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The Role of Battery Energy Storage in Large-Scale Solar Integration: A Business Case and Policy Analysis for Kosovo

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Affidavit

I, **HELENE STANGER, BA**, hereby declare

1. that I am the sole author of the present Master's Thesis, "THE ROLE OF BATTERY ENERGY STORAGE IN LARGE-SCALE SOLAR INTEGRATION: A BUSINESS CASE AND POLICY ANALYSIS FOR KOSOVO", 83 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted the topic of this Master's Thesis or parts of it in any form for assessment as an examination paper, either in Austria or abroad.

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Abstract

Integrating variable renewable energy sources into power grids poses significant flexibility and stability challenges, making energy storage systems a key pillar of the energy transition. Due to their distinct properties and economies of scale effects in recent years, battery energy storage systems (BESS) are an emerging technology for grid-scale storage applications. Particularly for countries like Kosovo, relying heavily on power generation from lignite with a lack of balancing capacities, BESS can present a valuable contribution to facilitating the integration of variable renewable energy sources such as wind and solar. To understand the potential role of BESS for large-scale solar integration in an emerging energy market context like Kosovo, this thesis combines a profitability analysis for different services with an assessment of the regulatory, policy and market framework in Kosovo.

Based on a case study located in Kosovo, four different business cases are calculated in an Excel model: (1) PV only, (2) BESS for energy arbitrage, (3) BESS for aFRR, (4) BESS for aFRR and arbitrage. Contrary to previous research, the results show that BESS costs have decreased enough to achieve economic feasibility for all scenarios including BESS; with the combined use for aFRR and arbitrage (variant 4) as the most profitable option. It is further shown that the operation strategy of a hybrid project (PV and BESS) with a single charging cycle per day using the electricity generated by the solar PV yields the highest results.

Expert interviews conducted with stakeholders from Kosovo – including the responsible ministries, the energy regulator, the TSO and international development organizations – were analyzed using the qualitative content analysis by Mayring to identify enabling and hindering regulatory, policy, and market conditions for the implementation of BESS projects in Kosovo. The findings are synthesized in a SWOT structure to provide an efficient overview for policy makers and investors.

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List of abbreviations

aFRR … automatic Frequency Restoration Reserve

BESS … Battery Energy Storage Systems

BSP … Balancing Service Provider

CAES … Compressed Air Energy Storage

DAM … Day-ahead-market

DoD … Depth of Discharge

DSCR … Debt-service-coverage rate

DSO … Distribution System Operator

EBITDA … Earnings before interest, taxes, depreciation and amortization

ENTSO-E … European Network of Transmission System Operators for Electricity

ERO … Energy Regulatory Office

ESS … Energy storage systems

FCR … Frequency Containment Reserve

GHG … Greenhouse gases

IDM … Intra-day-market

IEA … International Energy Agency

IRR … Internal rate of return

LCOS … Levelized cost of storage

LFP … Lithium-iron-phosphate battery

Li-ion … Lithium-ion batteries

ME … Ministry of Economy

MESPI … Ministry of the Environment, Spatial Planning and Infrastructure

mFRR … Manual Frequency Restoration Reserve

NCA … Nickel-cobalt-aluminum battery

NMC … Nickel-manganese-cobalt battery

NPV … Net present value

PHS … Pumped hydro storage

RE … Renewable energy

RES … Renewable energy sources

RTE … Roundtrip efficiency

SIB … Sodium-ion batteries

SoC … State of charge

TSO … Transmission System Operator

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1. Introduction

In the pursuit of reducing greenhouse gas emissions to mitigate climate change, international efforts aim at decarbonizing energy systems. With a third of greenhouse gas emissions stemming from the sector of electricity and heat production, the importance of this transition becomes evident (Our World in Data and Climate Watch 2024). In that vein, EU policies like the Green Deal, the Clean Energy Package or the recent Net-Zero Industry Act work toward increasing the share of renewable energy sources in the electricity mix. In addition to the needed switch in energy sources for electricity generation, the decarbonization of other energy sectors such as transport and heating also leads to higher electrification rates. The resulting surge in global electricity demand that is currently observed and projected for the near future heralds the "*new Age of Electricity*", as framed by the IEA (2025, 13).

Significant price reductions in recent years have led to exponential growth of the deployment of renewable energy generation technologies like solar PV and wind (IEA 2024b). However, the variability of these renewable energy sources constitutes a significant challenge for their large-scale integration into the power grid. Energy storage is thus an important pillar of the energy transition to mitigate the challenges arising from increased deployment of renewable energy sources. While pumped hydro storage currently is the prominent technology on a global level, grid-scale battery energy systems (BESS) are emerging due to their scalability, high efficiency, flexible location and fast response (Chowdhury et al. 2020). These characteristics also qualify BESS for different business models: Front-of-the-meter services include ancillary services like frequency regulation as well as short-term flexibility through arbitrage and enabling renewable integration via energy shifting (IEA 2024a).

While previous research papers have frequently found that stationary BESS generating revenue from such business models are not yet commercially feasible, the significant price reductions of batteries in the last decade may alter the business case of grid-scale BESS (Chowdhury et al. 2020; Miletic et al. 2018; Martins and Miles 2021; Sköld 2023; Zhang et al. 2021; Zhao et al. 2023). This thesis thus aims to re-evaluate the business case of adding a large-scale BESS to a solar PV project by comparing the revenue generation via arbitrage and via balancing. A 100 MW_p solar PV farm in Kosovo serves as a case study for the conduction of this business case analysis. The results from the cost-benefit analysis provide insights for investors and policymakers on the economic viability of battery energy storage for different business models.

While the feasibility of BESS depends on technological advancements and market revenues, its role in integrating solar energy is particularly relevant in regions with ambitious renewable energy goals. In this context, Kosovo presents a compelling case. The country seeks to expand its solar capacity while addressing grid stability challenges with the ambitious targets of reaching a share of renewable energy sources of 35% in gross final electricity consumption and the pioneering installation of large-scale battery storage capacity by 2031 (Republic of Kosovo 2023). In this vein, a second research focus of this thesis emphasizes the role of BESS in supporting Kosovo's goals of increasing solar PV integration into the power grid while enhancing grid stability and efficiency. In a qualitative research design, the regulatory and policy framework as well as market conditions for BESS in Kosovo are analyzed through expert interviews with policymakers, regulators, grid operators and development organizations. These results allow a better understanding of enabling and hindering factors to battery energy storage deployment in Kosovo as a means to achieve the announced RES targets. To investigate these research areas, this thesis is organized as follows: The literature review will outline the challenges of solar-integrated power systems and provide an in-depth overview of energy storage system services and their markets as strategies to mitigate these challenges with a focus on arbitrage, balancing and frequency control. Then, different energy storage technologies with an emphasis on mature and emergent BESS technologies for stationary storage will provide the theoretical background for deciding on a type of battery for conducting the business case analysis. Within the case study of Kosovo, light will first be shed on the current state of the energy system in Kosovo as well as the regulatory framework on a national and supranational level, followed by an analysis of the relevant policies focusing on increased RES integration in Kosovo as well as the electricity market conditions. Based on this analysis, a qualitative study of stakeholder opinions will contribute to an enhanced understanding of the feasibility of large-scale BESS and their importance for solar integration in the power grid.

This thesis contributes to the academic discourse on renewable energy integration by addressing a critical gap in research on economic and regulatory feasibility of grid-scale battery energy storage systems (BESS) in emerging energy markets. By combining a cost-benefit analysis of BESS business models with a qualitative examination of regulatory and stakeholder perspectives, this study offers a holistic approach to understanding both the economic and policy dimensions of energy storage deployment in Kosovo. The findings provide relevant insights for policymakers and industry stakeholders tackling the transition toward a more resilient and solar-integrated electricity system.

2. State of the Art

2.1. Solar-integrated power systems

Before delving into the key role of energy storage systems in the energy transition, it is indispensable to understand the wider context of renewable energy integration into the grid. This sub-chapter will highlight the climate-related importance of decarbonizing the energy system while also examining the economic and technological challenges of integrating renewable energy, with a focus on electricity market dynamics and the technological impacts of increased solar penetration

2.1.1. The role of a decarbonized energy system in climate action

Under the Paris Agreement (United Nations Framework Convention on Climate Change 2015), the United Nations member states have pledged to keep the rise in global mean temperature at well below 2°C. Since anthropogenic greenhouse gas (GHG) emissions are the main driver of climate change, this commitment implies a significant need for decarbonization, particularly in the energy sector as one of the largest emitters. Within that sector, electricity generation currently accounts for 44% of energy-related GHG emissions (IEA 2022). Hence, a reduction of GHG emissions from power generation is crucial in climate change mitigation (Jafari, Botterud, and Sakti 2022).

To achieve low-carbon electricity generation, an upscaled integration of renewable energy sources (RES) like solar PV and wind is required (Victoria et al. 2019; Arbabzadeh et al. 2019). Other than addressing climate change impacts, RES also contribute to energy security efforts: The geopolitical developments of the recent past have resulted in a shift of energy policy focus towards energy security – on a European level for instance illustrated by the REPowerEU package (Elomari et al. 2022; European Commission. Directorate General for Communication. 2022). Facilitated by historic price developments of solar PV, subsidies and technological advancements, RES have seen exceptional growth rates in recent years (Ranjan and Shankar 2022; Elomari et al. 2022). In 2030, solar PV is projected to account for around two thirds of RES (Khaleel et al. 2024).

Global electricity demand is projected to grow by 4% annually throughout 2027 with emerging economies as the main drivers (IEA 2025). Moreover, the decarbonization of other energy sectors such as transport and heating will also lead to higher electrification rates (Jafari, Botterud, and Sakti 2022). Ramping up the integration of electricity generated from solar PV in the power grid is thus an important prerequisite not only for climate change mitigation and energy security, but also for economic development.

2.1.2. Electricity markets and market challenges of solar integration

The economic implications of large-scale solar integration must be understood in the context of the functioning of modern electricity markets. Particularly advanced electricity markets are characterised by high levels of deregulation which have been found to lead to increases in social welfare and lower electricity costs (Johnathon et al. 2021). Electricity is traded on different markets: the day-ahead market, intra-day market, and real-time balancing market. 24 hours in advance, one hour's load demand is offered on the day-ahead-market (DAM) based on forecasted demands. To account for differences in the forecasted demand, the intra-day market (IDM) procures one hour ahead of dispatch. Real time pricing is utilized for balancing the system during an operational hour. The determination of the clearing price is a result of stacking generators' offers in the merit order until the market is cleared. Considering the low operational costs of RES, their marginal prices drop the overall electricity prices. This impact is labeled merit-order-effect (Johnathon et al. 2021; Shimomura et al. 2024).

As a consequence of the merit-order-effect, conventional power plants with higher operational costs are pushed out of the market which leads to changes in peak and base load capacities (Shimomura et al. 2024). Due to the priority dispatch of RES, negative pricing events as an extreme of low price periods are increasingly prevalent during high solar irradiation hours (European Union Agency for the Cooperation of Energy Regulators 2024; Johnathon et al. 2021). This "*rollercoaster of electricity prices*" imposes significant challenges not only for traditional power generators, but also for solar power generators (Stangl 2025). Another factor deteriorating the cost-effectiveness of solar power generation is power curtailment: RES are curtailed when there is an excess of available power due to low demand, system stability concerns or grid congestion. (Bullich-Massagué et al. 2020; Datta, Kalam, and Shi 2020; Shafiullah, Ahmed, and Al-Sulaiman 2022). Countries like China however illustrate that increased RES does not necessarily imply higher curtailment rates if timely measures like grid expansion, policy and system planning are taken (IEA 2023).

2.1.3. Technological challenges of solar-integrated power systems

Economic challenges such as revenue losses due to curtailment or negative price periods during peak generation times stem from technological challenges that come with the integration of solar electricity into the grid. One of the key challenges of RES is flexibility: Their intermittent nature due to variations in solar irradiation depending on the weather condition, night-time and season leads to variations in supply (Bullich-Massagué et al. 2020; Rajan, Fernandez, and Yang 2021). With increasing shares of solar PV in

the electricity mix, this variability on the supply side will amplify (Khaleel et al. 2024). While electricity from solar PV cannot be produced on demand, the electricity load throughout the day does not match the peak of solar irradiation between 11am and 3pm (Nwaigwe, Mutabilwa, and Dintwa 2019). In contrast, the electricity demand is characterised by a peak load in the morning and in the evening with a trough in the middle of the day. The resulting temporal mismatches between supply and demand throughout the day are evident in figure 1, due to its shape coined "*Duck curve*". (Pei et al. 2025).

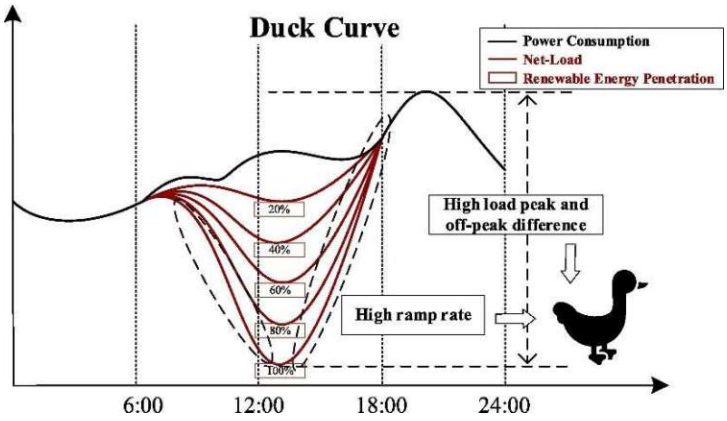

Figure 1 Duck Curve (Source: Pei et.al. 2025, 2)

Another critical feature is grid stability which is defined as the power system's "*ability to restore equilibrium after a disturbance*" (Khaleel et al. 2024, 7). Traditional means of power generation involve large rotating masses that maintain grid stability through inertia. Solar PV however lacks such grid-stabilising inertia since there is no rotating mass or kinetic energy stored (Bullich-Massagué et al. 2020; Khaleel et al. 2024; Rajan, Fernandez, and Yang 2021). Increased penetration with solar PV thus diminishes system inertia (Datta, Kalam, and Shi 2020), which affects voltage and frequency (Elomari et al. 2022). Frequency is an important index to indicate imbalances between load and generation (Ranjan and Shankar 2022). While the nominal frequency in the European synchronous areas is set to 50 Hz, deviations of more than 200 mHz can lead to overloaded transmission lines, damaged equipment or even system collapse (ENTSO-E 2018; Ranjan and Shankar 2022).

Different strategies exist to address these integration challenges in flexibility and stability both on the demand and the generation side. One of the key pillars in facilitating large-scale solar integration in the power grid are energy storage systems. The services they can provide to mitigate the introduced challenges will be discussed in the next subchapter.

2.2. Energy storage services and their markets

Flexibility and stability challenges that come with large-scale solar integration highlight the major role of energy storage systems (ESS) in the energy transition. By utilizing stationary ESS for different market-oriented services, non-dispatchable RES can be better integrated and system stability can be improved (Ahmad Hamdan et al. 2024; Bullich-Massagué et al. 2020; Chen et al. 2020). The applications of ESS include energy arbitrage; ancillary services such as frequency control, voltage support or black start capacity; power grid balancing and end-user applications such as peak shaving (Ahmad Hamdan et al. 2024; Haber 2025; Miletic et al. 2018; Zhang et al. 2021; Zhao et al. 2023). The following subchapters will provide an overview of the most prevalent markets for grid-level ESS services.

2.2.1. Arbitrage

Energy arbitrage in the context of ESS refers to the practice of storing energy during periods of low prices and dispatching the stored energy during periods of high prices, thereby generating revenue (Ahmad Hamdan et al. 2024). Considering the typical load profile introduced in chapter 1.1.3 and the corresponding effect of electricity demand on market prices, this signifies storing energy between 11am and 3pm when solar generation is high and selling energy during the morning and evening peak for higher prices. Strategic operation of an ESS within this business model can generate significate revenues from price differences in the market (Ahmad Hamdan et al. 2024). According to an expert from the field, profit margins in this business model are in the range of 150% of the cost of the traded energy (Eusch 2025, l. 23). The before-mentioned increase of negative price periods in recent years further emphasizes the relevance of this business model as ESS allow to realize revenues in a positive price period for the energy stored during negative price events (Martins and Miles 2021). However, Miletic et al. (2018) point out that large price differences are needed for energy arbitrage to be cost-effective.

Depending on the set-up of the ESS, the energy stored can either stem from the grid or directly from solar PV generation. Standalone ESS performing arbitrage purchase electricity at low cost from the grid during low price periods and feed the electricity back into the grid during peak price times. Without adapted market frameworks however, this results in double grid fees for charging and feeding-in, deteriorating the business case of arbitrage (Bundesverband Photovoltaik Austria 2025). To avoid these additional grid fees, a technical strategy is the operation of a solar PV plant combined with an ESS, where the ESS is charged directly from the generated renewable energy (Martins and Miles 2021). Another critical factor is the effectiveness of the energy storage technology

used. Since lower efficiencies involve higher losses during storage and generation, potential impacts on the arbitrage strategy needs to be considered.

The quite consistent daily peaks which are forecasted in the day-ahead-market allow more accurate forecasting of arbitrage opportunities than the more volatile intra-day-market. Even though the maximum potential revenues are higher in the intra-day-market, the lack of predictability makes the latter market less attractive for arbitrage (Martins and Miles 2021; Eusch 2025, l. 36). The software-modules used for steering the charging and discharging of the ESS thus utilize DAM prices. Fast reaction times are key in generating revenue from arbitrage, which is why industry leaders utilize AI-based software to perform arbitrage based on real-time price signals (Eusch 2025, ll. 43–45).

