with, so in the event of a shock, it is less than ideal to bounce back

1 More information on European Union's Energy Security and its Critical Infrastructure Protection is available at https://energy.ec.europa.eu/topics/energy-security/critical-infrastructure-and-cybersecurity_en

to how they were originally. Therefore, for these states it is highly important to blend development priorities with resilience imperatives to ensure a better future and a more resilient critical infrastructure. An example of such a state is Kosovo, a newly independent state with a highly damaged and aged critical infrastructure, especially energy, which affects all lifeline sectors.

The Global Energy Crisis has affected even the most well-developed member states of the EU; yet, its impacts are even more significant to Kosovo whose electricity needs exceed production capacities, especially during winter. Furthermore, Kosovar citizens faced significant power outages during August 2022 while the prices of energy bills have increased significantly. Thus, affecting the citizens' physical and mental well-being. Thus, developing a resilient critical infrastructure is a fundamental national security interest and an existential issue for a developing state like Kosovo.

While resilience stands as a new concept which is being operationalized in different fields, in this paper resilience is defined in line wihThe European Union, as the ability of individuals, communities, regions, or states "to withstand, cope, adapt, and quickly recover from stresses and shocks" without compromising their long-term development (European Comission 2016). As the meaning and use of the concept of resilience has been operationalized in various sectors, this policy paper focuses on developing a resilient critical energy infrastructure while exploring the resilience of Kosovo's power grid towards current recognized shocks and stresses to the energy infrastructure resilience.

Motivation for this research

The Government of Kosovo has not paid significant attention to developing national resilience. Moreover, developing critical energy infrastructure resilience is a wholly overlooked process that has not received any policy-making attention, despite Kosovo's vast problems with its critical infrastructure. This document outlines the essential findings and provides concrete recommendations to help the Kosovo Government develop its critical energy infrastructure resilience while serving as an example for other developing states aiming to achieve critical infrastructure resilience. Furthermore, this policy paper stands the first of its kind to operationalize resilience to the critical infrastructure in Kosovo. Its primary audience are decision-makers in Kosovo and the European Union involved with energy security policy.

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Research Questions

- What are the current threats to Kosovo's energy security?
- What are the shocks and stresses to Kosovo's energy grid?
- How could Kosovo develop a resilient critical energy infrastructure?

2 Methodology

To achieve the study goals and arrive to evidence-based energy security policy recommendations, this study employed qualitative research. Key data collection methods for this study included desk research and in-depth interviews with energy sector stakeholders in Kosovo.

Desk research

Desk research was essential in reviewing the existing literature in this topic while also allowing the development of an understanding of the concept of resilience, legal framework on critical infrastructure protection, energy security, understand the stakeholders, threats, hazards and risk management in critical energy infrastructure. Furthermore, desk research aided in collecting information regarding EU's energy security and poverty policy and exploring systematic reviews of evidence-based policy interventions in energy security.

In-depth interviews

In depth interviews were essential in understanding the current situation of the energy security and resilience and how decisions are made. For this study, in-depth interviews were conducted with decision makers in energy sector, engineers, and internal and external stakeholders. Specifically, in-depth interviews were conducted with high officials in Ministry of Economy (ME), the Energy Regulatory Office (ERO), the Kosovo Energy Corporation (KEK), the Distribution System Operator (KEDS), the Transmission System Operator (KOSTT), and the Kosovo Company for Supply of Energy (KESCO). The questionnaire for these in-depth interviews is available as Appendix A. The qualitative data collected was processed and analyzed through the MAXQDA Software.

The meaning and use of resilience have changed over time and in sectors. Therefore, if not specified, it might remain an ambiguous concept used differently by different people (Dahm et al., 2017). Thus, while this paper focuses on developing resilient critical energy infrastructure, it is essential to specify what we imply and how we operationalize resilience in energy systems.

3 Literature Review

Defining Resilience

In 1973, Holling presented resilience in science, and ecology, as the capacity of a system to persevere within a domain of attraction in the face of disturbances and changes in state variables, driving variables, and parameters. However, throughout the years, the term's use grew out of ecology, and currently, there are more than 70 definitions of resilience in the scientific literature (Fisher, 2015). The European Union defines resilience as the ability of individuals, communities, regions, or states "to withstand, cope, adapt, and quickly recover from stresses and shocks" without compromising their long-term development (European Comission 2016). Similarly, the United States National Academy of Science defined resilience as "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events." (2012, p. 1). Parallel to this, the U.S. Presidential Policy Directive 21 defined resilience as "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions" (2013). Such disruptions include deliberate attacks, accidents, naturally occurring threats, or incidents. In defining resilience, Micheal Bloomberg, former mayor of New York, framed it as a process to analyze the current situation to minimize the risk of disruptive future events.[2] However, many scholars conceptualize resilience more in terms of recovering than also planning in advance. Dahm et al. define resilience as the capacity of a system to recover after stress (2014). Similarly, Aldrich (2017) defines it as the ability to recover from shocks, including natural disasters. Also, McClymont et al. see resilience at a fundamental level relating to a system's ability to resume functionality in the wake of disturbances (2018). Thus, various cities and states define and operationalize resilience differently.

Exploring definitions of resilience led to an understanding that resilience is also framed in terms of spatial scope. Ganguly et al. note that resilience is studied across scales and these scales dictate the extent to which the criticality of infrastructure needs to be examined (2018). In this sense, two standard categorizations are community resilience and regional resil-

2 Mayor Bloomberg speech on the comprehensive report "A Stronger, More Resilient New York," is available at https://www.youtube.com/watch?v=UQCNuscFdos

ience. In community resilience, the interaction of infrastructures at community scales (e.g., neighborhoods, villages, cities, counties) with the people and economic assets within these communities is essential. In contrast, regional resilience covers larger geographical scales and might also go beyond a state's jurisdictions, political boundaries, and multiple sectors (Ganguly et al., 2018). This paper does not intend to explore how to make a community more resilient towards stresses and shocks to its critical infrastructure, rather it seeks to explore how could this critical energy infrastructure be resilient. Thus, this paper focuses on examining critical infrastructure through the lens of regional resilience.

Knowing how we define it and what we imply by it is crucial to achieving resilience. The meaning and use of resilience have changed over time and in sectors. Therefore, if not specified, it might remain an ambiguous concept used differently by different people (Dahm et al., 2017). Thus, while this paper focuses on developing resilient critical energy infrastructure, it is essential to specify what we imply and how we operationalize resilience in energy systems.

3.1. Engineering or Ecological Resilience?

Scholars distinguish between two main types of resilience- "engineering resilience" in material science and "ecological resilience," which refers to the resilience of complex adaptive systems. Engineering resilience refers to the ability of a system close to a stable point to return to it after a shock. Furthermore, the focus is on balance to which it will return after it has recovered, and such systems' behaviors are predictable (Holling, 1996). On the other hand, ecological resilience recognizes the system's unpredictability and stresses its ability to absorb disturbances to the system's function as the focus of resilience (Sharifi and Yamagata, 2015). While smaller in number, some scholars also recognize a third understanding of resilience- adaptive resilience. This type of resilience refers to how a system adapts to stress (Simmie and Martin, 2010). Moreover, it recognizes the system's unpredictability and focuses on its ability to learn and self-organize. Such a system does not return to its normal state but changes to a changed stable state (Kharrazi et al., 2015).