Besides the commercial argument of arbitrage as a business model, the market mechanism also contributes to meeting electricity loads better with non-dispatchable RES by shifting the generation to times with higher demands and thus higher prices. This political element underscores the relevance of ESS for the large-scale deployment of RES, especially if no additional capacities for continuous generation such as nuclear power plants are created (Eusch 2025, ll. 158–159). Energy arbitrage can hence support the transition to RES by increasing the financial viability of ESS and shifting energy to times where the demand is high.

2.2.2. Frequency control

Ancillary services are another set of services provided by ESS. They ensure a reliable and secure operation of the power grid (Jafari, Botterud, and Sakti 2022; Johnathon et al. 2021; Liu et al. 2020). The fast growth of RES in recent years has led to increased events of difficulties in frequency stability (Ranjan and Shankar 2022; Sköld 2023). Such events occur due to imbalances in the demand-supply equilibrium of the power grid, triggered for instance by outages of power plants, wrong load forecasts or increased feed-in of RES (Thien et al. 2017). In this vein, the reduction of system inertia concomitant with a decrease of conventional power plants can cause significant power imbalances challenging the grid (Hasan, Haque, and Mahfuzul Aziz 2024). Frequency control is a service activated within seconds after a disturbance has led to a deviation of the nominal frequency of 50 Hz in Europe (Bullich-Massagué et al. 2020; Zhao et al. 2023). By injecting power from the ESS into the grid in case of underfrequency or extracting power from the grid when the frequency is too high, the standard operating frequency is retained (Liu et al. 2020). Distinguished by their activation time, there are different types of frequency control. This section focuses on primary frequency control, also termed frequency containment reserve (FCR) which is activated within maximum of

30 seconds after a frequency deviation (Bundesverband Photovoltaik Austria 2025; Hasan, Haque, and Mahfuzul Aziz 2024).

Transmission system operators (TSO) usually carry the responsibility for frequency control (Zhao et al. 2023). The European Network of Transmission System Operators for Electricity (ENTSO-E) as the cooperation of 40 TSOs from 36 member countries has been legally mandated by the EU to facilitate cross-border network development and the integration of RES (EU 2019). Within continental Europe, frequency control is regulated by ENTSO-E. In accordance with EU Regulation 2017/2195 on electricity balancing, a common market (FCR cooperation) for the procurement of FCR has been established in Europe which includes currently twelve TSOs from nine countries, including the Austrian TSO APG (European Commission 2017). The respective TSOs are in charge of procurement and activation of frequency reserves when deviations of more than 200 mHz from the nominal frequency of 50 Hz occur. For that purpose, national TSOs conclude contracts with balancing service providers (BSPs) after they have gone through a prequalification procedure (ENTSO-E n.d.). Within the FCR cooperation, FCR is auctioned daily with symmetric products of four hours, covering both upward and downward FCR. A merit order list is created based on the pool of offers received by the national TSOs. The minimum bid size allowed is 1 MW, further there are limitations on exports. The price is determined by a cross-border marginal price which all BSPs receive per MW and duration offered, regardless of whether the capacity was used or not (ENTSO-E n.d.; Thien et al. 2017). According to the APG, the amount of FCR that is required to be available in Austria is +/- 72 MW. While there are larger amounts of FCR prequalified, not the entire amount is always available on the market. Depending on the clearing price and the merit order, the BSPs with the lowest bidding prices are selected (Engelmair 2025). According to representatives of the Austrian Institute of Technology, the expected revenues from FCR are in a medium range due to an expected market saturation (Esterl and Maggauer 2025). In contrast, (Eusch 2025, l. 133) points to the early development stages of the capacity market and thus does not anticipate that risk. While the cross-border trading of flexibility in terms of FCR is indeed possible within the FCR cooperation, this is not the case with other more remote states since grid connection is required to perform this service (Dolzer 2025), thus excluding Kosovo from the participation in the FCR cooperation at the current time.

2.2.3. Balancing

Primary frequency control is only part of a larger framework of balancing services. As governed by the Electricity Balancing Regulation, there are three different balancing

mechanisms in addition to FCR (European Commission 2017). Secondary control or automatic Frequency Restoration Reserve (aFRR), tertiary control or manually activated Frequency Restoration Reserve (mFRR) and Replacement Reserve (RR). While primary control immediately regulates within a few seconds after a disturbance, secondary control is activated a few minutes later with the target of restoring the nominal frequency (Kruse, Schäfer, and Witthaut 2022). The maximum time of activation for balancing service providers is five minutes. Tertiary control then replaces secondary control by manual activation. Replacement Reserve (RR) is only needed to restore frequency after significant disturbances after 30 minutes (Engelmair 2025). These services are currently largely performed by pumped hydro storage and natural gas power plants, with battery ESS emerging (Regelleistung.net 2024). In Europe, a common platform has been created for the exchange of balancing energy from aFRR following the Electricity Balancing Regulation: the PICASSO project. The aim of the PICASSO project is to reduce balancing costs and increase the availability of balancing energy to promote energy security and the integration of RES by facilitating cross-border exchange of balancing energy (ENTSO-E 2024). Similar to the procurement of primary frequency control, national TSOs are also responsible for the procurement of aFRR. According to ENTSO-E (2024), the process of procurement functions as such: The minimum balancing energy gates open the previous day, which allows balancing service providers to submit offers to their local TSO. The balancing energy gates close 25 minutes prior to dispatch. A local merit-order-list is submitted to the aFRR platform by the TSOs. An optimization process then creates a common merit-order-list, based on which balancing energy is dispatched upon demand. Researchers from the Austrian Institute of Technology provide positive estimations of the revenue potential in this market due to the increasing need for flexibility in the power grid (Esterl and Maggauer 2025). Cross-border exchange of balancing energy for mFRR is organized by the MARI platform but will not further be elaborated here considering the scope of this thesis, particularly since the revenue potential for BESS in mFRR is rather low according to estimations by Esterl and Maggauer (2025).

This chapter introduced the main services that ESS can provide and their business models. With the purpose of understanding the technological dimension of the use of ESS for grid stability and flexibility, the next chapter will delve into energy storage technologies with a focus on the fastest-growing ESS technology: battery energy storage systems.

2.3. Overview of energy storage technologies focusing on BESS

As outlined above, energy storage systems can provide crucial services for the power grid, underscoring their key role in stepping away from fossil fuels by large-scale RES integration (IEA 2024b). Without deployment of ESS, the buildout of renewables is only feasible to a limited extent (Arbabzadeh et al. 2019). To triple RES capacity by 2030, the IEA (2024b) identifies the need of a six-fold increase in energy storage capacities. The following subchapters will provide an overview of the wide variety of ESS technologies. Due to their specific features, battery energy storage systems (BESS) are particularly suitable for performing the above-mentioned services and will thus be the focus of this chapter. In addition to shedding light on the progress in BESS research, the geopolitical and environmental dimensions of batteries will be assessed before addressing the market development of BESS and its implications for BESS deployment in the context of RES integration.

2.3.1. Types of energy storage systems

Energy storage technologies are frequently classified into mechanical, electrical, chemical, electrochemical and thermal technologies (Bullich-Massagué et al. 2020; Liu et al. 2020). Mechanical ESS include pumped hydro storage (PHS) as the dominant ESS technology accounting for over 95% of global energy storage capacities (Bullich-Massagué et al. 2020; Silva et al. 2023). Off-peak electricity is used to pump water uphill to a reservoir to store energy, which can be reconverted to electricity through transforming the potential energy into kinetic energy, powering a turbine and producing electricity again (ibid.). Another prominent mechanical technology is Compressed Air Energy Storage (CAES). Similar to PHS, this technology requires specific locations and geographical features, impeding their more widespread implementation (Chowdhury et al. 2020). Electrical energy storage technologies include supercapacitors and ultracapacitors which are for instance applied in frequency control in electrical networks (Bullich-Massagué et al. 2020). Chemical energy storage solutions encompass fuel cells, while thermal ESS utilize latent heat or sensible heat (Liu et al. 2020).

Electrochemical storage technologies – batteries – have been emerging rapidly in recent years. Not including newly installed PHS, BESS already accounted for 85% of the remaining newly installed energy storage capacities in 2018 (Liu et al. 2020). In the European Union, the battery energy storage capacity has increased by 70% in 2023 (IEA 2024a). Properties like their flexible installation, modularity, rapid response, scalability, low-maintenance and short construction cycles underscore the important potential of BESS as a grid-level ESS (Chen et al. 2020; Chowdhury et al. 2020). According to the

IEA, battery storage in the power sector is the fastest growing energy technology in 2023 due to significant cost reductions in the past decade as well as progress in safety and lifetime (IEA 2024a). Batteries are based on an electrochemical redox reaction which produces voltage: In the charging process, electrical energy is transformed to electrochemical energy and vice-versa upon discharging (Bullich-Massagué et al. 2020; Silva et al. 2023). Key technical characteristics of BESS are the specific energy storage capacity (measured in Wh/kg) and the specific power (measured in W/kg) which indicates the maximum current that can be provided. Further relevant properties are their safety, lifetime, energy efficiency, state of charge (SoC), operating temperature, cyclability and modularity (Bullich-Massagué et al. 2020; Chen et al. 2020). These factors will be discussed in more details in a comparison of different types of battery technologies in the following sub-chapter.

2.3.2. Types of BESS and suitability assessment for ESS services

Battery technology is based on the electrochemical conversion of chemical energy into electrical energy. Ions move between a negative electrode (anode) and a positive electrode (cathode) through an electrolyte, while electrons flow in an external circuit generating current (Ahmad Hamdan et al. 2024; Liu et al. 2020). Depending on the materials used for the components, different types of batteries can be distinguished. The most mature technology are lead-acid (Pb-A) batteries whose drawbacks are limited specific energy storage capacity and a medium-length lifespan (Bullich-Massagué et al. 2020). Another quite mature and cost-competitive solution are nickel-cadmium (Ni-Cd) batteries. Their drawbacks include a low cell voltage of only 1.3 V, a low lifespan as well as high self-discharge properties (ibid.).

The fastest-growing and currently most prevalent battery technology are lithium-ion batteries (Li-ion) (IEA 2024a). Li-ion batteries are the leading choice for many applications due to their favorable properties (Ahmad Hamdan et al. 2024). They have been introduced by Sony in the 1990s and have been subject to many innovations in electrode material and design since (Chen et al. 2020). Materials used for the anode are typically graphite or black carbon considering their low cost and wide availability. Advanced material research investigates alternatives including silicon, alloy and metal oxides with increased capacity and lifetime (Chen et al. 2020). The concern with silicon however is its volume expansion during cycling, leading to a degradation of the electrode and thus a deteriorating performance of the battery (Ahmed and Maraz 2023). The cathode can consist of different lithium metal oxides such as nickel-manganese-cobalt (NMC), nickel-cobalt-aluminum (NCA) or lithium-iron-phosphate (LFP). The electrolyte is

typically an organic solution of lithium salts, may however also be semi-solid or solid in newer technologies (Chen et al. 2020; Liu et al. 2020). Li-ion batteries are generally characterized by high energy and power density, long cycle life (3000 cycles at deep discharge of 80%), high efficiency of over 95%, low self-discharge and fast charging capacities, making them the preferred choice for many energy storage applications (Ahmed and Maraz 2023; Bullich-Massagué et al. 2020; Chen et al. 2020). Specific configurations even allow efficiencies of over 98% (Ahmad Hamdan et al. 2024). A major concern in the public perception is the safety of batteries, mainly regarding thermal runaway. Advancements in thermal management systems and materials however have decreased the risk for thermal runaway significantly (Ahmed and Maraz 2023). Particularly lithium-iron-phosphate (LFP) batteries display significantly lowered levels of thermal runaway risk, which may contribute to their dominance in the market (IEA 2024a). Positive features such as longer lifetime and lower flammability are highlighted by the IEA (2024a), while the lower energy density of LFP batteries is not considered problematic due to their stationary application in the power sector.

Another important development in battery technology and particularly relevant for large-scale energy storage are sodium-ion batteries (SIB) (Ahmad Hamdan et al. 2024). Sodium-sulfur batteries (Na-S) as one type of SIBs are emerging in large-scale storage applications due to their high power and relatively high energy density, high efficiency, long lifetime, fast response, high safety and low cost (Liu et al. 2020). The main argument for SIBs is the abundance of sodium in the Earth's crust which addresses environmental, cost and supply chain concerns (Nekahi et al. 2024). Similar to LFP batteries, also SIB batteries are suitable for the use case of stationary storage due to their medium-high energy density which does not present a problem in contrast to the use case of e-mobility (ibid). For the operation of Na-S batteries, high operating temperatures are required, which limits their scope of application (Chowdhury et al. 2020). Further, high internal resistance and sodium erosion are identified as potential problems by Liu et al. (2020). Despite the lack of information about safety, there are indicators that the risk of thermal runaway may be reduced for SIBs due to their low melting point and high temperature stability (Nekahi et al. 2024).

The field of battery technology has witnessed considerable growth in innovative solutions judging by the rising number of patents (Ahmad Hamdan et al. 2024; Silva et al. 2023). Other emerging technologies include redox-flow batteries; solid-state batteries which combine the advantages of improved safety and stability; lithium-sulfur batteries with high theoretical energy densities and sulfur as an abundant and low-cost raw material as well as lithium-air batteries. The latter two still face technical hurdles and are therefore

not fully commercialized yet (Ahmed and Maraz 2023). A major challenge identified by Ma et al. (2025) in the context of emerging battery technologies is the integration of new processes in the existing infrastructure.

With lithium-ion batteries at the forefront of BESS for large-scale solar integration, several authors have assessed the suitability of battery storage systems for performing the services introduced in chapter 2.2. Jafari, Botterud, and Sakti (2022) indicate the suitability of BESS for daily energy arbitrage between peak and off-peak hours and the corresponding contribution to the integration of solar into the power grid. Martins and Miles (2021) underscore the role of lithium-ion batteries for performing ancillary services in a solar-integrated grid.

2.3.3. Geopolitical and environmental dimensions of BESS

Despite the pro-environmental intention of mitigating climate change through integrating more RES combined with BESS to deal with the adjacent challenges, batteries themselves enfold negative environmental impacts. Life-cycle assessments (LCAs) of BESS have been performed by several researchers, showing that their main negative impacts are the metal depletion potential, eutrophication potentials, human toxicity and land use (Chowdhury et al. 2020). In terms of global warming potential and ozone layer depletion potential, BESS performs better than gas turbines (ibid). GHG emissions associated with BESS are concentrated in the production phase and are similar across LFP and SIB technologies. The cathode material has been found to be the main cause of the environmental impact, which supports the case of SIB due to the abundance and easy extraction of sodium (Guo et al. 2023). The raw material extraction exerts pressure on ecosystems and socioeconomic systems (Metzger et al. 2023). This is illustrated for instance by the case of cobalt production, where the DR Congo holds the largest reserves: Adverse health effects such as DNA damages, cancer, nausea and vomiting have been attributed to the mining of cobalt (Hossain, Sarkar, and Sahajwalla 2023). Lithium mining on the other hand is associated with a decrease of the groundwater level due to the drilling of holes for pumping out the dissolved lithium (ibid). By increasing the recycling rates of batteries, more than half of the required materials by 2040 could be covered from secondary raw materials (Ahmed and Maraz 2023). Enhanced recycling can hence contribute positively to the challenge of the rising demand for critical raw materials (IEA 2024a). In addition to lowering the environmental impact of batteries, recycling could also decrease costs of raw materials significantly (Ma et al. 2025). Hazardous disassembly, explosion potentials and toxic electrode materials however present hurdles for increasing circularity rates (Hossain, Sarkar, and Sahajwalla 2023).

Pretreatment processes such as shredding further complicate the recycling process by creating mixtures which are difficult to separate (Ma et al. 2025). An automatization of disassembly and cleaner mechanical separation are proposed as means to reduce contamination and facilitate higher recovery efficiencies (ibid). Emerging technologies such as direct recycling and upcycling present an opportunity as they reduce the risk of metal contamination from electrode casing (Hossain, Sarkar, and Sahajwalla 2023; Ma et al. 2025).

Due to the extensive raw material requirements in BESS production, the geopolitical dimension of battery energy storage systems cannot be ignored. China accounts for over half of global raw material processing for lithium and cobalt and holds 85% of global battery cell production capacity (IEA 2024a). Together with Australia, China thus also emits two thirds of GHG emissions related to battery production (Ahmed and Maraz 2023). Only around 10% of the total supply chain for battery metals and cells are held by the EU, the US and Korea each (ibid). The uneven distribution of resources further adds to supply chain vulnerability (Nekahi et al. 2024). These supply chain structures are highly relevant in terms of market dynamics which will be discussed subsequently.

2.3.4. From cost challenges to emerging opportunities: The economics of BESS

For a net-zero emission scenario, already in 2030 over 500 GW of grid storage capacity will be required (Nekahi et al. 2024). To scale up capacities in the magnitude needed, enabling regulatory and market conditions are required since they shape the business case of BESS (Ahmad Hamdan et al. 2024; Chowdhury et al. 2020; Gailani et al. 2020). Such enabling interventions include policies supporting the deployment of energy storage like tax incentives or RES supporting regulations. These will further be addressed in chapter 2.4 below.

The main impediment to widespread adoption of BESS cited by a vast number of authors is storage technology cost (Ziegler et al. 2019; Ahmad Hamdan et al. 2024; Zhang et al. 2021; Jafari, Botterud, and Sakti 2022; Arbabzadeh et al. 2019; Bullich-Massagué et al. 2020). The investment costs of BESS do not only include the battery pack cost, but also power electronic inverters, an energy management system (EMS) and engineering, procurement and construction costs (Chen et al. 2020; Liu et al. 2020). Operation and maintenance further need to be taken into account in a cost assessment (Liu et al. 2020). A common measure for comparing costs associated with BESS over their lifetime are the levelized costs of storage (LCOS). Nevertheless, Nekahi et al. (2024) raises the point of varying cost evaluations across papers due to cell level or pack level costs, inclusion

of hardware and various energy densities and cathode compositions across technology types. The common argument across previous publications is that BESS costs do not yet allow an economical operation of a BESS for different services (Arbabzadeh et al. 2019; Bullich-Massagué et al. 2020; Chen et al. 2020; Chowdhury et al. 2020; Sköld 2023; Ahmad Hamdan et al. 2024; Jafari, Botterud, and Sakti 2022; Martins and Miles 2021; Ranjan and Shankar 2022; Zhang et al. 2021; Ziegler et al. 2019). Sköld (2023) for instance investigated the feasibility of a li-ion BESS for a commercial building. Modelling revenue generation from energy arbitrage resulted in a negative net present value (NPV), whereas frequency control showed a slightly positive one. Nevertheless, the author points to the limitation that only a certain number of actors can enter the frequency control market before it is saturated (Sköld 2023). Similarly, Zhang et al. (2021) referred to a business case calculation of energy arbitrage by BESS from 2014 which resulted in a required lifetime of 40 years to make the project feasible. Even though arbitrage with front-of-the-meter charging from RES delivers better results than arbitrage alone, the analysis by Martins and Miles (2021) still deems it an unattractive investment in terms of payback period and net-present-value. Further to be considered is a problem of simplification in literature identified by Jafari, Botterud, and Sakti (2022): They find that in some cases, business models do not account for roundtrip efficiency, impacts of BESS self-discharge and degradation and as a consequence overestimate the actual business case of BESS. Some paper propose to combine different services for revenue stacking and thus achieving a positive business case (Gailani et al. 2020; Miletic et al. 2018; Martins and Miles 2021). Martins and Miles (2021) evaluated the stacking of frequency control and balancing to be most profitable, however points to possible market saturation reducing revenues. Nevertheless, stacking comes with challenges of integrating the different services, since for instance capacity reserved for balancing or FCR cannot be utilized for arbitrage (Miletic et al. 2018).

Recent years however have altered the price situation significantly: Lithium-ion battery packs have decreased to a price of 115 USD/kWh in 2024 with a decrease of over 85% in the past decade (Statista Research Department 2025). Further cost decreases of around 40% between 2023 and 2030 are projected by the IEA (2024a). These significant drops in prices can be attributed to progress in research, manufacturing and economies of scale – particularly in China where the majority of BESS production is located (ibid). Taking the recent price developments into consideration, the results of previous research in terms of uneconomical operation of BESS for services facilitating large-scale RES integration may be contradicted. The first research question tackled within the scope of this thesis is thus the following:

(I) What is the business case of installing BESS with a solar PV farm when generating revenue from energy arbitrage versus from balancing?

The business case analysis required for answering this research question will be based on case study of a 100 MW_p solar PV plant located in Kosovo. Before the methodology for this pursuit is presented, the next chapter will thus shed light on the status of Kosovo's electricity sector in terms of RES integration as well as its regulatory and policy framework concerning renewable energy and BESS.

2.4. Case Study: Kosovo

The Republic of Kosovo is a partially recognized state located in the Western Balkans which has declared independence from its parent state Serbia in 2008 (Assembly of Kosovo 2008). Due to its non-universal recognition, Kosovo is still excluded from memberships in the United Nations or European Union. Austria however is among the majority of states which indeed recognize Kosovo's independence, hence this thesis will follow the Austrian stance on Kosovo's state status (Austrian Embassy, Pristina 2025).

With the lowest GDP in the Balkan peninsula, Kosovo is considered one of the poorest countries in Europe (GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH 2023). The economy is further marked by significant unemployment (ibid) Nevertheless, potentials of increasing investment attraction due to competitive cost structures and nearshoring trends are identified by GIZ (2023). According to the Austrian Embassy in Pristina (2025), Austria is one of the most active investors in Kosovo. Notably, the renewable energy sector in Kosovo is targeting foreign investors as part of the facilitation of Kosovo's energy transition (Republic of Kosovo 2025b). In this vein, Kosovo presents a particularly interesting case as an emerging energy market striving towards integrating more renewable energy sources.

2.4.1. Kosovo's electricity sector

This section provides an overview of the current status of Kosovo's electricity system, with a particular focus on generation capacities and the integration of renewable energy sources. It further outlines the design of the electricity market structures, before introducing the main stakeholders shaping the sector. Together, these components form the foundation for assessing the role of battery energy storage systems (BESS) in Kosovo's evolving energy landscape.

2.4.1.1. Status of Kosovo's electricity system

Currently, the electricity mix in Kosovo is largely dependent on lignite-based generation capacities, between 85% and 95% of power supply stems from lignite plants. The two aged lignite-fired power plants Kosovo A and Kosovo B provide insufficient reliability and flexibility and are significant causes of air pollution (Ministry of Economy of the Republic of Kosovo 2023b). Both plants require refurbishments to meet emission requirements as they are at the ends of their technical lifetimes. Due to high distribution losses, energy consumption is rather high relative to GDP and population (ibid). The share of renewables in the electricity mix is still at a low level of 6,3% in 2023, mainly stemming

from wind, hydro and biomass with little contributions from solar PV. (GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH 2023; Ministry of Economy of the Republic of Kosovo 2023b). Kosovo further lacks flexible and rapid response generation units as backup capacity and thus relies on cross-border transmission capacities from Albania (Ministry of Economy of the Republic of Kosovo 2023b).

2.4.1.2. Electricity market design

Kosovo is a recognized trading area within the Continental Europe Synchronized Area and as such is also part of the European Network of Transmission System Operators for Electricity (ENTSO-E) (KOSTT 2023a). Moreover being a member of the European Energy Community, Kosovo is legally obliged under the Energy Community Treaty to implement the EU target model in terms of electricity market design (KOSTT 2023a). As stipulated in Kosovo's electricity market design, the different electricity markets in Kosovo shall reflect the European model with a forward market where ancillary service contracts are procured, a day-ahead-market, intra-day-market and balancing market (KOSTT 2023a). Since April 2023, the DAM is operated by the Albanian power exchange market ALPEX and is thus coupled with Albania. The IDM is also organized by ALPEX, however not yet in full operation (Dolzer 2025). In addition, the regional auction platform SEE CAO (Coordinated Auction Office in South-East Europe) performs auctions for cross-border electricity capacity rights. The balancing market is operated by the national TSO which accepts bids and offers as well as utilizes ancillary services contracts to react to frequency imbalances (KOSTT 2023a). Primary frequency control is ensured by the lignite power plants with a capacity of 5 MW (GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH 2023). Secondary frequency control (aFRR) is procured by ancillary service contracts which include reservation prices for the positive and negative capacity reserved under the contract as well as utilization prices for the volume of energy utilized (KOSTT 2023b). According to KOSTT (2023), the TSO in Kosovo, the features of Kosovo's electricity markets are defined by competitiveness, transparency and market reflecting pricing, no cross-subsidization and environmental improvements. An assessment by the Energy Community (2023) points to improvement potentials in transparency of consumption and transmission as well as deregulating balancing market prices. Further, the EC assessment criticizes the high market concentration within the liberalized retail market ALPEX. Energy trading expert Dolzer (2025, ll. 88–90) confirms the illiquidity of the day-ahead-market and its very few market participants. The member registry published by ALPEX shows currently a total of 38 market participants (ALPEX 2025).

2.4.1.3. Stakeholder landscape in Kosovo's electricity sector

For a more profound understanding of the regulatory situation and policy landscape, this section introduces the actors shaping the electricity market. The ministry responsible for primary and secondary legislation as well as policy in the field of electricity is mainly the Ministry of Economy, partly in junction with the Ministry of Environment, Spatial Planning and Infrastructure (KOSTT 2023a). The Law on the Energy Regulator established the Energy Regulatory Office (ERO) as an independent regulatory agency responsible for setting up and enforcing a regulatory framework for the energy sector in Kosovo (Republic of Kosovo 2016b). ERO's obligations include licensing of energy enterprises, price regulation, facilitation of competition and the authorization of new capacities (ibid). The transmission system operator (TSO) and market operator in Kosovo is KOSTT who holds double responsibility for managing electricity transmission, grid stability as well as organization and development of the electricity market (ibid). While KOSTT is publicly-owned, the distribution system operator KEDS is privately owned (Republic of Kosovo 2025a). International stakeholders such as development organizations contributing to funding the energy transition in Kosovo will be discussed in the context of international regulations and support in chapter 2.4.2.1 below.

2.4.2. Regulatory and policy framework for RES and BESS integration

After having established an overview of the status of Kosovo's electricity system, the functioning of Kosovo's electricity market and the most relevant stakeholders, this next section investigates the regulatory framework and policies in the context of renewables integration and energy storage systems. As outlined above, the regulatory framework, policies and market conditions impact the business case of battery energy storage systems and are thus the second major focus of this thesis (Ahmad Hamdan et al. 2024; Chowdhury et al. 2020; Gailani et al. 2020). Before shedding light on Kosovo's policies and announced strategies for the energy transition, international and national legislation will be analyzed to identify the frame conditions for large-scale integration of renewable energy sources and BESS.

2.4.2.1. International Agreements and Support

One of the major supranational institutions globally concerning energy is the European Energy Community. Since its establishment in 2006, its purpose is the creation of an integrated energy market between the EU and contracting parties of neighboring countries (Council of the European Union 2006). Under Art. 9, the geographical scope of

the Treaty is extended to “the territory under the jurisdiction of the United Nations Interim Administration Mission in Kosovo”. In aspiration of becoming an EU member state, Kosovo has been a party to the treaty since the Energy Community’s foundation (ibid). The Energy Community Treaty provides for the implementation of the *acquis communautaire* on energy under Art. 10 which implies obligations for Kosovo under the EU legislation regardless of its non-member state status. In 2022, the Energy Community Ministerial Council further decided on the obligation of the EU electricity market acquis into the Energy Community with the electricity integration package (Energy Community 2022). Not only does this enable the full market integration of contracting parties including Kosovo into the single European market for electricity but also obliges Kosovo to implement the electricity balancing guideline (EB GL) (idid). The Guideline on Electricity Balancing aims at integrating balancing markets and facilitating energy storage systems to provide balancing services, hence impacting BESS business cases upon implementation in Kosovo (European Commission 2017, art. 3).

In addition to the obligations stemming from its membership in the Energy Community, the leaders of the Western Balkans have stated additional commitments in the Sofia Declaration (Regional Cooperation Council 2020). In article 1, the signatories commit to work towards net-zero in 2050 and set climate and energy targets in line with the Energy Community framework and the EU acquis for 2030, Further, they pledge to develop national energy and climate plans (NECPs), to revise their legislation to support the decarbonization of the energy sector and to increase the share of renewable energy sources (ibid).

Kosovo receives international support in implementing the obligations arising from the supranational agreements and treaties mentioned above. For instance, the EU has invested roughly 79 million euros in clean energy projects in Kosovo within the Western Balkans Investment Framework (2025) in the past 17 years. Another major partner is the German development organization GIZ which has supported Kosovo in drafting its national energy and climate plan (GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH 2023). Development banks such as KfW and EBRD also invest strongly into the clean energy sector in Kosovo (Cela 2025; KfW Development Bank 2024).

Since a major part of these international agreements requires transposition into national law, the next section will touch upon relevant national legislation impacting the integration of renewable energy and energy storage systems.

2.4.2.2. National legislation

To align Kosovo's legal framework with the EU regulations, the Law on Energy, Law on Electricity and Law on Renewable Energy Sources have been adopted to allow for the sustainable promotion of renewable energy sources in Kosovo (Ministry of Economy of the Republic of Kosovo 2023a).

The Law on Energy underscores this endeavor by stating in Art. 1 its target of increasing the use of RES. Art. 6 mandates the development of an Energy Strategy to plan energy policies and the development of the energy sector in Kosovo. This strategy will be discussed in more detail in chapter 2.4.2.3. The Law on Energy further contains legal provisions for statistical transfers and joint projects in Art. 13 (1.6) which allow cross-border transfers of energy from renewable sources (Ministry of Economy of the Republic of Kosovo 2023a). Art. 14 provides for priority access to the grid for electricity generated from RES. Emphasis is also put on attracting investment to the energy sector by creating a "one-stop shop" to make information available for (foreign) investors (Republic of Kosovo 2016a, art. 17). The Law on Electricity contains rules and measures for the functioning of the electricity market which has already been introduced in chapter 2.4.1.2. above, hence it will not be discussed in further detail at this point. The Law on the Promotion of the Use of Renewable Energy Sources contains set policy objectives and support schemes for increased shares of RES in Art. 2 as well as a binding target of 32% RES share in gross final consumption of energy in 2030 in Art. 6 (Republic of Kosovo 2024). Part of the policy objectives is the obligation to draft a national energy and climate plan (NECP) for the responsible ministries of environment and economy as per Art. 7. Moreover, the law accounts for innovative renewable technologies which include battery energy storage as per definition in Art. 4 (1.28). While producers benefitting from the support scheme outlined in Art. 2 may use energy storage technologies, the support scheme does not cover electricity drawn from the power grid to charge the storage system thus favoring hybrid BESS applications combined with renewable electricity generation (Republic of Kosovo 2024, art. 13). Art. 48 highlights the role of energy storage technologies to support the integration of renewable energy and enables the regulator to issue temporary authorizations to applicants for the development and testing of Innovative Renewable Technologies including BESS.

In addition to the national legislation discussed, Kosovo has brought forth several strategy and policy papers outlining the intended pathway towards the energy transition. The following chapter investigates the main developments in this area and their impact on renewable integration and facilitating the deployment of energy storage systems.

2.4.2.3. Policies facilitating the integration of RES and BESS

In line with the law on the promotion of renewable energy sources, Kosovo has drafted a national energy and climate plan supported by GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH in 2023. Under inclusion of fifteen stakeholders from different institutions, this plan suggests a strategy relating to the five dimensions of the Energy Union. Key targets and objectives include a share of 35% RES in the electricity mix by 2030 as well as greater diversification of the energy mix, reduced import dependency and the establishment of a well-functioning flexibility market which is crucial for enabling the business cases of frequency control and balancing for BESS.

In accordance with the law on energy, Kosovo has further published an Energy Strategy in 2023 pursuing the vision of achieving a sustainable energy sector integrated in the Pan-European market (GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH 2023). Among the five strategic objectives of the energy strategy, the most relevant in terms of energy storage are the improvement of system resilience, decarbonization and strengthening of regional cooperation and market functioning. The progress report on the implementation of the energy strategy published by the Ministry of Economy of the Republic of Kosovo (2024) indicates that achievements have been reached in the legal infrastructure as well as in market integration through the coupling of the day-ahead-market with Albania.

System resilience as one of the primary objectives of the energy strategy refers to system flexibility, network modernization and investments into new capacities. Particularly relevant in this context is the target of launching market-based reserve services as well as installing at least 170 MW of flexible regulation capacity by 2031 (Ministry of Economy of the Republic of Kosovo 2023b). The Ministry of Economy of the Republic of Kosovo recognizes flexibility as a challenge for the increase of RES integration. Currently FCR capacities of 5 MW are ensured by the lignite power plants in Kosovo while other ancillary services including +- 25 MW aFRR are provided by the Albanian power system (2023b). An assessment of the Western Balkans' competitiveness by the OECD (2024) reveals Kosovo's progress in energy policy including the drafting of the energy strategy and the NECP, the coupling of the electricity market with Albania (ALPEX) and the plan to develop the most important storage project in the Western Balkans. Showcasing Kosovo's commitment to the diversification and strengthening of its energy infrastructure, this BESS project should provide 170 MW of storage capacity that is needed to fulfil ENTSO-E energy reserve capacities. In this vein, further mid and long-term objectives in flexibility include the integration of flexibility providers in the system as well as joining the

balancing platforms PICASSO and MARI (Ministry of Economy of the Republic of Kosovo 2023b). Another milestone will be the setup of separate markets for ancillary services which will allow the participation of energy storage and RES operators in the flexibility market (ibid).

The new electricity market design reflects the ambitious targets of the energy strategy and allows for BESS integration as well as for procurement of flexibility through ancillary services contracts including from across borders (KOSTT 2023a). Renewable energy integration is supported in this framework through new trading platforms (namely ALPEX) as well as renewed balancing cost attribution rules (ibid). For the facilitation of flexibility, KOSTT proposes efficient price signals for the utilization of ancillary services and imbalance correction as well as flexible rules to ensure flexibility market participation of BESS. Moreover, 1400 MW of new wind and solar capacity are planned for installation until 2031 (ibid). Kosovo's TSO aims to start annual auctions for procurement of balancing services once a sufficient number of balancing service providers is present in the market (KOSTT 2023a). BESS will be treated as generators for purposes of accounting and transmission charging, allowing them to provide flexibility and perform energy arbitrage (ibid).