In cases where engineering resilience is found as more suitable, a methodology based on a resilience framework help to assess this resilience (Jesse et al., 2019). An essential framework, in this case, is Tran et al., which consists of five steps rooted in a deep knowledge of the system and the disturbances and producing a quantitative analysis. In contrast, the ecological resilience concepts allow for qualitative energy system analysis. Erker et al. developed an approach based on factual and value-level analysis, allowing the social and technical aspects to be considered while deriving policy recommendations.

It is essential to define "resilience to what and against what" since the system and the disturbance influence whether engineering resilience or ecological resilience is suitable for implementation and to answer our research questions (Erker et al., 2017). Since this research aims to develop policy recommendations, the concept of ecological resilience will be followed. Furthermore, in defining “resilience of what against what” this paper will explore the resilience of Kosovo’s power grid towards shocks and stresses.

3.2. Vulnerability and Adaptive Capacity

In general, resilience as a concept ensures the feasibility of a system by reducing vulnerabilities and increasing the adaptive capacity before, during, and after stressful events. Vulnerability refers to system exposure, sensitivity or predisposition to suffer of damage before the actual disturbance (Adger, 2006; Cutter, 1996). Additionally, such vulnerability might be reduced in advance by mitigation measures such as preemptive adjustments of functions, structures and strategies. The digitalization of critical infrastructure has brought to light the vulnerability of the power grid to cyberattacks. While critical infrastructure has long been exposed to physical threats and natural disasters, it is now increasingly exposed to cyber risks as well. These risks derive from a growing integration and interconnection of information and communications technologies with critical infrastructure and opponents focused on exploiting potential cyber vulnerabilities. Furthermore, as physical infrastructure becomes more reliant on complex cyber systems for operations, critical infrastructure can become more vulnerable to specific cyber threats, including transnational threats (CISA, 2019). Meanwhile, adaptive capacity refers to the changes in the system during or after the disturbance as a way of compensating for the already occurring damages (Erker et al., 2017). Thus, implementing resilience strategies in advance by reducing the vulnerabilities and enhancing adaptive capacities will minimize the impacts of damages.

A resilient system can reach three levels of resilience- preserving, restabilizing, or adapting functions and structures during a crisis (Erker et al., 2017). However, these three levels of resilience mentioned above that the system might adopt depend on the temporality and spatiality of the occurring crisis. Considering these levels, the theory of resilience aids in understanding whether a system might return to equilibrium or transform into a new desirable system if the changes are permanent. Moreover, Erker et al. distinguish between long-lasting disruptions that cause more significant damage to the system than short-term disruptions. Thus, a resilient energy system can swiftly recover from a shock while reinventing itself (Erker et al., 2017). As such, developing resilience strategies ahead, anticipating ways to reduce the vulnerabilities, and enhancing the adaptive capacity might minimize the harmful damages of crisis.

3.3. Energy Resilience

Energy as a service is a means to an end, a tool of society to achieve its basic needs (Bossel 2013). Thus, the energy system's resilience is highly interrelated to the resilience of our society. Fundamental needs of society must be covered to preserve the quality of life. Within these needs- housing, working, supply and mobility are mainly dependent on energy and infrastructure and constitute 90% of global energy consumption (Erker, 2017). Moreover, the quality of life is preserved by reducing the vulnerability and increasing the adaptive capacity of corresponding commodities to minimize the variation and negative deviation of quality of life of people (Erker, 2017). Thus, having a resilience energy system means having a system that is prepared to absorb the shocks or stress and ensure the provision of power to the population during and after these events. Furthermore, such resilient energy system does not merely involve technology but also a thorough policy-making process and social capacities.

Scholars have identified dimensions (layers) of energy resilience which work in together or concurrently to aid the system in avoiding permanent failures and bouncing back. These dimensions of resilience performance are engineering-designed, operational, and community (societal) resilience.

3.3.1. Engineering-designed resilience

The built-in or "engineering-designed resilience" refers to system assets designed to restore regular services after a short disruption without human intervention. This built-in resilience might be seen as an extension of a system designed for reliability and redundancy. Furthermore, this layer of resilience provides the opportunity for other or new innovative solutions, such as self-healing systems. These engineering-designed resilience enhancement strategies are physical/protective/mechanical and do not require human involvement. Key examples include redundant capacities, flexibility, storage, backup system, and physical protective measures (Shandiz et al, 2020). Other examples include microgrids (Hervas-Zaragoza, 2022; Moreno et al., 2022), grid interconnections, distributed generations (Rueda-Medina et al., 2013) and smart grid technologies (Alsuwian et al., 2022).

3.3.2. Operational Resilience

The second layer, "operational resilience," includes the technological and organizational measures employed when the disruption exceeds the capacity of engineering-designed resilience. It is focused on system-level performance and the operational characteristics of the system intended to mitigate the failure risk and support service recovery. Such examples are demand response, demand-side management strategies, prioritizing energy use, smart controls, and forecasting (Shandiz et al., 2020). This layer of resilience also consists of the process of decision-making- the team, organization level, or whole energy sector.

Advancing resilient critical energy infrastructures requires extensive public policy involvement supporting coordination and cooperation among stakeholders and political jurisdictions. Currently, the global energy system strongly depends on non-renewable energy resources, which comprise 80% of the global energy mix (IEA, 2022). Furthermore, these non-renewable energy resources are available in limited regions which require transportation to long distances for exporting/importing, which results in states-intergovernmental, political, and economic interdependencies. As such, the system is vulnerable to sources' constraints due to the surpass of natural capacity limits or an artificial restriction of access to sources affecting one or more energy sources. These artificial restrictions include international conflicts, political decisions, technical failures, and intentionally triggered disruptions of power plants, energy networks, or energy markets (Stoeglehner et al., 2016). Therefore, public policy is essential to operationalize resilience and overpassing barriers.

Energy infrastructure systems involve unique sets of public and private stakeholders, owners, and operators requiring extensive coordination and collaboration. While energy infrastructure owners and operations' fundamental goal is to achieve the highest productivity as an end in itself, they do not yet perceive the importance of this cooperation with other infrastructure owners (Ganguly et al., 2018). These stakeholders in these infrastructure systems might be internal and external. Internal stakeholders have employment, ownership, and investment interest in the system's operations. Internal stakeholders include power generation and distribution companies, public utility unions, and public and private investors. On the other hand, external stakeholders are those who derive a benefit from the successful functioning of the system. Key examples include customers, creditors, shareholders, and society. Internal stakeholders are the primary drivers of decision-making. Furthermore, typically they do not communicate in advance with external stakeholders to develop joint disaster management protocols if not required by a regulatory body (Ganguly et al., 2018). Undoubtedly, this lack of joint disaster management protocols contributes to disastrous consequences while extending the recovery period for independent systems after harmful events. Also, focusing on enhancing production while reducing new infrastructure costs puts systems at significant risk of collapse during extreme events (Ganguly et al., 2018). Hence, policymaking in energy resilience enables this coordination and collaboration among stakeholders and across political jurisdictions to address multiple risks.