Despite the promising developments in Kosovo's regulatory and strategic frameworks, energy storage technologies and particularly BESS have not yet been deployed in Kosovo, raising the question as to what regulatory, market and policy hurdles impede this development. The alignment with EU directives and regional market integration through ALPEX and future participation in balancing platforms like PICASSO and MARI set an important precedent. However, the realization of Kosovo's ambitious energy transition goals depends heavily on creating enabling conditions that attract investment and foster the operational viability of storage technologies. Consequently, the second research question tackled in this thesis is the following:

II) What regulatory, market design and policy conditions are necessary to enable BESS deployment to support large-scale renewable energy integration in Kosovo?

Through qualitative expert interviews with stakeholders including the responsible ministries, the transmission grid operator and international financing organizations the practical feasibility of large-scale BESS and their importance for solar integration in the power grid will be studied. The next chapter outlines the methodology followed for answering the two guiding questions of this research.

3. Methodology

This thesis builds on a mixed-methods research design to answer the research questions resulting from the identified gap in the literature review: A quantitative approach has been designed for research question (I) whereas a qualitative approach is utilized for research question (II). These following subchapters provide the details of the methodology applied to ensure reliability and transparency of the results obtained.

3.1. Research design – Question I

For the operationalization of research question (I) on the business case of BESS for large-scale PV installations, a case study of a planned 100 MW_p solar PV farm in Kosovo was utilized. The data shown in *table 1* on generation, investment and financing were provided by the project developers of the case study. For the business model calculations, the PV project was considered with the BESS as an add-on. Data on the location-specific generation [in MWh] of the solar PV throughout the year were provided by the case study and scaled up by considering degradation of the modules. Furthermore, since the project has concluded a PPA with an Austrian electricity trader, prices for the generated electricity were also given.

Table 1 Business Case Parameters (provided by project developer)

Case-study specific parameters	**Unit**	**Value**
First year of operation	[1]	2027
Tax rate	[%]	10%
Peak power of installation	[kW]	100 000
Energy yield	[kWh/kWp*a]	1 300
Degradation of modules	[% p.a.]	0,3%
EPC price excl. VAT and import tax	[€ / Wp]	€ 0,5988
Total purchasing price incl. VAT and import tax	[€]	€ 59 881 200
Depreciation time	[y]	20
Rent for land	[€/y]	€ 372 400
O&M costs	[€/y]	€ 1 224 000
Reserves for replacements year 1-5	[€/y]	€ 200 000
Reserves for replacements year 6-10	[€/y]	€800 000
Price escalation	[%/y]	2%
Equity	[%]	17,5%
Senior loan	[%]	65%
Senior loan interest rate	[%]	5%
Senior loan duration	[y]	15
Senior loan fees	[%]	2,5%
Mezzanine financing	[%]	17,5%

Mezzanine interest rate	[%]	10%
Mezzanine loan duration	[y]	15
Mezzanine loan fees	[%]	2,5%

Research question (I) focuses on a comparison of the business cases of utilizing BESS for the services of arbitrage and balancing. The source of revenues thus varies in these scenarios. As a third option, a combination of arbitrage and balancing was investigated. Previous to conducting the business case analysis, two interviews were conducted with Austrian experts on the electricity market and storage for solar PV to obtain information on potential data sources and business case considerations. The case-study specific parameters defining the BESS project regardless of the respective use cases are listed in *table 2.*

Table 2 BESS parameters considered in the business case (Source: Author's own illustration)

Case-study specific parameters for BESS	**Unit**	**Value**
Total Battery DC capacity	[MWh]	440
Total Battery AC capacity	[MW]	110
Depth of Discharge (DoD)	[%]	90%
Roundtrip Efficiency (RTE)	[%]	91%
Usable BESS DC capacity	[MWh]	360
Usable BESS AC capacity	[MW]	90
BESS degradation	[%/y]	3%
Purchasing price per kWh excl. VAT and import tax	[€/kWh]	€ 100
Depreciation time	[y]	10
O&M (% of investment)	[%]	2%
Grid fees	[€/MWh]	2,053€

The business case calculations were conducted in Microsoft Excel, including a profit-and-loss statement as well as a cashflow analysis. In the calculations including BESS as an add-on to the PV project, depth of discharge (DoD) and roundtrip efficiency (RTE) were considered by adjusting the total battery capacity to usable BESS capacity following formula (1):

$$BESS_{usable} = BESS_{total} * RTE * DoD \qquad (1)$$

For the first business case looking at energy arbitrage through BESS, the usable capacity at time point t [in years] was further corrected by its degradation d over time (2).

$$BESS_{usable,t} = BESS_{usable,t_0} * (1 - d)^{t - t_0} \qquad (2)$$

It was assumed that the total amount of energy produced by the PV plant during the low-price interval between 11 and 15 o'clock is fed into the battery. The residual electricity required to fully charge the usable battery capacity is taken from the grid. While the electricity generated by the PV plant is assumed to come at zero cost as the production cost is already accounted for in the PV's CAPEX and OPEX, the costs for additional electricity used from the grid are constituted by HUPX prices at the relevant hour, reduced by 20% trader margin. In the case of two cycles per day, the additional second cycle is charged at another low-price interval from 1 am to 5am completely by the grid and discharged during the second-highest peak in the morning from 7am to 11am. For discharged electricity which has not been generated by the PV but drawn from the grid, grid fees based on Energy Regulatory Office (2024) are charged per MWh. The total revenues and expenditures considered for the business case of arbitrage were calculated based on the following formulas (3) and (4):

$$REV_{arbitrage} = energy\ sales_{BESS,18-22} + energy\ sales_{BESS,7-11} + energy\ sales_{PV} \quad (3)$$

$$Cost_{arbitrage} = charging\ cost_{11-} \quad + charging\ cost_{1-5} + grid\ fees \quad (4)$$

$$REV_{net} = REV_{arbitrage} - Cost_{arbitrage} \quad (5)$$

The revenues for the business case of aFRR were constituted by reservation prices and activation prices retrieved from the transparency portal of KOSTT (2025). The total revenues from reservation for aFRR+ and aFRR- were calculated by summing up the average price per hour for aFRR+ and aFRR- over 8760 hours of the year 2024. For scaling this result up to the following years based on the assumed price escalation indicated in figure 2, the following formula (6) was applied:

$$REV_{aFRR\ reservation;t} = REV_{aFRR\ reservation;t_0} * (1 + price\ escalation)^{(t-t_0)} \quad (6)$$

In addition to that, revenues for activation were considered by calculating the average revenues according to formula (7) by utilising data from the balancing transparency portal derived from KOSTT (2025a) and scaling this result up similar to equation (6) to model the following years.

$$REV_{activation} = \left(activated\ hours_{aFRR+} * average\ electricity\ flow * price_{average}\right) + \left(activated\ hours_{aFR} \quad * average\ electricity\ flow * price_{average}\right) \quad (7)$$

The charging scheme follows the model described in the arbitrage case with charging costs for electricity drawn from the grid in addition to generated electricity. The major difference in this case is that due to the positive and negative direction of aFRR (aFRR+ and aFRR-), the BESS does not require to be fully charged, reducing the charging cost.

An ideal state of charge (SoC) of 50% is assumed. This also entails a longer lifetime for the BESS in this use-case due to non-complete daily cycles. In addition to the revenues from activation and reservation, the residual electricity generated by the solar PV is again sold directly and thus enters the model as direct energy sales.

Since only a portion of the BESS with the dimensions listed in figure 2 would be needed for aFRR, a third business case was investigated which combines aFRR with arbitrage. Here, the capacity reserved for aFRR was assumed to be 80 MWh initially which corresponds to 40 MW up and down capacity per hour, which is the current aFRR need of Kosovo. This leaves 280 MWh which can be used for arbitrage, following the same logic as outlined above. The revenues in this case are calculated based on the following formula:

$$REV_{combined} = REV_{aFRR\ reservation} + REV_{aFRR\ activation} + energy\ sales_{BESS,7-11} + energy\ sales_{BESS,18-2} + energy\ sales_{PV} \quad (8)$$

The BESS technology selected for this business case is a lithium-iron-phosphate battery ($LiFePO_4$) with a guaranteed lifetime of a minimum of 6000 cycles at normal operating conditions before reaching 70% of its original capacity according to the producer (Pomega 2025). For two charging cycles per day, this corresponds to a lifetime of approximately 10 years in the case of arbitrage where the battery is fully discharged two times per day and thus undergoes two complete cycles. With only one cycle per day however, the lifetime extends to approximately 15 years in a conservative view. For aFRR in contrast, due to the incomplete charging and discharging operation of the BESS, a minimum lifetime of 15 years is assumed in any case. For the combined case with two charging cycles per day, a slightly longer lifetime than for arbitrage alone can be assumed since around 20% of the battery are reserved for aFRR and the BESS thus does not undergo complete cycles daily. This thesis however follows a conservative view of a lifetime of 10 years for this use case. *Table 3* summarizes these assumptions. They are not only impacting the revenues generated by the PV and BESS system, but also entail increased OPEX expenditures when the battery is operated for a longer lifetime.

Table 3 Assumptions regarding BESS cycles and lifetime (Source: Author's own illustration)

Business Case	PV only	Arbitrage		aFRR		aFRR & Arbitrage	
Cycles / day	-	2	1	2	1	2	1
Lifetime [y]	-	10	15	15	15	10	15

The KPIs utilized to compare the different business cases were calculated under consideration of the entire solar PV project with the addition of the BESS. Considering

the target group of this thesis, investor-specific KPIs such as IRR and DSCR were selected for comparing the different revenue streams depending on the use case. The internal rate of return (IRR) as a KPI frequently used in financial analysis to estimate the profitability of an investment was calculated with the aid of the Microsoft Excel function *IKV* for the respective projected lifetime of the variants: For two cycles in variant 2 (Arbitrage) and variant 4 (combined aFRR & arbitrage), the IRR was calculated based on a 10-year-timeframe, for the other cases based on a 15-year-timeframe. The debt-service-coverage-ratio (DSCR) is another important metric particularly for investors and financing institutions to evaluate the extent to which dept repayments can be made with the achieved EBITDA. The annual DSCR was calculated based on equation *(9)*.

$$DSCR = \frac{EBITDA - ta}{redemption + interest\ rate} \qquad (9)$$

3.2. Research design – Question II

For an operationalization of research question (II), four targets were defined based on which the interview guideline was drafted. These targets (a-d) aim at a) understanding how the existing legal and policy environment affects BESS deployment, b) assessing how Kosovo's electricity market design enables or constrains BESS business models, c) understanding how international organizations contribute to shaping enabling conditions, d) capturing expert views on what is still needed to create an enabling environment for BESS. The resulting questions asked in the interviews can be derived from the interview guideline (Annex A2-A3). A differentiation was made in the interview guidelines to accommodate for specific information on grid fees for one of the interview partners (KOSTT).

The stakeholder institutions interviewed were selected through purposive sampling to cover the maximum variety of standpoints and expertise regarding the research question. *Figure 2* indicates the roles of the interviewed persons in their respective institutions.

Table 4 Overview of interview partners (Source: Author's own illustration)

#	Institution	Role(s)	Name(s)
I1	KOSTT – TSO	Alban Fetahu	Director of Market Operator Department
		Shyqeri Morina	Manager of the Market Administration and Development Sector
I2	ERO – Energy Regulatory Office	Petrit Krasniqi	Power System Analyst
I3	ME – Ministry of Economy	Luan Morina	Deputy Director of the Department of Energy
		Besiana Qorraj	Director for Project Implementation Unit for Renewable Energy
I4	MESPI – Ministry of Environment, Spatial Planning & Infrastructure	Servet Spahiu	Head of Department of Spatial Planning, Construction and Housing
I5	KfW Office Kosovo	Blin Berdoniqi	Local Expert - Regional Climate Partnership
I6	GIZ Office Kosovo	Avni Sfishta	Energy Efficiency Country Coordinator

The interviews were conducted on-site in Pristina during a research trip to the capital of Kosovo which allowed for a more profound understanding of the context that the stakeholders operate in rather than digital meetings would. With the exception of the interview with KOSTT (I1), all interview partners agreed to a recording of the conversation. Subsequently these recordings were integrally transcribed with the aid of the AI tool Cockatoo, however also made subject to an additional screening by the author of this thesis to avoid any errors in the AI transcription. The documentation of interview

1 with KOSTT is based on the notes that were taken during the interview as they did not consent to a recording. The referenced lines are attached in the annex of this work (A6-A15), full transcripts are available upon request. The processed interview material was then analyzed based on the content-based structuring qualitative analysis according to Mayring (2014). In addition to deductive categories which have been derived from the literature review, inductive categories were added based on the interview material to reflect mentioned content which has not been previously considered as shown in *table 5*. To improve the reliability of this thesis, clear definitions and coding rules were defined which served as guidelines for coding the interview material.

Table 5 Coding framework (Source: Author's own illustration)

Label of category	**deductive/ inductive**	**Definition**	**Coding rules (when necessary)**
Consideration of BESS in regulatory framework in Kosovo	deductive	Extent to which BESS is considered in existing regulatory framework in Kosovo	Explicit mentioning of laws as well as general perception on the consideration of energy storage in the legal framework
Legal barriers for BESS	deductive	Legal barriers (if any) that impede public/private investments into BESS	Also, legal barriers for PV projects more generally
Relevant policy frameworks for BESS implementation	deductive	Any policies mentioned that support or hinder BESS implementation	-
Role of NECP and Energy Strategy	deductive	Role of NECP and Energy Strategy for energy transition and BESS	-
Information on MCC BESS Project	deductive	Information on details and status of the project	-
Legal challenge with TSO ownership in BESS project	inductive	Information on problems encountered in the MCC BESS project with TSO ownership	-
Potential for BESS	deductive	Potential for BESS (general need as well as need in addition to the planned MCC BESS project)	-
Current lack of flexibility	inductive	Statements indicating current lack of flexibility in Kosovo's power system	not only related to BESS
Necessary market structures for BESS	deductive	Information on required market structures and market participation for BESS	-

Current organisation of FCR	deductive	Organisation of FCR capacities, procurement, provision	-
Current organisation of aFRR	deductive	Organisation of aFRR capacities, procurement, provision	-
Current organisation of mFRR	deductive	Organisation of mFRR capacities, procurement, provision	-
Outlook on balancing	deductive	Outlook on development of balancing capacities needed	for all types of balancing (FCR, afRR, mFRR)
Importance of cross-border electricity trade	deductive	Current and planned cross-border trade of balancing	Regional and supra-regional (EU)
Influence of international agreements on energy topics in Kosovo	deductive	Impact of obligations arising from international agreements and cooperations in terms of energy in Kosovo	-
Role of development partners in energy transition	deductive	Identification of focus areas for international development aid in the energy sector	-
Aspirations for EU integration	inductive	Perceived importance of the energy sector to comply with EU regulations	-
RES buildout and other storage projects	inductive	current projects in the energy field	in terms of RES and energy storage

4. Results

The results of the conducted research will be presented in the following subchapters, focusing on the business case calculation from research question (I) in chapter 4.1. and delving into the results obtained from the stakeholder interviews in chapter 4.2. The results of both research questions will be merged and discussed in chapter 5.

4.1. Business case – results

As outlined in the methodology in chapter 3, a profitability analysis was performed to answer the research question on the feasibility of different business models of BESS in combination with solar PV projects, based on a case study located in Kosovo. While the original plan involved looking at the business case of arbitrage and FCR, several interview partners indicated that the case of aFRR is more relevant in terms of frequency control: Electricity market expert Dolzer (l. 263-267; 2025) underlined that he does not perceive the provision of FCR services as a significant opportunity for BESS due to the importance of inertia which is rather provided by conventional power plants. This is confirmed by several stakeholders interviewed in Kosovo (I1, I2, I3, I6) which all state that FCR provision in Kosovo is provided by the lignite power plants with no intentions of changes in the foreseeable future. However, Dolzer points to the suitability of BESS for secondary frequency control (aFRR) (l. 154-156). Hence, the business models discussed in this thesis are the PV as a standalone (variant 1), the additional use of BESS for arbitrage (variant 2), the use of BESS for aFRR (variant 3) and finally a combination of the two latter variants by using BESS for both aFRR and arbitrage (variant 4). The fourth variant was added to account for the remaining capacity of the chosen battery size when only used for aFRR and to increase profitability. In a first vein, the analysis was performed based on the assumption of two charging cycles per day. Due to high additional costs from charging the battery over the grid in the second cycle, the impacts on the KPIs chosen to evaluate the profitability were quite significant. Hence, an additional analysis was performed for all four variants with one charging cycle only, where the major share of the power required stems from the electricity generated by the solar PV. *Table 6* shows the results for the KPIs for the different variants, differentiated by the number of cycles per day. As the numbers reveal, all business models including the BESS yield an IRR higher than 10%. Also, except for the case of the PV only, all business cases do not show a DSCR below 100% in any year of operation which is the minimum required to cover the dept repayments from the generated revenues. This result thus shows that all analysed options are profitable in the case of the investigated project with variant 4 yielding the highest IRR of 34.8%.