The policymaking process for energy system resilience consists of four stages: issue/problem identification, assessment of options/policy formulations, adoption and implementation, policy evaluation, and monitoring (Ahmadi et al., 2022). The first stage of issue/ problem identification consists of identifying the current situation, the organization of the reference energy system, and identifying potential risks. This stage consists of the main steps to organize the problem. The policy formulation involves developing an energy system resilience model, scenario development, and specifying the resilience indicators. Moreover, this phase is a crucial phase of policy formulation. The adaptation and implementation consist of calculating the system's optimal state before the events in different scenarios, calculating the system's optimal state after the event in different scenarios, and result discussion (Ahmadi et al., 2022). Lastly, policy evaluation/ monitoring refers to minor adjustments aligned with changes and goals, calculating energy resilience indicators in optimal states and identifying the best scenarios.

3.3.3. Community Resilience

Lastly, community and societal resilience need to be raised as part of the solution when appropriate, expressly when the first two layers are insufficient to address the disruption. Community resilience is a process that can restore, maintain or enhance community well-being and social ties in the face of natural disasters or sudden change (McCrea et al., 2015). However, in energy resilience, this definition is extended to include the cooperation, collaboration, and partnership needed between the energy service providers and the demand-side consumers (the community). Thus, community-societal energy resilience consists of the actions that should be taken within the community by some or all the community users to maintain the minimum allowable community-social services. These actions include mass relocation, effective use of community resources during a disruption, and increasing social capital bonding, bridging, and linking (Shandiz et al., 2020). For instance, Aldrich's (2022) research on the 2011 catastrophe in Japan found that the communities that had lower mortality levels and bounced back easier after the tsunami were the ones that had higher levels of stronger social ties.

3.3.4. Shocks and stresses to the energy system

Operationalization of resilience in energy systems is crucial since they are in a state of continuous change and often cope with external influences. While the theory of resilience explores the effects of stress and shocks, it is essential to clarify what they both mean and how they differentiate. Shocks refer to sudden changes, while stresses refer to continuous alterations (Smith and Striling, 2010). Standard shocks might include the sudden introduction of new technology or a natural disaster. Regarding stresses, Hughes, says that an energy system must meet three criteria: accessibility, affordability, and acceptance. If the system can no longer meet one of the three criteria, it experiences stress (2015). Similarly, scholars make a difference between acute and chronic threats. Acute threats refer to sudden hazards such as earthquakes, pandemics, cyber-attacks, hurricanes, and tornados. At the same time, chronic stresses include slow and cyclic hazards such as chronic flooding, rising sea levels, and increasing ambient temperatures.

Climate change is a rising stress, chronic threat to the energy systems. Changes in the nature, intensity, and frequency of climate-related extreme events have enhanced the risk of failure in energy systems since the current energy systems have been designed based on previous climate-related assumptions (Charani

Shandiz et al., 2020). The rises in ambient temperatures due to climate change directly affect the energy system, resulting in lower electricity generation efficiency for fossil fuels and renewable sources. Furthermore, it poses an increased challenge to electricity infrastructure transmission lines, for the likelihood of fires occurring in transmission lines is expected to increase. While these fires might not always cause electricity outages, they increase electricity maintenance costs and decrease transmission line efficiency (Satheye et al., 2011).

Additionally, higher temperatures also enhance cooling needs and lower the efficiency of mechanical cooling systems (Charani Shandiz et al., 2020). Moreover, Kelly-Pitou et al. (2017) also presented climate change as an example of the relationship between stress, shock, and resilience, where resilience imperatives could be used to protect the communities from the sudden damage of climate change while also helping to ease the long-term impacts of it.

Kosovo Energy Cooperation currently covers 90% of energy demand, it lacks liquidity due to the dependence on lignite-fired thermal for energy production. Consequently, the lack of energy liquidity makes the Kosovo energy system dependent to the imports and international energy prices.

4 Current situation in the energy sector and the grid's current capacity

Kosovo's energy system relies vastly on lignite-fired thermal power plants (nearly 93-94%), and almost six percent of the energy production derives from Renewable Energy Sources (RES) such as wind and solar energy. Considering the fact that Kosovo possesses the world's fifth-largest proven reserves of lignite[3], its electro-energetic system depends on the generation capacities of the two thermal power plants: Kosova A and Kosova B. The critical problem with these power plants is the old infrastructure of energy generation, where the newest block of Kosovo A, A5, was developed in 1975, while Kosovo B became functional in 1983-1984.[4] Thus, these blocks have overpassed their operational lifespan, leading to unstable security of supply, making the system unreliable and dependent on imports, despite the regular restorations and investments. [5]

Although Kosovo Energy Cooperation currently covers 90% of energy demand, it lacks liquidity due to the dependence on lignite-fired thermal for energy production. Consequently, the lack of energy liquidity makes the Kosovo energy system dependent to the imports and international energy prices. As Kosovo covers nearly 15 percent of its energy needs from imports yearly, this fact had harmed the state and its energy system since 2021, when energy import prices vastly increased globally. Moreover, the situation worsened in the winter months of 2022, considering the high reliance of the consumers on electricity for heating since only two municipalities in Kosovo, Prishtina and Gjakova, use district heating.[6] Such lack of thermal energy capacities highly impacts the security of supply since, during the winter season; the consumption rises from 800 mW to 1400 mW. [7]

3 https://www.trade.gov/country-commercial-guides/kosovo-mining-and-minerals
4 In-depth interviews with high officials at KEK and Ministry of Economy of the Republic of Kosovo
5 In-depth interview with high official at KEK
6 In-depth interviews with the Department of Energy at the Ministry of Economy and KEK
7 Ibid;

Despite the challenges, Kosovo has started focusing on shifting to renewable energy sources to meet its obligations under EU legislation and enhance the system's liquidity and flexibility. While previously, the Government of Kosovo has considered developing a new coal power plant, Kosova C (Kosova e Re), this idea is now off the table due to its environmental and public health implications. [8] Currently, around 100mW of Kosovo energy capacities are produced by RES, with two wind generators operate in Kamenica, that in Bajgora and the Solar Park in Gjakova. [9]As the KEK thermal power plants produce energy 24 hours, the consumption is not always the same at different parts of the day and seasons; therefore, relying on solar and wind power allows the combination of these sources during the peak periods while ensuring security of supply.

4.1. Vulnerabilities and weaknesses

The critical energy infrastructure in Kosovo has several vulnerabilities. The primary weakness is energy generation, as nearly 80% of energy comes from lignite thermal power plants; thus, due to this high reliance on power plants, any breakdown has a direct impact on the whole system's operation. While Kosovo became an independent regulatory zone for electricity in 2020, any such deviations from generation and supply might lead to penalization by the European Network of Transmission System Operator (ENTSO-E) network that maintains the transmission system. In the past year, such deviation in supply have led to monetary fines as well. Parallel to this, prolongated deviations [10]also might lead to expel from ENTSO-E and International Energy System (IES).

The losses in distribution system stand as another key vulnerability of the Kosovo energy system. The distribution network experiences two types of losses - technical and commercial. Technical losses occur due to network, system, obsolescence, transformers, and equipment, while commercial losses are due to misuse in the network. Currently, the losses in distribution stand at 18.45% and investments in the network are important in reducing technical losses in transmission and distribution. [11]

Kosovo's energy system lacks secondary and tertiary energy reserves. Energy storage is essential to create security, especially when there is a surplus of energy produced by RES when there is no consumption. To ensure future capacity from RES, Kosovo needs to have a flexible market that works well and stimulates different flexibility options.

8 In-depth interview with the Department of Energy at the Ministry of Economy of the Republic of Kosovo, March 2023
9 Interview with high official at KEDS, March 2023
10 In the absence of a budget to cover the losses of the north from the electricity used but not paid for in the northern part of Kosovo, to cover this consumption, electricity is withdrawn in the form of diversions from the Electric Power System of Continental Europe. These deviations contradict the KOSTT/ENTSO-E Agreement and represent financial obligations for KOSTT as an independent regulatory area towards ENTSO-E, responsibilities for which it is invoiced". Read more on https://nacionale.com/politike/kostt-e-konfirmon-me-40-milione-eurot-e-qeverise-kurti-do-tu-paguhet-rryma-serbeve-ne-veri
11 In-depth interview with high official at Ministry of Economy of the Republic of Kosovo, March 2023

For example, if Kosovo wants to have 1300 mW from wind and solar energy, it needs a backup reserve so that energy that flows for 24 hours is stored. The current system is unsustainable regarding resource diversification due to its obsolescence and a resource like coal, which is not flexible. Hence, the system needs to be flexible to integrate large capacities from RES. Battery storage can ensure this energy is used more conveniently, and in unfortunate situations of system failure or disaster, this accumulated energy might be used. [12] In 2022, the Millennium Challenge Corporation Board approved the $202 Million grant to improve Kosovo's energy security and efficiency.[13] With support from MCC, the battery project is a step towards this goal. At the same time, some legal conditions must be met until May of 2024 before the procurement of 170 mW from batteries, 45 of which are for KOSTT for tertiary regulation and the rest is for a battery that conserves energy at night. Once regional markets and political barriers are removed and reserves are developed, the energy market in Kosovo will be more reliable and sustainable.

Advancing the energy market in Kosovo is crucial to increasing the security of supply and ensuring lower prices for citizens. Furthermore, Kosovo needs to establish an open and competitive energy market. A key barrier to such an open and competitive energy market is internal security which enables the affordability of the competition that would make the wholesale and reserve markets cost-efficient. Kosovo must integrate into the EU electricity market and its goal is to create a free and competitive energy market. The essential step in this regard is the establishment of ALPEX in 2020 as a power exchange and electricity market operator jointly owned by the Transmission System Operators in Albania and Kosovo (OST and KOSTT). While Alpex will act as the market operator for both Albania and Kosovo, it will aid in the reduction of prices because the consumers choose where they want to buy, enabling affordability and enhancing the climate for investments. Furthermore, it will match in a centralized auction the hourly bids and offers to sell and purchase energy; thus, revealing a transparent hourly price that might be projected and used to attract investments. Parallel to this, it enhances the liquidity of both energy markets since while Kosovo relies heavily on coal-based power plants for electric energy, Albania relies on hydropower. Thus, they would complement one another- day and night. [14] On April 11th 2023, ALPEX became operational for Albanian Bidding Zone. Meanwhile, it will become operational in August for Kosovo Bidding Zone and Market Coupling Albania-Kosovo as well.

4.2. Legal Framework

In 2018, The Kosovo Government ratified Law NO. 06/L-014 On Critical Infrastructure. This Law aims to preserve and

12 In-depth interview with high officials at KOSTT and KESCO, February 2023
13 Millenium Challenge Corporation (2022) "MCC Board Approves $202 Million Grant to Improve Kosovo's Energy Sector" Available at https://www.mcc.gov/news-and-events/release/release-070122-mcc-board-approves-kosovo-compact
14 In-depth interview with high official at KEK, March 2023

protect national and European critical infrastructure and citizens and prevent incidents while minimizing potential damages to critical infrastructure while enhancing resiliency. Moreover, it identifies Critical Infrastructure sectors and criteria while guiding their management, including risk analysis, characteristics of Safety Plans for Owners/Operators, roles and responsibilities of Security Coordinators of Critical Infrastructure, and penalties for non-compliance. [15] This Law classified the National Critical Infrastructure into sectors based on shared interests facilitating cooperation between Sector partners and stakeholders. Moreover, the second listed infrastructure is energy (production, transmission, distribution and storage). However, no document, strategy, or action plan addresses the development of resilient critical energy infrastructure in Kosovo.

In February of 2023, the Government of Kosovo adopted the Law on Cyber Security. This law notes the need for the establishment of the Computer Security Incident Response Teams (CSIRTs) at national level and such teams may be established in sectors of the critical infrastructure. Furthermore, these CSIRTs should also be established in the Operators of Essential Services (OES), which refer a public or private entity that possesses national critical infrastructure according to the respective Law on Critical Infrastructure. Furthermore, this law obliges the OES to permanently apply organizational, physical and information technology security measures for: preventing cyber incidents, resolving cyber incidents and preventing and mitigating an impact on the continuity of the service or the security of the system due to a cyber incident[16]. Also, another key element of this law is that it establishes the Cyber Security Agency, which will be responsible of implementing this Law.

The Critical Energy Infrastructure of Kosovo operates in accordance with a package of laws, beginning with the Law on Energy[17], Law on Electric Energy,[18] Law on Energy Regulator,[19] Law on Renewable Energy.[20] However, the Law on Energy, Electric Energy, and Energy Regulator will need to be reviewed and updated in line with the new obligations that derive from the Energy Treaty, EU package of energy laws, but also the areas where the stakeholders have observed policy and regulations deficiencies. [21] Parallel to this, the Department of Energy has drafted the concept document for revising these laws, which is expected to occur in October 2023. Thus, Kosovo's energy sector is at a cross-road in updating its legal ener-

15 Law No. 06/L-014 ON CRITICAL INFRASTRUCTURE is Available at https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=16313
16 Assembly of the Republic of Kosovo (2023) LAW NO. 08/L-173 on Cyber Security, Available at https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=70933
17 Assembly of the Republic of Kosovo (2016) LAW NO. 05/L-081 ON ENERGY, Available at https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=12689
18 Law No.05/L-085 on Electric Energy, Available at http://ero-ks.org/2016/Ligjet/LIGJI_PER_ENERGJINE_ELEKTRIKE.pdf
19 Assembly of the Republic of Kosovo (2016) Law No. 05/L-084 On the Energy Regulator, Available at LAW NO. 05/L-084 ON THE ENERGY REGULATOR
20 Assembly of the Republic of Kosovo (2018) Law No. 06/L-079 On Energy Efficiency, Available at https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=18216
21 In-depth interviews with the Department of Energy at the ME and KOSTT

gy infrastructure in line with its changing energy priorities and EU energy policies while also trying to accommodate the existing coal-based power plants.

In December of 2022, the Government of Kosovo approved the new energy strategy for 2022-2031, which is also expected to be approved by the Assembly. [22] This energy strategy is rooted in diversifying energy sources deriving from the lignite-power plants and renewable energy. The objectives of this strategy are to guarantee the security of the energy supply, achieve sustainability and climate neutrality, and ensure affordability for citizens. [23] This document oversees the development of new capacities from wind and solar energy with 1200 mW and those of prosumers with 100 Mw. Therefore, the capabilities will be increased by 1300 mW, and up to 35% of the energy will be generated from renewable energy. Parallel to this, the strategy also foresees interventions in the existing aged thermal power plants, where the interventions in Kosovo B will enhance energy efficiency and generation. In contrast, Kosovo A's renovations will strengthen the security of supply. [24] While the strategy has received significant recognition, it has also been critiqued due to its need to elaborate the transition process. Moreover, it fails to address the question, "What after the lignite power plants are shut down?". Kosovo lacks RES capacity to meet the needs, which has remained unaddressed by the strategy. Parallel to this, RES depend on investments that yet need to be secured. Undoubtedly, the lack of capacity to produce solely through RES and the lack of investors would leave Kosovo dependent on energy imports. [25] Meanwhile, the possibility of gas supply has been left as an analysis possibility yet to be addressed adequately.