Table 6 Overview of KPIs for all variants (Source: Author's own illustration)

	IRR		$DSCR_{average}$		$DSCR_{minimum}$	
	1 cycle/day	2 cycles/day	1 cycle/day	2 cycles/day	1 cycle/day	2 cycles/day
Variant 1: PV only	7,9%		200%		94%	
Variant 2: Arbitrage	11,2%	5,6%	222%	227%	105%	121%
Variant 3: aFRR	27,4%	19,3%	398%	389%	243%	198%
Variant 4: Arbitrage & aFRR	34,8%	30,6%	467%	495%	318%	298%

Variant 1 only considers the revenues from direct generation with prices from a PPA with a trader and thus yields an IRR of close to 8%. Variant 2 includes the use of a BESS for energy arbitrage. While the IRR with two cycles per day is lower than operating only the PV as in variant 1, an operation with a single cycle per day results in a higher IRR. This is due to two reasons: As the investment into BESS comes with prices of around 100€/kWh, significant additional revenues to direct energy sales from the PV are required to achieve an attractive IRR for the hybrid project. In addition to the increase in CAPEX, the charging costs for the BESS in the second cycle exceed the revenues generated from that second cycle. Hence, the business case of adding a BESS for energy arbitrage with two cycles per day deteriorates the business case of the standalone PV. Variant 3 shows significantly higher IRRs for both operation strategies. Due to the assumption that the state of charge (SoC) of a BESS used for aFRR should always be around 50% to allow for both positive (power injection into the grid) and negative aFRR (power withdrawal from the grid), the charging costs are less than half of the ones for arbitrage. Even in the case of a single cycle per day, a much larger part of the required charging power stems from the solar PV generation and only around 10% from the grid. While the revenues from capacity reservation and activation are in a similar range to those achieved in arbitrage, the costs are thus much lower, allowing for higher net revenues. Furthermore, the BESS lifetime in case of aFRR is longer due to the incomplete cycles in contrast to arbitrage, where the BESS is fully discharged once or twice each day, generating revenues over a longer period of 15 years in this case study. Considered in these calculations is the current aFRR need of Kosovo of 40 MW as well as the projected increased need to around 60 MW starting from 2032 upon completing the RES targets lined out in the Energy Strategy as stated by KOSTT (I1). Variant 4, the combined case, dedicates a portion of the BESS to aFRR to cover the complete domestic aFRR needs of Kosovo (40 MW up to 2031, 60 MW from 2032) while the rest of the battery is utilized to perform energy arbitrage on the DAM. Based on the assumption of requiring 40 (60)

MW per hour in both directions (aFRR+ and aFRR-), 80 (120) MWh are reserved for aFRR. The remaining 280 MWh (184 MWh from 2032 on accounting for degradation) are used for arbitrage. The portion reserved for aFRR again requires a SoC of 50%, whereas the arbitrage portion of the battery needs to be fully charged. The charging costs are thus slightly lower than in variant 2, while the revenues are even higher than in variant 3 due to the additional arbitrage revenues. This leads to very high internal rates of return of 30% (two cycles/day) or 35% (one cycle/day). As *figure 2* visualizes, a common trend across all variants is the higher IRR with one cycle per day.

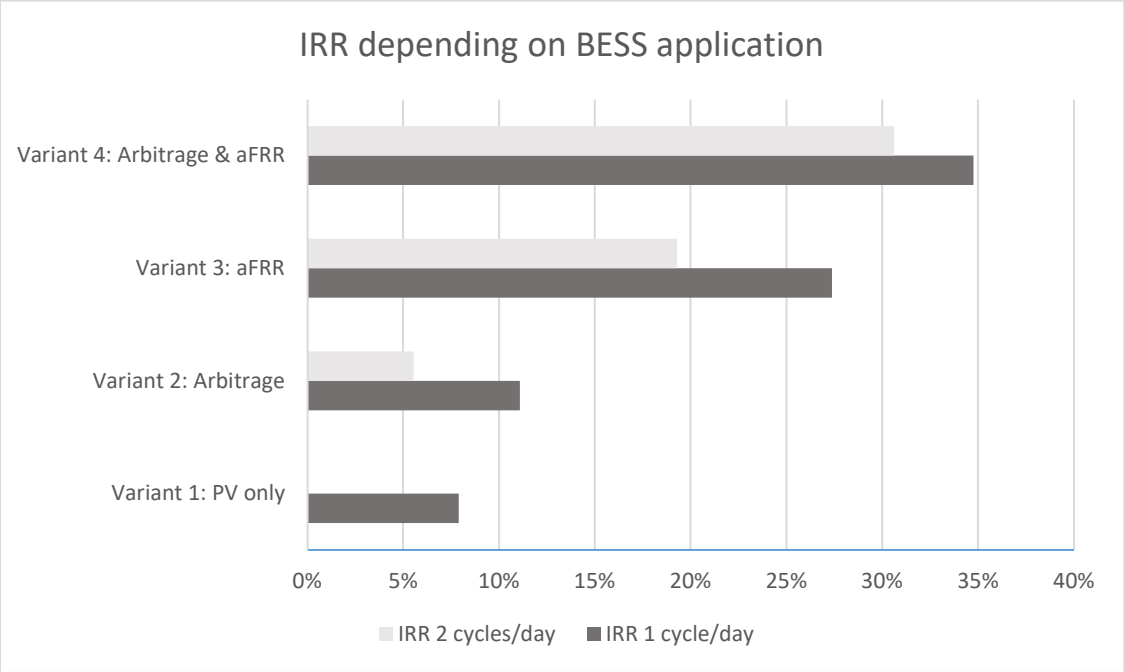

Figure 2 IRR depending on BESS application (Source: Author's own illustration)

The driver for this result is the significantly lower BESS charging cost in the case of one cycle per day charged between 11-15 o'clock from the solar PV. For a second cycle, the charging costs are in the range of €10 million per year in this model and additionally lead to grid fees charged for feeding electricity back into the grid which has been previously retrieved from the grid to charge the BESS. Another driver for higher IRR with a single charging cycle per day is the extended lifetime of the battery in these cases, entailing revenues for longer periods of time while not facing higher initial investment costs, only more OPEX over their lifetime.

Considering that the DSCR should be higher than 100% in each year to be able to cover the dept repayments, *figure 3* below visualizes the annual trends of the DSCRs of the different variants. Since the year 2027 includes the income from the loans in that year, it is excluded from this representation to avoid a distortion of the actual meaning of the DSCR for the project developers.

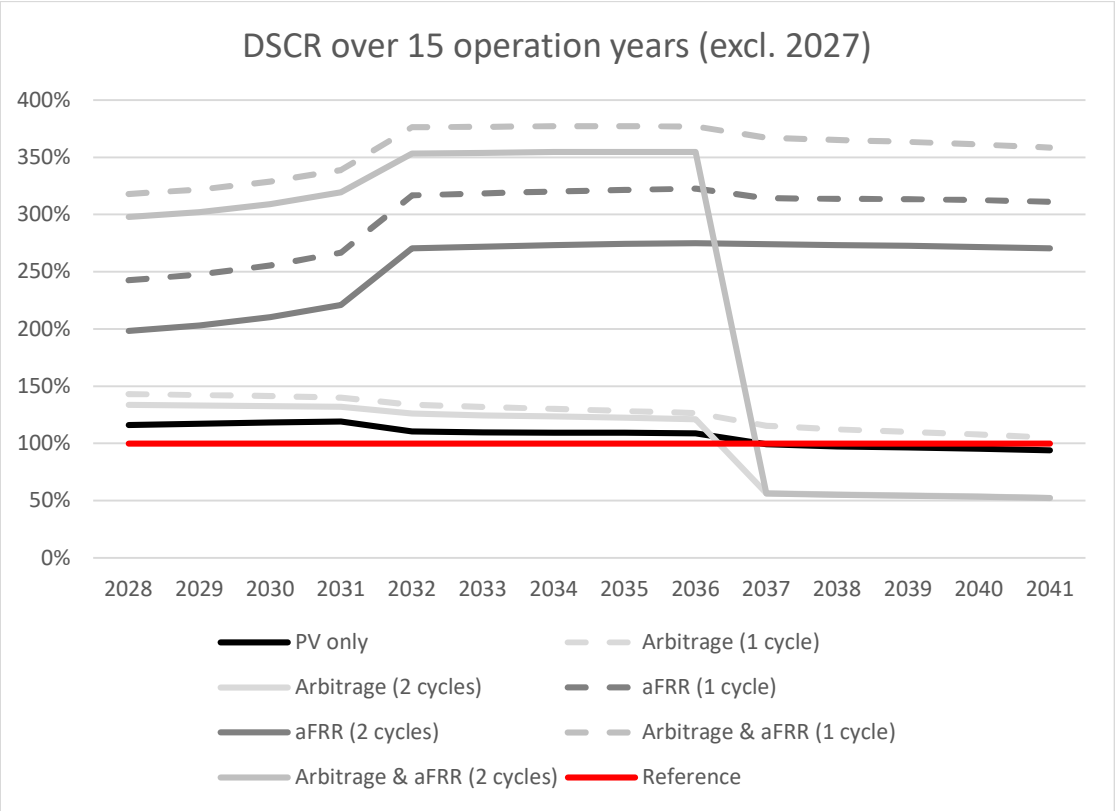

Figure 3 DSCR over 15 operation years (excl. 2027) (Source: Author's own illustration)

Similarly, the DSCR over the project lifetime shows that the variants with one cycle per day provide better results. In all cases except for variant 2 (aFRR), the dotted line indicating the single cycle operation yields higher DSCRs. The two sharp drops in DSCRs from 2036 to 2037 for both variant 2 (arbitrage) and variant 4 (combined case) are explicable due to the shorter operation time of 10 years, while revenues in the residual years from 2037 on are only produced by the direct generation by the solar PV. A sensitivity analysis was conducted for BESS degradation as shown in *figure 4*, revealing no significant alterations of the business cases upon higher or lower degradation rates.

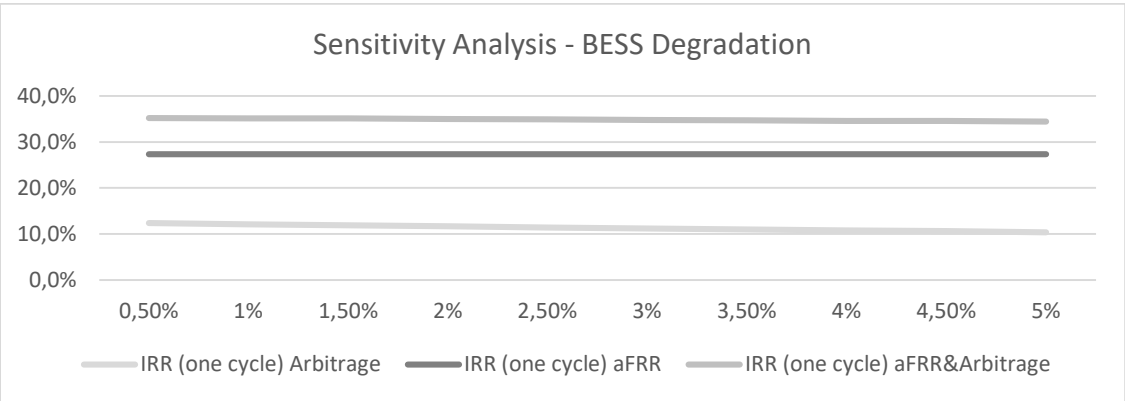

Figure 4 Sensitivity Analysis - BESS degradation (Source: Author's own illustration)

4.2. Stakeholder interviews – results

The material collected from the interviews with the major stakeholders in the context of BESS in Kosovo allows insights into the regulatory framework, market design and policy conditions which are necessary to enable BESS deployment for supporting large-scale renewable energy integration in Kosovo. The results from these interviews are presented below based on the themes identified in the content-based structuring qualitative analysis outlined in chapter 3.2.

4.2.1. Consideration of BESS in Kosovo's regulatory framework

In response to being asked about the consideration of BESS in Kosovo's regulatory framework, the main primary laws in the energy sector including the Law on Energy, the Law on Electricity, the Law on the Energy Regulator and the Law on Renewable Energy Sources were mentioned by 50% of the interviewed institutions (ERO, Ministry of Economy, GIZ). Both GIZ (I6, l.91-95) and ME (I3, l.295-296) refer to the transposition of the clean energy package which requires the consideration of ESS in the relevant legislation. Especially Art. 13 of the Law on RES was highlighted which provides for the option of energy storage for privileged producers of RES (I3, l. 53-58; I2, l2. 168-174). In this vein, the interviewee representing GIZ underscores the technology-neutral approach of this legislation, not restricting its application only to BESS (I6, l.85-87). While MESPI highlighted the regulatory competence of BESS-related matters being in the hands of the Ministry of Economy, BESS are indeed mentioned in spatial planning and construction laws, requiring permits by MESPI for BESS with over 10 MW storage capacity (I4, l. 4-7). While KOSTT and KfW did not refer to any specific legislative frameworks, both refer to the MCC BESS project as a project of national interest which thus entails streamlined efforts to creating an enabling regulatory and policy framework for BESS (I1; I5, l. 60-63).

4.2.2. Legal barriers for BESS

Most stakeholders agree that there are no evident legal barriers for BESS; the Ministry of Economy even states that there is legal clarity regarding BESS in Kosovo (I1; I2, l. 46, I3, l. 285-286; I4, l. 20; I6; 144-147). While KOSTT does not frame this as a legal barrier, they mention that grid fees for BESS feeding electricity back into the grid will be the same as for generation, deteriorating the business case for arbitrage (I1). Another hurdle pointed to by ERO, the Ministry of Economy and GIZ is the ongoing development of secondary legislation accompanying the Law on RES due to the currently non-functioning government, causing hesitation among decision makers (I2, 30-33; I3, l.13-16; I6, l.6-8). Another issue raised by multiple stakeholders is the lengthy permission

procedure of up to two years, with issues in the field of spatial planning of municipalities impeding the faster development of RES generation units and thus also BESS (I3, l. 83-95; I4, l. 20-25; I6, l.105-108). KfW raises the point that the current NECP and Energy Strategy oversee the increased need for flexibility capacities with the ramp-up of RES generation by only considering the MCC BESS project (I5, l. 68-71).

4.2.3. Role of BESS in the energy policy framework

In terms of policy support for BESS, the main recurring policy mentioned were the auctions organized by the implementation unit of the Energy Department in the Ministry of Economy for wind and solar generation supported by 15-year power purchasing agreements (PPA) for private investors (I2, l. 189-191; I3, l.32-36, I6, l.28-31). While KfW underlines that the framework and policies for BESS are there due to the MCC project, he identifies a lack of a "*policy framework which supports the entry of the private sector on this specific sector, which is battery storage*" (I5, l.75-76). Most stakeholders agree that the national climate and energy plan (NECP) as well as the Energy Strategy are the most relevant strategic documents in the energy sector in Kosovo. While the NECP is in the competence of MESPI, the Ministry of Economy is responsible for the Energy Strategy (I3, l.111-113). Considering their impact on further investment in BESS, representatives of GIZ and KfW exhibit contradicting views: GIZ perceives the inclusion of the MCC BESS project in these strategy papers as a measure which "*opens a door for such kind of investments*" (I6, l.141), the representative of KfW points to the limitation of the inclusion of only that specific project which in his view impedes further investment (I5, l. 98-103). Further, he raises the argument for the need of follow-up policy instruments like auctions or tenders for BESS (I5, l.84-86).

4.2.4. Existing market design and outlook

One of the main challenges in Kosovo's electricity market is its rather recent decentralization which is still ongoing (I5, l.8-11). In order to achieve an attractive situation for investors, KfW mentions a secure market as a precondition (I5, l.72-73). Prior to the MCC project, new market rules including market design and balancing rules were released by ERO, ensuring that BESS are able to participate in the market (I1; I2, 29-30; I5, l.173-175). Regarding primary frequency control (FCR), those stakeholders informed about FCR all provided the same answers: Currently FCR is ensured by the lignite power plants Kosovo A and B free of charge, there are no plans to change this provision in the future (I1; I2, l. 115-117; I3, l. 225; I6, l. 221-222). For aFRR, the interviewees refer to an agreement with Albania, where Kosovo purchases the secondary reserves from the Albanian TSO which organizes weekly auctions (I1; I2, l.

76-77; I6, l.227-230). Previously these capacities were 25 MW, now due to increased needs for flexibility 45 MW per hour are purchased, paying for both reservation and utilization of the capacities (I1; I2, l.63-64). ERO recently released the maximum allowed revenues which puts a cap on aFRR prices (I2, l. 94). ERO further underscores that in past auctions on aFRR, no offers except from the Albanian TSO were received which is why currently no market for aFRR is in place (I2, l.76-78). Asked for an outlook on balancing needs, all stakeholders agree that national resources for balancing are favorable as they would entail lower costs and more security (I1, I4, l.60-62; I6, l.176-177). Particularly the decommissioning of Kosovo A and B in 2050 as well as the buildout of RES generation are predicted to entail increased balancing needs of 60 MW up to 100 MW (I1, I2, l.71-73; I5, l.113-117). KOSTT confirms that auctions are planned in the future to procure these aFRR needs (I1).

4.2.5. Cross-border electricity trade

One major advancement in electricity trade in Kosovo is the joint market with Albania, ALPEX (I1; I2, l. 128-129; I3, l.176-177; I5, l.191). Via this market, also balancing capacities are traded since Albania and Kosovo are part of the same LFC block (I2, 124-125; I3, l. 176-178). While the creation of ALPEX aims at creating more competition and thus lowering electricity prices, the issue concerning the lack of liquidity of this power exchange market is brought up by KfW and the Ministry of Economy. They note that the illiquidity could be addressed by BESS through load shifting (I3, l.242-243; I5, l.210-211). Particularly during peak periods, imports are necessary to cover the required electricity demand which involves high costs (I3, l.95-96; I6, l.59-61). In the short- and medium term, regional electricity market integration possibly with extensions to neighbors such as Greece is discussed, whereas the integration into the European balancing platforms is rather a long-term goal (I6, l.217-219).