Currently, the Ministry of Economy and the Ministry of Environment and Spatial Planning are in the process of drafting the National Plan on Energy and Climate 2025-2030. This document involves critical objectives and policies to address climate change and promote a sustainable energy future. This plan also includes measures to achieve the energy and climate targets approved in The Energy Community through improving energy efficiency, security energy and the energy market, and the development of renewable resources energy. [26]While these Ministries are drafting such a document, it is yet to be seen whether it will address energy resilience.

4.3. Stakeholders and Policymaking

Energy infrastructure involves various public and private stakeholders, including owners and operators, who must collaborate to ensure proper coordination

22 The Draft Energy Strategy of the Republic of Kosovo 2022 – 2031 is available at https://konsultimet.rks-gov.net/viewConsult.php?ConsultationID=41424
23 Interview with high officers of the Department of Energy, Ministry of Economy, February 2023
24 Ibid;
25 Interview with high official at KEK. Other analyses of the strategy is available at https://kosovo.energy/a-eshte-strategjia-e-re-zgjidhje-per-krizen-energjetike/
26 Ibid;

and collaboration. According to the Law on Electric Energy, in Kosovo's energy sector, there are several institutions with divided responsibilities, including the: Ministry of Economy (ME), the Energy Regulatory Office (ERO), the Kosovo Energy Corporation (KEK), the Distribution System Operator (KEDS), the Transmission System Operator (KOSTT), and the Kosovo Company for Supply of Energy (KESCO). The ME is responsible for drafting laws and policies and monitoring the implementation of these laws in energy, mining, and telecommunications. The ERO is the independent regulatory body of the sector and reports to the Assembly of Kosovo. The KEK is the state-owned company that produces most of the energy in Kosovo. Meanwhile, KOSTT, KEDS, and KESCO are private companies operating in transmission, supply, and distribution. While KEDS and KESCO buy energy from KEK, that energy is transmitted by KOSTT. If that energy is insufficient to meet the demand, KEDS accepts it in international markets, and KOSTT transmits it again. Thus, all the stakeholders continuously need to cooperate, and if this chain is broken, it might result in a crisis.

All these stakeholders participate in working groups established by the Assembly of Kosovo. Furthermore, the ME continuously consults with these stakeholders on topics and issues related to the sector. Moreover, this corporation between stakeholders and institutions has increased, especially during energy crises. For instance, in 2022, the Ministry of Energy and the Judicial Council cooperated regarding legal actions toward the distribution of energy losses.

Developing stable policies, incentives, and regulations is critical for creating a resilient energy sector. Moreover, these policies must be developed following clear regulative and simplified bureaucratic procedures. For instance, as there are currently various initiatives related to solar panels, there needs to be more precise regulation on how this energy will be implemented. Parallel to this, the bureaucratic procedures also harm the willingness of consumers to become prosumers since connecting to the grid and having the right to self-consume the generated electricity and delivering the excess of generated electricity to the supplier takes a long time. [27] The rapid technology progression requires rapid updates on rules and regulations and incentive tariffs. Incentive policies can attract investment, especially in small countries with weak economies, and policymakers should focus on creating attractive policies with controllable mechanisms to prevent unhealthy competition.

4.3.1 How do stakeholders grasp energy security?

Stakeholders in a sector need to understand and operationalize an issue correspondingly to ensure effective communication, collaboration, and decision-making. Moreover, while the energy infrastructure systems involve a combination of public, and private stakeholders, they must have a common understanding

27 In-depth interview with high official at KEK, March 2023

of energy security to ensure system resilience while preventing misunderstandings, miscommunications, and conflicting goals. While the International Energy Agency (IEA) defines energy security as "*the uninterrupted availability of energy sources at an affordable price*". [28], all energy stakeholders in Kosovo grasp energy security in light of the energy security of supply and often use it interchangeably. Energy security of supply, having enough energy to produce and liquidity without relying on imports, is a national security issue that enables a state to cover 90% of energy demand and attract investments while ensuring economic development and political stability. [29]Parallel to this, the importance of energy security, the ability to supply energy to consumers without power outages, is increasing due to its fundamental role in crucial life functions and lifeline sectors, including the banking system, given the rise of digitalization and technology. [30] On a similar note, it is essential to evaluate on how do energy stakeholders grasp energy resilience.

4.3.2 How do stakeholders grasp Energy resilience?

Resilience stands as a new concept which has not been operationalized in different fields in Kosovo. Furthermore, such operationalization of resilience in energy sector has not previously been neither researched on neither operationalized in Kosovo's energy system. However, a level of awareness towards energy resilience as a concept that needs to be operationalized was observed in KOSTT. While previously there were parameters that aided in assessing the security of supply such as availability and reliability of the system, currently the transmission system is combining these indicators with other mechanisms due to the increased interconnectedness of critical infrastructure systems, exposure to cyberthreats, climate change and natural catastrophes. [31] Thus, the transmission system operators (TSOs) have started paying attention on how ready is the system to absorb a stress, shock, for how long it is capable to absorb that stress while supplying energy and how capable it is to return to its stable state. However, to other stakeholders a resilient energy system is perceived differently. A resilient energy system is one that can generate energy fully without relying on imports and is balanced between electrical and thermal energy. This is achieved through a combination of energy sources, such as coal and renewable energy sources (RES), which enhance the liquidity and flexibility of the system. [32]

All stakeholders proposed interventions or upgrades are necessary to improve the grid's resilience. Energy storage can also contribute to resilience by allowing for stored energy to be traded, as long as political barriers are removed and energy storage technologies are developed.[33]

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28 International Energy Agenct (2023) "Energy security" Available at https://www.iea.org/about/energy-security#:~:text=The%20IEA%20defines%20energy%20security,economic%20developments%20and%20environmental%20needs.
29 In-depth interviews with high officials at KEK, Ministry of Economy and KEDS, February-March 2023
30 In-depth interview with high official at KOSTT, February 2023
31 Ibid;
32 In-depth interview with high official at KEK, March 2023
33 In-depth interview with high officials at the Department of Energy, Ministry of Economy of the Republic of Kosovo, February-March 2023

Parallel to this, the decentralization of the energy system is another important factor in building resilience. Microgrids, smart grids and meters are examples of decentralized systems that allow for the system to continue operating even in the event of a catastrophic event. The more decentralized the system, the more independent it becomes and the better it can function under shocks. However, managing a decentralized system requires developing an understanding of how to manage microgrids and other independent networks that ensure resilience of the system. [34]

There should be more investments on the grid- related to the generation and rehabilitation of current capacities. Furthermore, the transition from a coal-based grid to RES has a high cost which requires vast investments to ensure the infrastructure for such transition. [35] Moreover, the transmission needs to develop further its infrastructure to include the RES into the system and to be able to distribute that energy from the production point to the other areas. [36] Parallel to this, considering the unpredictability of RES, this integration of RES into the system should be done in line with the development of the reserves where this energy will be stored. [37] Undoubtedly, while most of these interventions involve engineering designed resilience, technology and infrastructure, such interventions must be coupled with informed energy policy and decision-making.

34 In-depth interviews with high officials at KOSTT and KESCO, February 2022
35 In-depth interview with official at KESCO, February 2022
36 In-depth interview with high official at KEK, 2022
37 In-depth interview with high officials at the Department of Energy, Ministry of Economy of the Republic of Kosovo, February-March 2023

5 Assessing Risks and Shocks

Not all stakeholders in the energy sector perceive and assess risks and shocks to Kosovo's energy resilience. Furthermore, not all of them have the same opinions of what should be the priorities of national preparation for stresses and shocks to Kosovo's energy resilience. While the survey asked all the interviewed stakeholders to rate the priority level of needed national preparedness for a list of stresses and shocks to the energy system, it was evident that most of them were more concerned regarding new technology, equipment failure, and cyber threats. All the interviewed stakeholders assessed the need to prepare for new technology (4.25) and (technology failure) 4.12, followed by cybersecurity (4) as the key risks and shocks to the system. In contrast, the interviewees do not perceive climate change as a threat (2.5), earthquakes (3.1), floods (2.5), draughts (1.6) physical attacks (1.71).

5.1. New technology

New technology is an essential tool to improve the current network capacity. While the energy infrastructure in Kosovo is gradually modernizing, the importance of new technology will also be increased with the enhanced focus on RES and Kosovo A and B rehabilitations overseen by the draft energy strategy. Such new technology is perceived as highly important, especially in transmission and distribution. For instance, in the distribution sector, equipment introduced post-war was designed to work at two voltage levels, 10-20 volts. Recently, a shift from 10 volts to 20 kilovolts has enabled consumers to receive electricity with better quality and lower losses. Although the new technology has advantages, it requires careful consideration to anticipate possible failures. New equipment is easier to manage but should be supervised based on manufacturer specifications, including the equipment's lifespan, maximum load capacity, and repair or replacement timeframe.[38] Thus, the process of introducing new technology also requires a thorough analysis of how

38 In-depth interview with high official at KEDS, March 2023

that technology should be used without causing any harm to the current system. Parallel to this, while new technology has eased the monitoring and controlling of energy infrastructure, it has also enhanced the vulnerability to cyber-security.

5.2. Equipment failure

Considering Kosovo's aging energy infrastructure, equipment failure is a critical risk that the central government should enhance preparedness. Outdated capacities in the system are primarily due to old production equipment that has exceeded its lifespan. For example, the Kosovo B power plant was built in 1983-1984 and is now at the end of its lifespan. Due to its age and uncertainty about its reliability, there is a risk of equipment failure. Therefore, it is essential to replace outdated equipment and ensure the safety and reliability of the energy system.[39]

Such equipment failure is mainly present in the generation, where equipment obsolescence can occur with meter outputs, technical problems, and pipe bursts due to the aging of the pipes that transport heated water in the boiler house. When a problem occurs, the affected unit stops, the tube is repaired or replaced, and the unit resumes operation. [40] Thus, to ensure the reliability of the energy system, regular revisions and maintenance should be carried out to identify weak points and replace outdated equipment. These regular revisions may involve replacing devices such as transformers during periods of low demand, such as in the summer when only one transformer is needed. [41] Therefore, it is essential to prevent such technology failure to enable the day-to-day operation of the system

5.3. Cyber-threats

Kosovo needs to focus on protection from cyber-attacks as it modernizes its network. As each country moves towards modernizing its energy management systems, including energy distributors, stations, lines, and generation plants, it is essential to note that they are all monitored from a distance, and the Internet plays a significant role. [42] Thus, protection against cyber-attacks is now primary and of great importance.[43] Parallel to this, with the liberalization of the energy market, the roles of the system operator and other participants, such as different generators, traders, and suppliers, are becoming increasingly important. Moreover, it is expected that an IT emergency response team to be established by 2025. [44] With today's IT-controlled and monitored equipment, the system is more exposed to cyber risks, which makes creating security measures crucial to prevent unauthorized access. While cyber-attacks constantly threaten the EU infrastructure, Kosovo must develop a strategy to protect its critical energy infrastructure.

39 In-depth interview with high official at the Department of Energy, Ministry of Economy of the Republic of Kosovo
40 In-depth interview with high official at KEK , March 2023.
41 In-depth interview with high official at KEDS, March 2023.
42 In-depth interview with high official at KOSTT, February 2023.
43 In-depth nterview with high official at KEDS, March 2023.
44 In-depth interview with Department of Energy, Ministry of Economy, March 2023

As global warming stands as a critical stress to the energy systems, the stakeholders in the energy sector do not perceive rising temperatures as a threat. Considering the nature of the raw material, coal, frosts, or even high temperatures do not affect the raw material. Furthermore, the global warming does not threaten Kosovo's energy system since the circuit breakers can tolerate different temperatures, while shrinkage is partly due to the effect of iron; during the summer, they expand; thus, it does not affect the system. [45] However, it might threaten the states producing electricity from renewable sources such as water.

5.4. Community Resilience

Considering the vast importance of energy in the lives of the communities, it is essential to understand if the energy sectors in Kosovo share the responsibility of building resilient communities that are better prepared to handle any potential energy-related disruptions. However, the energy stakeholders in Kosovo mainly grasp communication with citizens in terms of informing them regarding predictable disruptions or restorations in the network while not perceiving it in light of cooperation needed between the energy service providers and the demand-side consumers- the community.

Even though the Government has enhanced its efforts to raise awareness regarding energy saving, the energy stakeholders still need to take measures to improve the community's resilience to deal with disruptions in energy supply. By working together with local communities, they can develop more effective strategies to ensure that communities are better prepared to handle any potential energy-related disruptions.

45 In-depth interviews with high officials at KEDS and KEK, March 2023

Policy Recommendations

Developing a Resilient Critical Energy Infrastructure in Kosovo:

- As a vast amount of energy in households in Kosovo is used for heating, the Government of Kosovo should focus on enhancing the thermal energy capacities. While it conducts feasibility studies in eight municipalities, it should focus on finding investors and securing funds to improve thermal energy capacities.

- Since Kosovo aims to rely vastly on RES and integrate them into the transmission system, the Government must enhance its current budget for incorporating such RES into the system while allowing for investments in the transmission infrastructure.

- While commercial losses are a crucial weakness of the distribution system, the Government must invest in smart meters. Smart meters help prevent losses in the electric energy distribution system through improved accuracy, real-time monitoring, load management, and theft detection. Thus, smart meters provide utilities with more accurate and timely information on energy usage and distribution, which can help prevent losses and improve the efficiency of the electric energy distribution system. Hence, the marginal enhancement in the system's flexibility justifies their cost.

- Considering the vast importance of energy storage to energy resilience, the Government of Kosovo should focus on meeting the legal conditions, and the political barriers should be removed by May 2024 before procuring 170 mW batteries.

- As the Law on Critical Infrastructure in Kosovo lists energy (production, transmission, distribution, and storage) as critical infrastructure, the Government of Kosovo should draft a document, strategy, or action plan to address the development of resilient critical energy infrastructure in Kosovo. Countries such as the U.S., United Kingdom, Japan, Australia, Germany, and Norway have developed critical energy infrastructure resilience plans to enhance this resilience against extreme weather events, information sharing, risk assessment, cyber-attacks, and infrastructure failures. These plans and strategies can serve as potential approaches for Kosovo to develop its energy infrastructure resilience plans and strategy. However, it is essential to note that Kosovo's specific context and challenges must be considered when designing such plans and strategies.