4.2.6. International agreements, development support and EU integration

The Energy Community is highlighted by most stakeholders as one of the most relevant supranational agreements in the field of energy, entailing obligations to transpose the EU energy acquis into domestic law (I2, l.26-27; I3, 23-24; I4, l.84-86; I6, 248-250). Both GIZ and KfW representatives perceive the Energy Community and similar agreements such as the Green Agenda or the Sofia Declaration as instruments to steer the Western Balkans in their energy transition, providing a “thinking-out-of-the-box approach” rather than continuing with electricity generation from lignite (I5, l. 224-225; I6, l.248-249). Development partners such as GIZ and KfW support the implementation of these obligations, both by monetary and non-monetary support. Neither KfW nor GIZ have so

far supported any BESS projects in Kosovo (I5, l.41-42; I6, l. 320-321). The one organization doing so in Kosovo is USAID with the Millenia BESS project (I5, l.48-50). Further, ENTSO-E requirements on balancing, particularly for FCR and aFRR were brought up by the Ministry of Economy, underlining the role of BESS to fulfill these obligations (I3, l. 185-187).

4.2.7. Perceived potential for BESS

All interviewed stakeholders agree on the fact that Kosovo is dealing with imbalance in its electricity grid due to inflexibility stemming from the lignite power plants (I1; I2, l.68-73; I3, l.73-75; I4, l.74; I5, l.152-154; I6, l.47-49). Particularly once the lignite power plants will be decommissioned and large amounts of RES are deployed for generation, this need for flexibility will increase (I3, l. 73-75; I5, l.141-146). Since clear targets are set for the buildout of RES, GIZ identifies a strong political will also for energy storage solutions, which is confirmed by the statements of MESPI and ME (I3, l.260-261; I4, l.140-142; I6, l.154-156). KOSTT, KfW and GIZ thus see a huge potential for energy storage solutions such as BESS to provide flexibility and support baseload generation from RES (I1, I5, l.264-265; I6, l. 203-205).

4.2.8. MCC BESS project

A recurring theme in all conducted interviews was the MCC BESS project, a 170 MW BESS financed by the US institution MCC with split capacity – 45 MW operated by KOSTT for aFRR provision, 125 MW operated by a newly founded company for mFRR and arbitrage (I1, I2, l. 138-140). Included in the NECP, this project is considered a project of national interest as KOSTT and MESPI indicate (I1, I4, l.6). With the aim of addressing the stabilization of Kosovo's power grid as well as serving as a pilot for developing the required legal framework, this project is considered the largest BESS in the Western Balkans (I1; I4, l.130-137). While many of the interviews are focused on this project only, KOSTT still identifies further business opportunities for other BESS projects due to increasing balancing needs in the near future (I1). Contrary to all other interviewees, one provided insider information on the US's potential withdrawal from the project which would result in huge untapped potential for private investors (I6, l.190).

5. Discussion

Building on the results presented in the previous section, the following discussion interprets these findings in light of the research questions and existing literature. It also explores the broader implications, limitations, and contextual factors influencing the integration of battery energy storage systems to facilitate the transition to a decarbonised power system in emerging energy markets like Kosovo.

5.1. Discussion – Business case results

The results of the business case analysis conducted in pursuit of answering research question *(I) (What is the business case of installing BESS with a solar PV farm when generating revenue from energy arbitrage versus from balancing?)* show that all investigated options for a hybrid project of PV in combination with BESS are profitable in the selected case study. These findings contradict the literature published in previous years where BESS costs were still at higher levels (Arbabzadeh et al. 2019; Bullich-Massagué et al. 2020; Chen et al. 2020; Chowdhury et al. 2020; Sköld 2023; Ahmad Hamdan et al. 2024; Jafari, Botterud, and Sakti 2022; Martins and Miles 2021; Ranjan and Shankar 2022; Zhang et al. 2021; Ziegler et al. 2019). The cost developments projected by the IEA for the upcoming decades could further contribute to improving the business case of BESS even more (IEA 2024a). As the results show, the lifetime required to make the BESS project feasible is between 10 and 15 years depending on the use case which is easily achievable with current BESS lifetime benchmarks of between 6000-8000 cycles in contrast to the study conducted by Zhang et al. (2021) which projected a minimum required lifetime of 40 years for a BESS project performing arbitrage. Even though Jafari, Botterud, and Sakti (2022) frequently found the neglection of roundtrip efficiency or degradation as a cause for overestimated business cases for BESS, the results in this thesis illustrate that even under consideration of these parameters, positive business cases can still be achieved. As reflected in the literature (Martins and Miles 2021), the technical strategy of operating a PV combined with an ESS and thus charging the BESS directly from generation is more favorable also due to the circumvention of additional grid fees. This finding is also unequivocally represented in this work, as a single charging cycle per day fed by the generated electricity is more profitable for all analyzed options. Furthermore, the findings support the hypothesis suggested by several authors including Gailani et al. (2020), Martins and Miles (202 and Miletic et al. (2018) of revenue stacking providing better business cases. As shown in chapter 4, the business case of variant 4 which combines the services of balancing (aFRR provision) with arbitrage yields the highest IRR since the full battery capacity is used productively. The

results of the business case analysis thus indicate quite clearly that while all operation options are profitable, the highest IRR is yielded by the combination of aFRR and arbitrage and the operation with a single cycle per day powered by the electricity directly produced from the solar PV farm.

5.2. Discussion – Interview results

The results from the stakeholder interviews on the regulatory, policy and market conditions for BESS in Kosovo (research question II) shed a quite positive light on the existing framework in Kosovo. While little legal barriers are identified, a strong political will reflected in the strategy papers and development of the MCC BESS project as well as the recent adaptations of the market design and rules indicate a positive environment for the development of BESS (I1, I2, I3, I4, I5, I6). In the regulatory sphere, most stakeholders (I2, I3, I4, I6) highlight the Energy Community as the most relevant supranational agreement. Following the obligation under art. 10 of the Energy Community Treaty, the legislative organs repeatedly mention their efforts in transposing the acquis on energy matters (I2, I3). As the annual implementation report of the Energy Community (2023) on Kosovo shows, this is partly reflected in Kosovo's achievements. One area of improvement mentioned in this report is the deregulation of balancing market prices, which is reflected in the interviews by stakeholders pointing to planned aFRR auctions once market participants are established (I1, I2, I3). While the implementation of the clean energy package is discussed by two stakeholders (I3, I6), no specific mentioning of the guideline on electricity balancing occurred within the interviews, even though it includes relevant rules for balancing (European Commission 2017). Other international agreements such as the Green Agenda and the Sofia Declaration were not referenced directly by the legislative stakeholders interviewed, the development partners however referred to them as instruments which enabled a different pathway towards RES instead of lignite power generation (I5, I6). Particularly interesting in this vein is the combination of hard and soft power through international agreements and regulations on the one hand and development aid on the other hand, supporting and facilitating Kosovo's energy transition. On the national level, emphasis was placed on the Law on RES by several stakeholders, especially its article 13 on energy storage (I2, I3, I6). As outlined in the interviews (I3, I6), this article follows a technology-neutral approach, allowing for different types of energy storage: "*1. Privileged Producers that use energy storage technologies and, consequently, store electricity produced may benefit from the Support Scheme established by this Law at the time of its scheduled delivery to the grid. 2. The Privileged Producers shall not use the electricity drawn from the power system to charge the storage system. The transmission system operator shall provide to the*

Renewables Energy Operator the related information required to offset the Support Scheme payments in accordance with this Article." (Republic of Kosovo 2024). Since art. 13 (2) specifically excludes standalone ESS from benefitting of support schemes, the legislation favors hybrid projects where RES generation is coupled with an ESS. However, none of the interviewed stakeholders was able to provide more information on the indicated support schemes, which leads to the conclusion that are currently none in place. The other article relevant for BESS in this law is art. 48 on the use of innovative renewable technologies: *"1. In order to increase the use of energy from Renewable Energy Sources, as well as to support energy system integration, the development of Innovative Renewable Technologies shall be encouraged. 2. The Regulator shall issue a temporary authorization to interested applicants, to develop and test Innovative Renewable Technologies.".* According to the definition provided in art. 3 (1.28), such innovative renewable technologies include but are not limited to energy storage including BESS. While the implementation report on the Energy Strategy highlights Kosovo's achievements in terms of legal infrastructure (Ministry of Economy of the Republic of Kosovo 2024), several interview partners indicated that due to the currently non-functioning parliament, the Law on RES is not fully operational as secondary legislation required for its operation has not been passed yet (I2, I3, I6). Another legal barrier that has not been touched upon in the energy-storage specific literature are the lengthy permission procedures which have been mentioned by both ministries interviewed (I3, I4). A recurring argument in Kosovo's publications as well as the interviews is the challenge of flexibility in the power grid with increasing shares of RES in generation (Ministry of Economy of the Republic of Kosovo 2023b; I1, I5, I6).

In terms of policy framework, the interviews support the previous literature analysis which revealed the Energy Strategy and the NECP being the most relevant policy papers in terms of BESS. Particularly the 170 MW of flexibility that is included in the Energy Strategy refers to a specific BESS project financed by the US government as all interview partners indicated (I1-I6). Framing it as a project of national interest (I1, I5), the MCC BESS project was identified as a driver to streamline efforts for creating an enabling framework for BESS. If the project is realized indeed, this would correspond to covering the entire aFRR need for the time until 2031, from 2032 on around 60% of the national need by that single project. However, auctions are planned to be organized on a regular basis to ensure that other market participants can also join the aFRR market (I1, I2). While the implementation of the MCC project according to the interpretation of the interviewed stakeholders is beneficial for other BESS projects in terms of regulatory development, it also significantly impacts the business case of other projects. This is not

reflected in the business case analysis conducted in this paper and would deteriorate the BESS options with aFRR and aFRR & Arbitrage significantly. For that reason, the potential withdrawal of the US government as suggested by one interviewee (I6) would leave an attractive business opportunity for other investors to benefit from the regulatory and policy conditions already created for the MCC project while not having to face this major opponent in the market.

In the market dimension, the interviews are in line with the NECP in terms of FCR which is provided by the lignite power plants (GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH 2023). Since there are no plans for changing this provision, there is no potential market for FCR, rendering this business case irrelevant for the case study investigated in this work. The positive revenue potential of aFRR due to the increasing need for flexibility in the power grid in Austria as identified by Esterl and Maggauer (2025) also showcases in Kosovo, being confirmed by both the results of the profitability analysis and the stakeholders (I1-I6). While Sköld (2023) points to the danger of market saturation in frequency regulation, the interviews show contrasting opinions: Some are convinced that the potential for balancing services will rise in the upcoming decades resulting from the ramp-up of RES generation (I1, I2, I3, I4, I5), others perceive the current market gap as a unique opportunity for a BESS project, reflecting the risk of market saturation (I6). In terms of cross-border electricity trade and potentials for BESS, the Energy Strategy foresees mid-and long-term plans of integrating flexibility providers in the PICASSO and MARI platforms as well as setting up ancillary service markets (Ministry of Economy of the Republic of Kosovo 2023b). While future auctions for ancillary services are indeed mentioned by several stakeholders (I1, I2, I3), the integration in the European electricity balancing market is perceived as rather long-term (I5, I6), with a stronger focus on regional integration.

5.3. Synthesis of findings

To further synthesize and critically assess the findings from the literature review, stakeholder interviews, and business case analysis, a SWOT framework is applied. This structured approach highlights the key strengths, weaknesses, opportunities, and threats associated with the integration of battery energy storage systems (BESS) in solar power systems within the context of Kosovo. Based on the SWOT framework, the findings of this thesis are synthesized in *table 7* to provide project developers aiming to install a BESS system in Kosovo as well as the relevant stakeholders within the country an overview of the current situation.

Table 7 Synthesis of findings (Source: Author's own illustration)

Strengths	**Weaknesses**
• Positive business case for all options • highest IRR from combined aFRR & arbitrage provision (revenue stacking) • Supporting policies in place (Energy Strategy, NECP) • BESS considered in legal framework (§13 and §48 Law on RES) • Strong political will for energy storage • Membership in Energy Community; energy acquis	• Operation with two cycles/day unprofitable • BESS treated as generators, implying grid fees • Law on RES not yet fully operational due to not passed secondary legislation • Lengthy permitting procedures particularly due to spatial planning and zoning • Decentralisation of energy market ongoing • Currently no balancing market in place
Opportunities	**Threats**
• Planned auctions for ancillary services • Urgent and increasing need for balancing capacities due to planned RES capacity installation (up to 100 MW aFRR needed) • Reduction of peak time imports and corresponding social benefits • Regional market coupling for balancing services • Eventually participation in PICASSO and MARI platforms • Projected future cost reductions of BESS	• Continuation of MCC BESS project • Except for the MCC BESS project no consideration of other BESS projects in the policy papers • Risk of market saturation for aFRR • Environmental impacts of BESS • Lack of recycling infrastructure for BESS favouring other energy storage technologies

5.3.1. Strengths

The synthesized results merged in *table 7* represent the findings from the literature review, the business case analysis as well as the stakeholder interviews. As described in more detail above, the major framework conditions in terms of profitability, policies and regulatory matters are given in Kosovo, enabling the implementation of BESS projects. Supporting the findings of Gailani et al. (2020); Martins and Miles (2021); or Miletic et al. (2018), revenue stacking from aFRR and arbitrage is found to be the most profitable business case also in this thesis.

The strong political will towards energy storage identified in the interviews is reflected in the Energy Strategy and NECP as the basis for policy instruments as well as the recently adapted legal framework, particularly the Law on Renewable Energy Sources (§13 and §48). Additionally, Kosovo's membership in the Energy Community is considered a strength as several stakeholders have highlighted the importance of EU integration for Kosovo and their striving to not endanger this endeavour.

5.3.2. Weaknesses

Nevertheless, some barriers to the development of BESS projects in Kosovo were also identified within this work: The business case analysis showed that the operation of two daily cycles is not profitable for a BESS project, which from a system point-of-view enfolds the effect of not shifting the night-time generation from conventional power plants to the peak load in the morning. Further deteriorating the business case are the grid fees that BESS face in Kosovo as they are treated as generators (I1; (KOSTT 2023a). While this is also the case in Austria, other countries including Germany already have grid fee exemptions in place for BESS (Dolzer 2025; Eusch 2025).

Even though generally no legal barriers for BESS in Kosovo were explicitly identified by the stakeholders in the interviews, a recurring note was made to the secondary legislation required to support the primary Law on Renewable Energy Sources. Moreover, the lengthy permission procedures and the issues arising from spatial planning and zoning laws were perceived as hindering for fast deployment of BESS. Even though the market rules and market design published by (KOSTT 2023b) outline an energy market following the European model, this market is not yet fully in place as its decentralisation is still ongoing (I6). Moreover, due to the lack of market participants, no balancing market is yet in place in Kosovo, adding insecurity for investors aiming to develop a project in this sphere.

5.3.3. Opportunities

However, as indicated by several stakeholders and stipulated in the electricity market design (KOSTT 2023b), aFRR auctions will be held once a sufficient number of market participants is established. Consensus among the stakeholders and the literature (GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH 2023) is established concerning the need for flexibility capacities in Kosovo which will increase further upon the planned buildout of RES until 2031 as set out by the Energy Strategy (Ministry of Economy of the Republic of Kosovo 2023b). While the precise values for the needed aFRR in the future range from 60 to 100 MW, the increasing trend is clear (I1, I2). Another opportunity for the deployment of BESS brought forth in the interviews is the reduction of imports at peak times that energy storage could provide. Since the imports significantly drive electricity tariffs in Kosovo (I3, I6), this could also contribute to addressing energy poverty. The long-term strategy for cross-border trade of balancing capacities includes the joining of PICASSO and MARI in the Energy Strategy, which was however not reflected in the interviews where the focus is rather on regional integration than on European integration, at least for mid-term horizons (I3, I5). The cost reductions for BESS projected by the IEA also represent an opportunity for the realisation of BESS projects in Kosovo (IEA 2024a).

5.3.4. Threats

The major (commercial) threat for other BESS projects in Kosovo is the MCC BESS project as it is dimensioned to cover the current aFRR need completely as well as operate the remaining capacity for performing arbitrage. Since the current US foreign development politics follow a rather retreating trend, there is the possibility that this project will no longer be financed (I6), opening a window for other project developers. The lack of considering other BESS projects in Kosovo's strategy papers is however identified as a potential barrier by one stakeholder (I5), particularly since the MCC BESS project is framed as a project of national interest. The risk of market saturation for balancing as identified in the literature (Sköld 2023) is evident, but due to the projected electricity generation mix the opportunity of increasing balancing needs is prevailing in the interviews. While no opposition to the urgent requirement of energy storage for a RES powered grid was found, batteries as an energy storage technology were not unequivocally perceived as the only solution. Rather, PHS were mentioned as an alternative with the hurdle of limited suitable locations in Kosovo (I2, I3, I4, I6). Particularly the negative environmental impact of BESS also highlighted in the literature

(Chowdhury et al. 2020; Guo et al. 2023; Metzger et al. 2023) were reflected in some of the interviews as a concern regarding this ESS technology (I4, I6).

5.4. Limitations

While this thesis provides valuable insights into the role of BESS in large-scale solar integration in Kosovo, several limitations must be acknowledged that may influence the interpretation and generalizability of these findings. As emphasized before, the data used for the business case analysis are specific to the case study analysed in this thesis. Moreover, several simplifying assumptions were made in the business case calculation to allow for the use of Microsoft Excel instead of more complex modelling software including taking averages for aFRR activation and scaling up 2024 prices with a fixed price escalation percentage without considering external events possibly influencing the prices in a different way. In addition to that, the mFRR market was not considered in the business case analysis and could be subject of future analyses. Particularly considering the geopolitical and environmental dimensions of BESS, future studies should also evaluate the potential for alternative storage technologies and their respective suitability for Kosovo. In light of the fast-paced advancements in storage technologies and energy policy, this thesis offers a timely entry point into the role of BESS in Kosovo, with future research needed to track ongoing technical, economic, and regulatory developments.

6. Conclusion

Through the combination of a cost-benefit analysis of BESS business models with a qualitative examination of regulatory and stakeholder perspectives, this study offers a holistic approach to understanding both the economic and policy dimensions of energy storage deployment in Kosovo.

Based on a case study located in Kosovo, different operation strategies for a hybrid BESS project coupled with a 100 MW_p solar PV farm were analyzed. All business cases including a BESS yielded better results than the operation of the PV as a standalone. Higher internal rates of return were achieved by the provision of balancing services (aFRR) than from arbitrage, with revenue stacking by combining both services yielding the highest IRR. The results further showed that a single operation cycle per day achieves better results as the battery is charged during the peak solar hours of the day, requiring little additional power from the grid for charging.

Interviews with six stakeholders – including the transmission grid operator, the responsible ministries, the energy regulator as well as development organizations – provide context to existing legislation, strategies and policy papers. The findings show that little regulatory, policy or market barriers exist for BESS in Kosovo mostly due to the planned implementation of a large-scale US funded BESS project of national interest. This strong political will is also reflected in the relevant strategy papers including the Energy Strategy of the Republic of Kosovo and the National Climate and Energy Plan (NECP). Supranational agreements such as the Energy Community, the Sofia Declaration and the strong interest for EU integration support Kosovo's energy transition and integration of energy storage. The rather recent and still ongoing decentralization of the energy market as well as the major generation capacities held by the lignite power plants Kosovo A and B however still hinder fast RES deployment and create insecure market conditions for energy storage technologies such as BESS. A major concern in the electricity system is the lack of flexibility which will further increase upon the addition of up to 1400 MW of variable RES until 2031 as stipulated in the Energy Strategy. Hence, the interviewees unambiguously support the deployment of BESS to address this challenge and provide balancing capacities.

As the findings of this thesis illustrate, the development of a BESS project in Kosovo is both commercially feasible and politically desired if used for balancing services. This alignment in economic feasibility and strategic political goals presents a compelling case

for the development of BESS projects in Kosovo, particularly for first-movers due to the limited market potential in terms of balancing.

Further, the results of this thesis underline the importance of energy storage technologies in the energy transition, as balancing needs grow to ensure grid stability with the rising integration of variable renewable energy sources like wind or solar. While BESS are just one technology available, this thesis has shown that they are particularly suitable for the context of Kosovo due to their technical properties equipping them for balancing, their modular and location-independent setup not requiring certain geographical conditions and their increasing commercialization.

While this thesis offers a starting point on understanding the role BESS in large-scale solar integration in Kosovo, future research could incorporate additional services such as mFRR to the analysis and include detailed modelling of revenue volatility and risk management strategies for BESS as market mechanisms in Kosovo continue to mature. The fast-paced developments in battery technologies as well as the evolving market in Kosovo indicate that economic projections as the one presented here must be continually re-evaluated in the light of new data and policy or regulatory changes. Nevertheless, this thesis contributes to a broader understanding of how emerging energy markets like Kosovo can harness energy storage technologies to enhance grid flexibility and accelerate the integration of renewables, thereby shaping a resilient solar-integrated electricity system.

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Interview Guideline – general

Topic	Question
Legal and policy framework for BESS	In your view, what regulatory frameworks are essential to enable and scale battery energy storage systems?
	To what extent does Kosovo's current regulatory framework support BESS deployment?
	Are there specific legal barriers that currently prevent or complicate the development of BESS projects? What are the main institutional or administrative hurdles investors face when developing BESS projects?
	What policy instruments are required from your perspective to kick-start BESS deployment?
	What role does the NECP or the Energy Strategy play in shaping the framework conditions for BESS?
	How do you assess the potential for other BESS projects in addition to the 170 MW project planned in the energy strategy? For different services?
Assessment of electricity market design	What kind of market structures are needed to ensure BESS can participate in and be compensated for providing flexibility?
	Can BESS currently participate in Kosovo's electricity markets (e.g., energy, balancing, ancillary services)? If not, what are the main barriers? How is the balancing market for FCR and aFRR currently organized and what opportunities does it hold for BESS?
	What are mid- and long-term prospects for ancillary products offered by BESS?
Cross-border integration	How important is cross-border electricity trade and market coupling for creating value streams for BESS?
	What institutional or market preconditions are needed for BESS to participate in regional balancing and flexibility markets?
	Do you see opportunities or constraints for cross-border flexibility trading involving BESS?

Impact of international donors	How do international agreements (e.g., Energy Community, Sofia Declaration) influence Kosovo's obligations regarding energy storage and flexibility?
	In what ways do international donors (e.g., GIZ, KfW, EU) support or shape the development of energy storage infrastructure in Kosovo?
Outlook	In your opinion, what are the most urgent steps Kosovo should take to enable BESS deployment?
	What changes in market design or grid codes would most improve the business case for BESS in Kosovo?
	How optimistic are you that Kosovo will achieve the flexibility targets set in its Energy Strategy by 2030?
	Where do you see the greatest opportunity for BESS to add value in Kosovo's power system?

Interview Guideline – KOSTT

Topic	Question
Legal and policy framework for BESS	In your view, what regulatory frameworks are essential to enable and scale battery energy storage systems?
	To what extent does Kosovo's current regulatory framework support BESS deployment?
	Are there specific legal barriers that currently prevent or complicate the development of BESS projects? What are the main institutional or administrative hurdles investors face when developing BESS projects?
	What policy instruments are required from your perspective to kick-start BESS deployment?
Assessment of electricity market design	What kind of market structures are needed to ensure BESS can participate in and be compensated for providing flexibility?
	Can BESS currently participate in Kosovo's electricity markets (e.g., energy, balancing, ancillary services)? If not, what are the main barriers?
	What are mid- and long-term prospects for ancillary products offered by BESS?

Business Case for BESS	How does FCR market work?
	How does aFRR market work?
	How could BESS participate in each of these markets? Business Case: How does renumeration work for FCR? What prices can be assumed in business case? If cooperation with BESS project in Kosovo, what would be the frame conditions?
	How does renumeration work for aFRR? Which of the data on homepage can be used for business case calculation? Which data do I use, how does the procurement and price determination work (reservation + activation price)?
	Is the BESS project (170 MW) expected to cover all needs for FCR / aFRR? Imports to Albania possible?
	What grid fees are charged when using electricity from grid to store in battery and selling it at high price points?
Cross-border integration	How important is cross-border electricity trade and market coupling for creating value streams for BESS?
	What institutional or market preconditions are needed for BESS to participate in regional balancing and flexibility markets?
	Do you see opportunities or constraints for cross-border flexibility trading involving BESS?
Outlook	In your opinion, what are the most urgent steps Kosovo should take to enable BESS deployment?
	What changes in market design or grid codes would most improve the business case for BESS in Kosovo?
	How optimistic are you that Kosovo will achieve the flexibility targets set in its Energy Strategy by 2030?
	Where do you see the greatest opportunity for BESS to add value in Kosovo's power system?

Template: Declaration of consent for interviews

Declaration of consent
(Qualitative interview)

Research Project: Master Thesis *„The Role of Battery Energy Storage in Large-Scale Solar Integration: A Business Case and Policy Analysis for Kosovo"*

Institution: ETIA program offered by TU Vienna / Diplomatic Academy Vienna

Author: Helene Stanger, supervised by Dr. Mario Ortner

Interviewer: Helene Stanger

Date of interview: _____

We, _____ and _____,

representatives of the institution _____,

agree to participate in an interview within the research project stated above. We have been informed about the scope of the research project. We can stop the interview at any time, disagree to further interviews and reject our consent to the recording and transcription of the interview without facing any disadvantages.

We give our consent for the interview to be recorded and transcribed subsequently. For the use of the interview in the said research project, (*please mark*)

- ○ all personal data will be removed from the text and used anonymously.
- ○ our personal data may be used in the text.

_____ _____

Place, date Signature

_____

Signature

Interview Transcript – cited sections only

Interview: Martin Dolzer

Line number	Transcript
75-76	Das wäre nicht möglich. Das wäre wirklich nur im angrenzenden Nachbarland möglich. Da geht es um die Netzanbindung ins benachbarte Ausland.
85-93	Im Kosovo gibt es eine Börse seit, also ich glaube das müsste grob so zwei Jahre ungefähr sein, die Alpex ist das ja, die gleichzeitig Albanien und Kosovo vom ersten Tag an gekoppelt auch bei den Märkten bedient. Und da gibt es einen Day Ahead-Markt, der ja noch sehr illiquid ist, aber der zumindest einmal da ist, Intraday ist wirklich erst im Aufbau und das gleiche dann auch mit Systemdienstleistungen bzw. mit Regelenergie. Also da ist man, glaube ich, im Kosovo noch relativ weit weg davon. Was ich mir schon vorstellen kann ist, wenn man jetzt auf diese Märkte dann längerfristig denkt, dass sich das natürlich entwickeln wird und dass man dort sicher eine Regelenergie dann für das benachbarte Ausland nutzen bzw. anbieten wird können.
154-156	Ja, also generell würde ich sagen, die Batterien bieten sich vor allem für den sekundären Regelenergie-Markt an. Das ist das, was wir in der Praxis so sehen, dass das vor allem bei sekundärer Regelenergie geboten wird.
179-186	Also mit so Standardgrößen von circa zwei Stundenspeichern, teilweise sieht man einen 1-Stundenspeicher, auch weil es von den Investitionskosten besser sind, aber im Wesentlichen hängt es an den Netztarifen derzeit. Und wenn diese Netztarife fallen sollen, oder wenn die zumindest dem Pumpspeicher gleichgestellt werden, also wir zahlen ja Netztarife für den Pumpspeicher in Österreich, das sind aber reduzierte Netztarife, dann wird natürlich der DAM und Intradaymarkt attraktiver und im Bereich Regelenergie hat man heute schon die Situation, dass man dort eben entsprechend Netztarif befreit ist bzw. geringere Netztarife dann zahlt.
263-270	Genau, nicht wirklich. Dort geht es eher um Schwungmasse, die man im Netz dann braucht. Das sind eher teilweise Laufwasserkraftwerke. Laufwasserkraftwerke wären in Kombination mit Batteriespeicherung natürlich, die primär regelenergiefähig werden. Da haben wir ein Projekt gemacht, wo wir zum bestehenden Laufhäuserkraftwerk einen Batteriespeicher getan haben, um das primär regelenergiefähig zu machen. Aber die Frequenzregelungen, da sehe ich definitiv den alten Kraftwerkspark im Vorteil, weil es dort um relativ große Schwungmassen geht, die man dann im Netz hat und die gute Stabilität erzeugen. Das bietet der Batteriespeicher nicht so wirklich

Interview: Ingram Eusch

Line number	Transcript
22-24	Das ist das erste Geschäftsmodell, wenn man den Aufschlag hernimmt, dann kann da durchaus um 150% mehr im Schnitt erzielt werden, als man einkauft.
36-38	Nein, es ist immer Day Ahead. Weil ich berechnen, prognostizieren und irgendwie einstellen muss. Diese Software-Module, die betrieben werden, gehen nach dem DAM Preis, weil sie das ja steuern müssen
43-46	Also, naja, die Software, das sind schon AI-basierte Software-Module, vor allem die Ngen ist da glaube ich europaweit schon führend. Die haben 65 Programmierer eingestellt bei Ngen, die seit drei Jahren nichts anderes programmieren wie diesen Algorithmus. Und wenn du da extrem schnell in Millisekunden richtig reagierst, verdienst du Geld.
133-136	Also das ist noch so in den Kinderschuhen. In zehn Jahren vielleicht. Nein, aber glaube ich nicht, Marktsättigung. Der Strommarkt wird sich verdoppeln bis 2040 laut Prognosen, Önip und so weiter. Und die Volatilität wird größer werden, weil natürlich Erneuerbare viel mehr werden und dadurch sehr viel mehr aus- und abgeglichen werden muss
158-159	Insofern sage ich, die Speicher sind absolut notwendig, wenn du nicht kontinuierlich Strom produzierst wie mit Atomkraftwerken. Dann brauchst du Speicher.

Interview 1: KOSTT

The interviewed persons did not agree to record the interview. These are the interview notes taken by the interviewer.

There are several projects ongoing in the field of RES: Hydropower (80 MW operational, 10 MW non-operational); Wind → 206 MW in total, currently another project is in the pipeline with 100 MW; will be realized in 2-3 years (136 MW operational; 70 MW non-operational); Solar (14 MW operational, 100 MW non-operational (Gjakova; PPA is signed as an incentive from the government to guarantee prices); Biomass (1.4 MW operational). Disadvantaged base position due to 90% energy generation stemming from coal due to historical and resource reasons.

Currently: largest BESS project ongoing in the Western Balkans which will enfold significant improvements for balancing the system. Imbalances in Kosovo's power system currently impact the country's neighbors as well as Continental Europe at times. The battery capacity is thus split: 45 MW will be operated by KOSTT for balancing (aFRR), the rest will be operated by a newly founded company for arbitrage and mFRR. The issue with balancing is the following: KEK, the generator, states that they have no flexibility in terms of generation – once ramped up they can neither produce more nor less. So between midnight and 6:30 am a vast excess of energy is pushed into the system because they cannot lower the generation. This energy will in future be fed into the battery to be sold in the morning and thus come with added value.

Political issue: process of EU integration. Kosovo wants to ensure this goes smoothly and thus has to perform accordingly to not risk this process. Thus it is important for them to find solutions for balancing. The

market rules and market design as well as market balancing all include BESS. This means parties can participate in yearly auctions which are in the future planned to happen every month or week. There are also plans to organize auctions for balancing energy, but none are currently organized. There is a lack of auxiliary sources in the region, with only Albania as a hydro powerhouse providing some. There is currently zero potential for balancing in Kosovo. KOSTT tested an auction last year, but no offers were received which leads to the conclusion that no potential is available. Historically there is only one bidder for mFRR, the Albanian Power Generation company KESH. For aFRR there is an agreement with the Albanian TSO OSTT. OSTT holds auctions on a weekly basis, Kosovo purchases its aFRR from Albania. Albania is in an advantageous position as they have 98% hydro and are thus a regional powerhouse of auxiliary services. However, KOSTT states that it is possible and recommended to have national sources for aFRR. For mFRR, the TSO in Albania organizes the auctions with their conditions. Kosovo then purchases from them. The BESS would participate in Kosovo's market. Sometimes around 250 MW per hour are required which one company would have to push or take all. If 30% of the generation capacities fall out at night, all this energy needs to be provided at once. For aFRR, currently 40 MW are needed. Future agreements could allow for Kosovo to provide this within the country. Important is to make sure that the capacities can be absorbed in Kosovo.

Currently, Kosovo pays for reservation and for utilization. For FCR, there are no auctions because the generation provides it for free. It is also not planned to organize any auctions. KOSTT is not convinced that KEK really has zero flexibility. But the issue is that KEK is used to generating as much as possible which is not the case anymore and hence causes problems as it still operates the same way. While KOSTT does discipline market participants, this is an ongoing issue. Kosovo's power system is not big, only 5-6 MW of FCR are needed. In the big BESS project, aFRR will in future be provided by KOSTT. Arbitrage will also indirectly contribute to balancing the system and mitigate the issue. However if 250 MW are out of the system, there will still be a problem. The implementation of this BESS project will significantly alter the business case for other batteries. However, the planned increase of RES to 1450 MW will also entail increased needs for aFRR with around 60-65 MW. Also, KOSTT will start auctions once there other market participants and are obliged to do so to ensure fair market conditions.

Cross-border trading is not intended for balancing, only with Albania since they are part of the same LFC block. The 170 MW project is entirely funded by the US government and is planned for completion in 2026-2028. As a firewall between the system and the market, KOSTT still has to organize auctions and communicate with the market to ensure that other companies can also participate, even though the system operator owns a battery. There is a very narrow path in legislation: KOSTT went to the market with a call for aFRR, however no-one expressed interest and thus the alternative was to implement this battery project. The intention is however not to mess with the market but select the best offer once other market participants have joined. For arbitrage, the grid fees are just like those for generation. This is currently in development, thus KOSTT cannot provide any further information. In the legal framework, no major complications are evident. The 170 MW BESS is a project of national interest and thus all efforts aim at addressing any problems in the most effective way. On the policy framework KOSTT does not have that much information. One month ago the Board of the newly founded company which will operate the other share of the BESS intended for arbitrage was nominated (ESCRO). The 170 MW project will have significant impacts in the short-term, in the mid- and long-term however the situation is different and will also offer business opportunities since the generation is increasing and thus advanced procedures will be necessary. It is a very important project because the pressure to act in terms of balancing is major. For the utilization rates of aFRR they have to check with the system operation department.