- Kosovo's energy sector is at a cross-road in updating its legal energy infrastructure in line with its changing energy priorities and EU energy policies while also trying to accommodate the existing coal-based power plants. Thus, Kosovo needs to use this momentum to blend development priorities with resilience imperatives to ensure a better future and a more resilient critical infrastructure.

- As the Government is drafting the National Plan on Energy and Climate 2025-2030- it is essential to include and address energy resilience in light of climate change, considering that climate change is a rising stress, a chronic threat to the energy systems.

- As the National Draft Strategy on Energy projects the shift to RES, the bureaucratic procedures for investment and development of private RES should be eased to enable the investments. Furthermore, clear regulations should also be developed regarding prosumers' connection since an accurate guide is currently lacking.

- Considering the rising influence of extreme weather events on unforeseen disruptions to electricity generation and supply, performing a risk analysis of disorders in power systems with the help and support of specific modeling approaches is highly essential. Different software and simulation tools allow for determining the probabilistic risk of disruptions in electricity generation and supply. These tools will enable an understanding of existing power systems' weaknesses and threats to energy supply security caused by stresses and shocks and give information for decision-making for improvements.

- The Government needs to take measures to enhance the community's resilience to deal with disruptions in energy supply. By investing in community resilience, stakeholders can improve the ability of the community to respond to and recover from any energy-related disruptions.

- With the modernization and interconnectedness of energy systems, the shift towards RES and energy security requires adequate protection of critical infrastructure, especially against cyberattacks. Thus, during this modernization and digitalization, its essential to incorporate resilience cybersecurity best practices into organizational operations, planning, and procurement; prioritize cybersecurity investment needs; and establish the basis for region-wide cybersecurity information sharing.

- As Kosovo has recently developed its Law on cyber-security through which it has found its Agency for Cybersecurity, it is essential for the Energy Sector to establish the National sectoral CSIRT to oversee and respond to cyber incidents in critical energy infrastructure as regulated by the Law On Cybersecurity. Similarly, Operators of Essential Services (OES) should establish CSIRTs of to respond to cyber security incidents affecting an operator of essential services as regulated by the Law On Cybersecurity.

6 Policy Aspects of Development and implemtentation of Critical Infrastructure Resilience

Infrastructure systems are geographically spread and often operate within varying political jurisdictions. Beyond engineering and technical solutions, advancing resilient critical infrastructures requires extensive public policy involvement in supporting coordination and cooperation among political jurisdictions. As such, public policy is essential to operationalize resilience and overpassing barriers that will be discussed in this section.

Infrastructure systems involve unique sets of public and private stakeholders, owners, and operators requiring extensive coordination and collaboration. While CI owners and operation's fundamental goal is to achieve the highest productivity as an end in itself, they do not perceive the importance of this cooperation with other infrastructure owners. Undoubtedly, this lack of joint disaster management protocols contributes to disastrous consequences while extending the recovery period for independent systems after harmful events. *As such, the Kosovo Government must play a key role in enabling this coordination and collaboration among infrastructure sectors and across political jurisdictions to address multiple risks.*

Most public and private sectors overestimate their capacities to respond to challenges that might arise related to their critical infrastructure systems. Furthermore, they do not consider how unprepared they are to handle foreseeable events and uncertainties that might arise from infrastructure systems' complex interdependencies. Also, focusing on enhancing production while reducing new infrastructure costs leads to systems at significant risk for collapse during extreme events (Ganguly et al., 2018). *While resilience is still a new concept in Kosovo to CI owners and decision-makers, it is crucial to* *strengthen expert and public understanding of vulnerabilities and consequences of inadequate investment in resilience. As such, training and education play a crucial role in understanding the importance of resilience in CI (CISA, 2019). The Government must offer these training programs to governmental officials, infrastructure owners, operators, and the public.* [46] ***These training and exercises also enhance relationships among stakeholders that might also affect their future cooperation.*** [47] ***Developing greater trust and understanding within a sector facilitates a more effective response in times of crisis.*** (See **Appendix B** for a list of potential topics of training).

Many times, stakeholders lack a cohesive approach to advancing resilience across interconnected critical infrastructure systems. In places where a wider accepted consensus of what is required to make an infrastructure resilient is lacking, stakeholders rely on approaches that they perceive as local success stories. In these cases, resilience engineering efforts focus on individual assets, resulting in insufficient understanding and insight to design parameters necessary for system or network resilience (Ganguly et al., 2018). *In Kosovo's case, where stakeholders are still unaware of resilience as an integral approach to critical infrastructure, it is vital to advance and establish this joined approach to resilience with resilience design and engineering at its core. This integrated approach also requires new engineering practices that acknowledge the interdependencies of sectors, especially lifeline sectors. Also, it is imperative to have a document that guides and oversees this integrated approach to help stakeholders achieve resilience. This document would form a consensus on what is required to make a system-of system resilient and present the design parameters necessary for these systems› resilience.* See **Appendix C** for an example of steps on how to develop such a plan).

Stakeholders lack sufficient incentives to create resilience. Moreover, many infrastructure owners seek to maximize efficiency and profit with the minimum investment while not perceiving such infrastructure's impact on national security. Therefore, a key challenge is convincing the infrastructure owners to invest in safeguards due to their cost. Private and public infrastructure owners have also mastered transferring risk to someone else while not cooperating to take risk directly (Ganguly et al., 2018). As such, the Government should incentivize to invest in critical infrastructure resilience, as required by the law. *The Government of the Republic of Kosovo shall provide financial incentives for owners/ operators of infrastructure as required by the law.* ***Furthermore, it should develop new measures and rewards that would support the CI owners and operations to make sound risk management choices and decisions. This process involves incentives that promote resilience parallel to resilience metrics that measure critical infrastructure performance, operations, and management to market-based return on investment.***

46 Critical Infrastructure Training webpage has links to many different training offerings; others are provided by professional societies, individual companies, trade associations, and academic institutions. (https://www.dhs.gov/critical-infrastructure-training).

47 An example of an exercise for the electric grid is GridEx. Read more on https://www.nerc.com/pa/CI/ESISAC/Pages/GridEx.aspx

Conclusion

Resilience is a newly developed concept that has found operationalization in different fields. While currently, there are more than 70 definitions of resilience; it is broadly defined as the ability of individuals, communities, regions, or states “to withstand, cope, adapt, and quickly recover and adapt from stresses and shocks. While currently, no paper addresses the development of resilient critical infrastructure and energy resilience, this paper explores the current situation of Kosovo’s electric grid, its legal framework, stakeholders, vulnerabilities, and the shocks and stresses that threaten the power grid.

The energy system’s resilience is highly interrelated to the resilience of our society. Having a resilient energy system means having a system that is prepared to absorb the shocks or stress and ensure the provision of power to the population during and after these events. Furthermore, such a resilient energy system does not merely involve technology but also a thorough policy-making process and social capacities. Thus, it is essential that policy-makers in Kosovo act on this research and move forward with the above-stated recommendations.

As resilience as a concept ensures the feasibility of a system by reducing vulnerabilities and increasing the adaptive capacity before, during, and after stressful events, this paper found that key vulnerabilities of the critical energy infrastructure in Kosovo derive from the vast reliance on the very old lignite thermal power plants, which are prone to failure, and any breakdown directly affects the whole system’s operation. Furthermore, other key vulnerabilities include the lack of energy storage and the losses in distribution. Undoubtedly, the digitalization of critical infrastructure has brought to light the vulnerability of the power grid to cyberattacks.