Interview 2: ERO

Line number	Transcript
26-33	Because we have to fulfill the energy community secretary obligations in transposing the energy package. So it's quite urgent for us. So that issue regarding the fact that the battery storage was not mentioned in our legislation now is sorted out and it is mentioned in our renewable energy law and it will be part of the law on electricity as well. Based on that of course we will have to amend, which we already did, amended the market rules last year. We have to amend now all the secondary legislation which derives from the primary legislation. Of course we have nine months to do that after the laws are approved in our parliament. So within nine months all the existing secondary legislation will have to be amended.
46	There are no legal barriers that will prevent the private sector to invest in energy storages.
63-64	On the other hand, with renewable energy sources rising, we need energy storage. It will be necessary for us to have at secondary reserve is about 45 or 47 MW.
68-73	According to our national energy strategy, 2031? That's our goal. To have at least 600 Megawatts of solar energy. Solar and wind? Dual generation, sorry. 2 times 600 megawatts solar and wind. *And you would estimate that secondary reserves of around 100 MW would be required to balance the system?* Yes, to balance the system.
76-80	We have an agreement with Albanian TSO because many times we announced the option for purchasing this AFRR but there were no TSOs interested on this kind of auction, so only Albania responded and we have an agreement with them. We have an agreement, until now it was 25 MWh per hour, now we have increased that to 40 MWh per hour. For the automatic reserve.
94-95	We recently approved the maximum allowed revenues and they requested for about 62 euros per megawatt.
115-117	We don't have a market for primary frequency control. It's the responsibility of the generator. According to our legislation, the primary frequency restoration is the responsibility of the generator
124-125	Now, first of all, we have to explain that together with Albania we are in one block. Regulation, yeah. How do we call this? A balancing block? A balancing block.
128-129	So, if our traders here buy, purchase the energy on Alpex, that includes the interconnection capacities, But sometimes it will make things complicated for a TSO.
138-140	Now, we didn't explain that according to the agreement that they had with MCC, the total capacity is 170 megawatts, which 45 will be used for TSO and the other 125 megawatts will be used for arbitrage.

168-174	Privileged producers that use energy storage technologies and consequently store electricity produced may benefit from the support scheme established by this law at the time of its scheduled delivery to the grid. The privileged producer shall not use electricity drawn from the power system to charge the storage system. The transmission system operator shall provide to the renewable energy operator the related information required to offset the support scheme payment in accordance with this argument.
189-191	According to recently approved long renewable energy sources, I think the only way now is through the auctions. We recently have announced this auction for 100 megawatt of wind power.

Interview 3: Ministry of Economy

Line number	Transcript
13-16	Currently we are dealing with a second legislation framework. Some of them we have quite developed, some of them we are working on it, but as soon as we have a new one we are going to proceed further in order to complete this legislation framework with regard to the proceed further in order to complete this legislation for what we really want to address.
22-24	We will go to our obligation towards EU integration process, or let's say better, we are part of the signed energy community treaty. So we take the obligation as well to be aligned with the energy Acquis. So we report to the national target
32-36	And us as an implementation unit are responsible to develop the auction process, competitive process for auction of renewable energy sources. So based on energy strategy that we approved, we set 600 megawatts from wind and 600 megawatts from solar. So this capacity will be developed and will be constructed based on competitive procedures, so auction process.
53-58	That is one article 13 that mentions that energy storage. But this energy storage is for the privileged producer. Because a privileged producer is when you are selected as a winner on auction process, and you are eligible to be part of support scheme that you offer. And then this privileged producer that use energy storage, I'm just reading the article, if it's okay. So privileged producer that use energy storage technology and construct and store electricity produced may benefit from the support scheme established by the law.
73-75	But regarding the BESS battery energy storage and this capacity that we are going to construct, it will be so important to have this battery storage if we have a lot of renewable energy on the grid. So we need this kind of balancing on the system.
83-96	Always are, like everywhere. As well in in EU countries, we have a permission period around two years. So things like that, we have a situation like this, we have as well in Kosovo. But what we are trying to do is to create kind of one-stop-shop to support for our implementation of renewables, to simplify the process and speed up the process of getting the right license in order to have a

	necessary condition for further implementation. So this is in general. But what we are interested in as well, and as well the legislation, the main law on renewables create conditions are as well, how we, the main law on renewables, create conditions, are as well how we are dealing with not only with the so-called old approach in generation to generate electricity from renewable, but as well how we can involve communities like household sector and others to implement small and medium capacities for their needs. So in order to reduce the impact for electricity or to reduce the gap that we have already in terms of security of supply. Because not everything what is consumed in Kosovo in terms of electricity is produced in Kosovo. The rest is imported and the prices, one going to have huge impact in our tariffs.
111-113	This National Plan for Energy and Clima is still a draft. It's under the responsibility of Ministry of Environment and Special Planning. Maybe you will discuss about that.
176-178	But also this ALPEX that we have in Kosovo. But also this Alpex that we have with Albania and also they have this hydropower plant, a lot of them, so it's a good fit on our energy system. The cooperation with Albania is more or less needed in our energy system.
185-189	But being part of ENTSO-E we have to fulfil as well two criteria which are the primary and secondary reserves and these capacities batteries are going to contribute in that in terms of transmission while this 45 megawatts is going to be used for secondary reserves. Okay and for moment we don't have any secondary reserve. Okay and the primary reserves are covered by Kosovo A and Kosovo B currently.
225	*Do you see any perspectives for a market in Kosovo for procuring primary or secondary balancing reserves or capacities?* No, we didn't foresee this kind of activity so far.
242-246	The idea to open further market within the country and to be integrated with the other countries is to create much more competition in the electricity supply side. So that means better prices. That's why we agreed with Albania to create a power exchange, joint power exchange, but with the possibilities to be integrated with other PXs in the region.
260-261	But we have to have the obligation as well to provide within the country capacities in terms of storage. So, it is according to the directive which is 90 days. Three months.
284-286	We have these kind of three laws that are in a revision process. And we need to adopt as soon as possible, because when investors come, they want to have the same condition that they are in a member state or in our region, for example. So we need to follow the steps that member states is following.
295-298	Now we are dealing with the clean energy package. The possible changes are going to be in line with these directives related to the clean energy package. The targets are there. The commitments from our side are there. Just now, we have to implement and move forward in terms of implementation phase.

Interview 4: Ministry for Environment, Spatial Planning and Infrastructure (MESPI)

Line number	Transcript
4-7	We have in general our law special planning law and construction law. It's defined the capacities by megawatts. If it's lower than 10 megawatts, it's going to municipalities for permits. If it's higher than 10 MW, it's going to the Ministry. It's considered by law like a national interest, more than 10 MW. With batteries, we don't have any project, no. It's in process.
20-25	I think no. Permitting process, what a barrier can be, if it's this type of project are planned documents, spatial planning. But in any case, since 15 years we didn't develop new spatial plan of Kosovo. I think it's in process to develop and with spatial plan of Kosovo we can arrange all whatever it is the place to allow that. But for the moment, it needs to be in plans of municipality. For the moment. If it's in the plan, no problem. I think in three to five months can be issued permit. If it's in plan.
60-62	I think yes. I mentioned if we are going to invest in solar and wind, they need storage. If they don't have storage, it is very difficult to be positive, to win. Just in the middle of the day they can have full of energy, in the evening nothing. They need to balance that
74	We have lots of problems with disbalance.
84-86	Our role is just in energy efficiency buildings. Other things are in Ministry of Economy. But we coordinate with them, report to them. We have from time to time meetings with them.
140-146	I think batteries can help everywhere. How we are going to develop the system with renewable energy. It's batteries necessary even for if you have just private businesses, it's obligatory. What is the problem? If you build a huge plant with solar, if you have to invest in that, and in batteries, it's almost impossible for the moment. Just huge investors. Otherwise, it's very difficult. From my point, t's very costly.
130-137	I think this project of MCA, they can clarify, they do the rules, all the rules, how they can go. This case can be, we need to use that case to create rules if it's necessary separate rules for that. And for investors it's important to have a clear picture and the process to have a how to say how to apply the place if it's allowed or not and to standardize thinking is not wrong. In there in there how to say duties even to do trainings. In the time when they started to think about that, one of the components was to do training not just for us, but for all parties, Ministry of Economy, Environment Department, our Department, Inspection Department, and we will see how it's going.

Interview 5: KfW

Line number	Transcript
8-13	Now you must understand that in Kosovo, the energy sector has been centralized for decades, so to say. So policies, company structures, everything was developed under the structure, under one top-to-bottom approach, where all the energy sector revolved around only one single company that owned, or state owned, which owned all the assets, basically, from coal mines to generation of electricity to transmission line, distribution line, and supply.
41-43	While we have not worked with battery storage in Kosovo during the past years or ever, all the investments do need storage capacities. As I said earlier, the energy sector in Kosovo is quite inflexible.
48-50	So the MCC as it is currently working, probably you're going to meet them on the upcoming days, is working on a 200 megawatt battery storage system, which a portion of it will be managed by KOSTT for their operation, balancing operation, and another will be managed from a new entity which will be formed, which has been formed already.
59-76	I mean the initial project which is being covered by MCC has already laid the groundwork for new capacities of battery storage to be launched. So the framework and the policies which are needed are already there. Energy regulatory office has implemented many rules in which specify how the battery storage assets can be managed and should be integrated in the system. So for that, I think we're mostly set. What is a limiting factor, it is the fact that the Energy strategy and the National Energy and Climate Plan do not oversee for the upcoming 5 to 10 years, do not oversee new battery capacities being added to the system. So basically it is the 200 megawatt which is provided by MCC, where it was identified all the existing projects which already had funding, but no new project was identified as a possible investment opportunity. What it was overseen on the energy strategy and the national energy and climate plan, it is the new generating capacities in renewable basing and solar. And for those to be integrated then the need for new battery storage capacities may rise again and maybe it will pick up the interest of the private sector. While this private sector will usually tend to enter a market after it is secure enough. For them to enter this kind of market, they will probably need subsidies or they will need some form of agreement, either a PPA or something similar in which their investment can be predictable and secure enough for them to go. But as it stands now, there is no policy framework which supports the entry of the private sector on this specific sector, which is battery storage.
84-87	But apart from the feasibility study, then you need follow-up instruments which can support the investment on the battery storage, either that being like tender calls for battery storage or auctions, same as we had with Solar and Wind right now, or an instrument similar to those which can pick up the interest of the private sector to apply.

96-104	While it is a bit optimistic on generation capacities of renewables, in the other fields it does not diversify as much in terms of unidentified funds. So basically, it has chosen a bit of a safe path, so say, on its implementation, at least for some of the components, as it is for BESS. So basically, for a project to be mature enough and to be considered, to be picked up for investment, it needs to follow up a full process, entering the energy strategy, other sectoral strategies, then also being entered on a single project pipeline from the country and so on. So it needs to follow up all the necessary steps for the investors or for IFIs or DFIs to be interested in investing in the future.
113-123	But by any chance, if the thing comes for decommissioning either possible A and B, then a huge need for renewable energy to be entering the system would be there. And once that very flexible and very unpredictable energy is there, then you need to follow up infrastructure to make it stable enough, to make it predictable enough for the market to operate successfully. That can be achieved either through batteries or full in-market integration with other countries, either Lithuania, Hungary, Greece, North Macedonia, Serbia, or whatever, but you either need to be dependable on the other countries in the region to get the energy when you need, but also to send the energy when you don't need to send it away, or you need capacities which are battery storage capacities within the country in order to kind of soften that huge curve of production and demand, differentiating between the production and demand. So the need in the future, it will rise.
141-147	So the idea is for 2050 all the generating capacities at least once that's the association of the energy community and the EU, for all the coal generating capacities to be decommissioned, with 2030 as an intermediate target, some of the generating capacities being decommissioned. So yeah, the deadlines are coming. But for that to be done, still a lot more work is needed, especially in ensuring that you have a stable energy system, either with battery storage or having good integration with other countries in the region in which you can have access and soften the blow of removing some of the largest producing capacities.
152-154	Currently, the supply is basically done with a single supplier monitoring console. It is centralized with KEK being the largest supplier in Kosovo, having a few others which are certified by ERO, the regulatory office, but they are the single largest supplier in Kosovo.
174-176	I think so, yeah. ERO has already formed all the necessary regulations and rules in which the BESS can operate within the electricity market. That was done prior to the start of the investment of the MCC project.
191	I mean now we have a joint electricity market with Albania and there is an electricity market in which the energy is traded, in which electricity is traded.
210-212	The other section, regional market, it's already set up. The only problem is liquidity which the market itself is facing. And that can be solved with having BESS capacities, we'll just sell it when liquidity is needed a lot more.

224-233	I mean, the international obligation for sure to put Kosovo in a more thinking outside of the box. As I said initially, the whole electricity market for decades has been quite centralized. And the idea when they started thinking of building new generating capacities, the idea was to continue with the same tradition of having another coal power plant. So naturally, you would go to the easiest and cheapest option, which at the time used to be coal power plants, and to the ways in which you have easy access to resources. But the international obligation can be a strong motivation for countries such as Kosovo to follow another one that initial targets of 25% or even 20-20 targets in renewable were set, then basically Kosovo was forced in a way to launch new mechanisms which promote renewable energy.
262-267	I mean the battery storage project which already is existing is starting from one of the development partners which is MCA, which they have closely cooperated with the government of Kosovo that define the needs and how they can stabilize the whole electricity market in the long term once the base load generating capacities are out. They identified the shortcomings, one of the biggest one being no battery capacities, either from basic technologies or the others being available in the country

Interview 6: GIZ

Line number	**Transcript**
6-9	The thing is that the law on renewables has to have the secondary legislation in force in order to be fully operational. It was adopted last year and the secondary legislation is not yet adopted. So it means that the law itself, as it is now, is not fully implementable. So this creates a barrier because then the rules of the institutions really to take decisions, it is a little bit, I would say, hesitant, if I may say.
28-31	I assume that you've been told in the ERO about the call for solar PV that was last year and the call for the wind auction, both under auctions, when the government is providing PPA for 15 years and the investment should be a private investment, so it means that an investor can develop a project, it will have a guaranteed price for 15 years to sell this electricity to the Kosovo market and then after 15 years, 1-5, it will be able to operate in the private market.
46-56	The other thing is Kosovo energy sector, or let's say generation sector, is not very sort of flexible in terms of absorption because we are relying 90% on electricity generation from Lignite. So it means if we would have at midday overproduction from renewables, we will still not be able to reduce the generation from Lignite. Because you know how these thermal power plants operate. Especially these in Kosovo, which are pretty old and they do not have enough flexibility of reducing the production. When it's more generation from the renewables, so basically they are doing like flat production. And with that, they

	don't create a very, I would say, favorable condition for the renewables in Kosovo. So that's why some kind of studies would be sort of appropriate to make a load shift and transfer this generation from point when you have overproduction to the late afternoon or late evening when you have overconsumption in the country.
58-60	So basically during these peak hours we are obliged to import. And then this import is creating other problems with tariff, with social impact and energy poverty and not to go.
84-88	But Kosovo, I mean, honestly speaking, you know, a regulatory framework is not something that explicitly addresses the battery storage. Either storage technology. It means that when these regulatory frameworks were developed, This was like 2021, 22, 23. And it's 2019, 2020, and 2021. So it means that time, the battery stories were not sort of a topic that could, let's say, could be a technology solution for Kosovo
104-108	I mean the only I would say the legal barrier that currently exists is this municipal zoning map. Because we are locked for the moment. We would be developing this project since years later. But just because of this municipal zoning map we were not able to obtain the construction condition
141-145	*Even though the project is, I mean, kind of a public project in a way, right?* Because it's... Yeah, but I mean, if we want to look only in the logistics sector, it means that the application of batteries will not be hindered by obstacles in the regulatory framework. So it means it will be purely on the investors to decide what kind of technology we use. And but no, but the regulatory framework will not create any obstacles.
148-157	In the NECP, in the energy strategy of Kosovo, it is foreseen that by 2030 Kosovo should have 1400 MW of renewables installed in the country. So it means around 700 megawatt of the wind and 700 megawatt of solar. It could be like plus minus, you know, 100 megawatt to be more solar or more wind, but approximately they are aiming for half to be renewables from solar and half from wind. So it means in terms of potential, there are potential there are there because there is political will, there is strategic orientation of the country, there is sort of targets that needs to be met on the country level. With the current, let's say, development having only the auctions, personally, I think, it would not be possible to reach these targets, to have 1,400 MW of renewables, if the government thinks they do only the auction procedures.
175-178	Because even if the price of electricity will still be the same it means we still have to pay extra for the transmission. So it means having it here, this is my perception, it will be much more favorable for the country and also cheaper for the consumer.
190	*And it is stopped now?* It is stopped, yes. *Ah, because KOSTT earlier said that they don't know.* I am an unofficial, right?

201-205	Of course. I mean, the one that comes first in, for sure, it will be, you know, grabbing this potential because the others afterwards, I mean, the system will not need any more capacity for balance. So this will be for sure.
217-219	*For the balancing market for primary frequency control for FCR, it's currently I think all provided by Kosovo A and Kosovo B rates and that is planned to stay that way. Do you have any information on that?* Yes, exactly. *Okay, great. It is planned to stay that way? Do you have any information on that?* Yes, it will stay.
225-231	So basically until 2018 or 2019, we were somehow a regulated block with Serbia, but with political agreement, transmission system operator in Kosovo became independent transmission system operator, and then they signed agreement with Albania and they created this regulatory block, Kosovo and Albania. So it means for the regulatory part, Albania is very good because they do have hydro and they have quite a lot of capacities, let's say installed capacities on hydro. How much batteries will help the region, I mean, also depends on the development in other countries
248-250	Energy community is an instrument that supports all the Western Balkan countries plus all the members like Georgia and other countries, Ukraine, to sort of to, how to say, to transform or to align their regulatory framework with EU requirements.
320-321	I mean for the batteries, we are not doing it at all. But what we are doing, we are trying to support, well not we are trying, we are supporting quite heavily the mainstay of this red battery framework. Basically, I mean, GIZ itself is supporting more energy efficiency and renewables for self-consumption. So it means we are more focused on the demand side.