The scholarship on energy security recognizes three layers of energy resilience that work together or simultaneously to aid the system in avoiding permanent failures and bouncing back. Such dimensions of resilience performance include engineering-designed, operational, and community (societal) resilience. This study found that engineering-designed resilience enhancement strategies such as enhancing flexibility, storage, and backup systems, microgrids, distributed generations, and smart grid technologies such as smart meters are highly important in developing energy resiliency in Kosovo. Furthermore, the stakeholders in Kosovo deem these elements as crucial since they affect the day-to-day performance of the system.

Regarding operational resilience, the study found that, currently, the policy-makers are unaware of the concept of resilience and how such resilience could be developed in the energy sector in Kosovo. Furthermore, the energy sector has yet to use strategies such as Demand-side Management and demand through which the stakeholders can improve their ability to adapt to changes in energy security and enhance their overall resilience to energy-related risks. In line with this, while energy generation stands as a key problem that the Kosovo energy sector faces, it appears that most energy stakeholders grasp energy security in light of the energy security of supply, despite the fact that such security of supply refers only to a segment of the energy security.

As community resilience stands as the key layer when the two first layers of resilience are insufficient to address the disruption, community resilience in energy resilience is yet an unexplored topic and approach where there is no cooperation, collaboration, or partnership between the service providers and consumers. Thus, no actions have been taken yet to increase social capital bonding and bridging, which is crucial in cases of shocks and stresses to the energy grid.

This study found that, despite the rise of climate change as a chronic threat to the energy systems, the energy stakeholders in Kosovo are not concerned regarding its effects on the critical energy infrastructure. Furthermore, the stakeholders do not perceive natural hazards as a threat to the energy resilience on which the state should enhance preparedness due to their low probability. Rather, they are more concerned regarding standard shocks such as the sudden introduction of new technology, equipment failure, and cyber threats. Such a lack of understanding of the harms of climate change in energy systems prevents these stakeholders from developing policies to prepare and protect the communities from the sudden damage of climate change while also helping to ease its long-term impacts of it. Similarly, the lack of preparedness for high-impact, low-probability events, such as natural disasters, leaves the energy system unprepared for such shocks that might have tremendous effects.

Kosovo's energy sector is at a cross-road since its key laws will be reconsidered and amended, while the draft strategy that will give direction to the energy sector in Kosovo focuses on enhancing the reliability of RES while moving away from the lignite power plants. As such, it is essential that throughout this transition and changes, the decision-makers blend resilience imperatives into developing a resilient critical energy infrastructure in Kosovo that is well-prepared to withstand, absorb and continue providing services to the citizens of Kosovo during and after different shocks and stresses occur.

Appendicies

APPENDIX A. In-depth interview Questionnaire

1. **Could you please introduce yourself and the institution you work for?**

2. **How do you understand energy security? How do you perceive Kosovo's current energy security situation? What about the system's resilience?**

3. **How does the grid currently handle disruptions or failures?**
   - *How does it currently prioritize and manage risks?*
   - *What are the potential consequences of a failure or disruption in the grid?*
   - *What are the critical performance indicators currently used to monitor and evaluate the grid's performance?*

4. **What is the electricity grid's current capacity, and how does it compare to peak demand?**
   - *Are energy shortages a threat throughout 2023? If yes, why?*

1. **Rate the priority level of national preparation for the following stresses and shocks to Kosovo's energy resilience**

SHOCKS/STRESS	Not a priority	Low priority	Medium priority	High priority	Essential
Earthquakes					
Cyber-attacks					
Equipment failures					
New technology					

SHOCKS/STRESS	Not a priority	Low priority	Medium priority	High priority	Essential
Physical attacks to the grid					
Chronic floods					
Increasing ambient temperatures					
Heat waves					
Droughts					
Other, please specify:					

2. **How do you grasp the vulnerabilities or weaknesses of the energy system in Kosovo? Are there any known vulnerabilities or weaknesses in the current energy infrastructure?**
    - *If yes, what are these transmission, supply, and distribution vulnerabilities?*
    - *What is the system's adaptive capacity during or after these disturbances?*

3. **How do you understand energy resilience? What do you mean by it? What interventions or upgrades are necessary to improve the grid's resilience?**
    - *Do these interventions only involve technology? If so, what kind of technology and infrastructure?*
    - *Probe redundant capacities, flexibility, storage, microgrids, backup, and a diversified system.*

4. **How are the internal and external stakeholders, such as ministries, government agencies, transmission, distribution companies, and communities, involved in risk management and decision-making in energy resilience?**
    - *What about cooperation with other political jurisdictions to address multiple and cross-boundary risks?*

5. **Which organizations and institutions do you work with in ensuring energy resilience and security?**
    - Could you possibly rate the quality of these cooperations from 0-2, where 0 is *poor*, one (1) is *fair,* and two (2) is *good*?

6. **Have any policies been developed to ensure Kosovo's energy system's resilience? If yes, please elaborate on these policies. In not, what policies should be developed to enhance Kosovo's energy resilience?**

7. **Does your institution take any measures to enhance the community's resilience to deal with disruptions in energy supply?**

8. **Is there anything I did not ask you about that you perceive as necessary to share with me regarding this topic?**

Appendix B. Potential Training Topics

Potential Training Topics

- Best practices for physical security
- Active Shooter
- Identifying and Reporting Suspicious Activity
- Insider Threat
- Credentialing
- Bag Screening
- Patron Screening
- Sector Best Practices (e.g., chemical, energy, water)
- Supply chain risk management and third party dependency
- Incident Management and Response
- Bomb Threats
- Countering Improvised Explosive Devices
- Vehicle Threats
- Suicide Bombers
- Cybersecurity
- Exercises
- Terrorism Threats, Tactics, and Trends
- ICS and Operational Technology
- Risk Assessment (Threat, Vulnerability, and/or Consequence) and Mitigation

Appendix C. Basic Steps for a Critical Infrastructure Security and Resilience Plan

Basic Steps for a Critical Infrastructure Security and Resilience Plan

- Establish goals and objectives
- Identify existing examples of relevant critical infrastructure security and resilience plans or programs
- Determine the scope
- Identify the stakeholders
- Document roles and responsibilities
- Establish coordination and information sharing mechanisms
- Set timelines
- Build a risk management framework
- Design and conduct assessments
- Conduct training and education, including exercises
- Establish metrics
- Promote the program through outreach and awareness

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Donika Marku has over seven years of experience in research. She completed her Bachelor's studies in International Relations at the American College of Thessaloniki in Greece and the Open University in the United Kingdom. Due to her academic profile and work experience, she was granted the Fulbright scholarship, which enabled her to study Security and Resilience at Northeastern University in Boston, USA. During her Master's studies, she specialized in critical infrastructure resilience and protection. Previously, Donika was a researcher at the Kosovar Centre for Security Studies (KCSS) , covering public safety, foreign policy; integrity in the security sector, and public perceptions in Kosovo. Currently, Ms. Marku is a research analyst at UBO Consulting, covering social and political research topics. She is highly committed to designing evidence-based interventions that help public, private, and non-profit sectors make better-informed decisions and policies.