KOSOVO

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Energy storage options for the Republic of Kosovo

Most relevant possibilities and first analysis of regulatory situation in Kosovo

by Lukas Feldhaus, Besnik Haziri

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About the German Economic Team

Financed by the Federal Ministry for Economic Affairs and Climate Action, the German Economic Team (GET) advises the governments of Ukraine, Belarus, Moldova, Kosovo, Armenia, Georgia and Uzbekistan on economic policy matters. Berlin Economics has been commissioned with the implementation of the consultancy.

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Executive summary

Due to the growing deployment of renewable energy sources, particularly solar and wind, energy storage systems are gaining importance, as they can provide flexibility and energy security in an energy system dominated by renewable energy. The costs of renewable generation technologies are declining greatly, which in turn allows the international decarbonisation policies to become even more ambitious and demanding. Kosovo, which is on the verge of renewing its energy system and may introduce large amounts of renewable energy sources, would benefit from developing energy storage systems jointly with the new energy sources it is currently planning.

Different kinds of energy storage are available: it is possible to either store heat or electricity, store it via a chemical reaction, create new energy carriers, or store heat by heating up a well-suited material.

The main indicators to decide which type of energy storage to use are a) costs of installation and usage, b) how much energy a device can hold (in kWh) and c) how much power (in kW) can be pumped out at once. Additionally, it is helpful to assess how long it takes for a storage system to automatically discharge. An ideal energy system features a wide range of different energy storage systems, some for storing heat, some for electricity, some for very short storage, and some for seasonal storage, e.g., for storing heat energy from summer to winter. An overview over the qualities of different energy storage types, such as batteries, hydrogen, flywheels, and molten salt systems can be found in Table 1.

To install these systems, investors, project developers and authorities need clear guidelines what kind of energy storage is needed. Regulatory efforts to define what energy storage is, where it can be built, and by whom, would be helpful to foster first projects. In the medium term, a well-regulated energy market would also incentivise and remunerate power companies for installing and using energy storage systems.

1. Introduction

Energy storage systems can provide different types of services for an energy system, such as energy arbitrage and ancillary services. By storing energy in times of high supply and low demand, they can then release their energy during times of low supply and high demand. Thus, they can balance demand and supply from hour to hour, or even from month to month. Ultimately, all such services improve power supply to customers, make it more reliable and therefore also enhance the supply security of the two most important forms of energy: electricity and heat.

In Kosovo's energy sector, there are several areas for energy storage applications. First, energy storage would fulfil the requirements of the European Network of Transmission System operators (ENTSO-E) about so-called secondary reserves which can supply electricity within seconds after being called upon. Kosovo is a member of ENTSO-E and thus obliged to implement these requirements. Secondly, energy storage systems would also help to tackle the increased integration of intermittent renewable energy and enable peak load shifting at distribution level. Due to energy storage´s many applications, Kosovo will need to and benefit from setting up its own energy storage systems in the future.

Therefore, this Technical Note will provide a general overview of different technologies with the aim to shed more light on the most applicable solutions for Kosovo. For a quick overview and comparison of the different technologies, please see Table 1.

2. Different energy storage options

2.1 Electricity storage options

2.1.1 Pumped hydroelectric storage (PHS)

Pumped hydroelectric storage offers bulk electricity storage, as it can provide large capacity storage relative to other technologies. It is furthermore a technology that can provide both baseload power and balancing services, thus increasing grid reliability. PHS systems are large-scale energy storage plants where water is pumped to a higher level for storage during high renewable energy generation periods. When water is released from the reservoir, i.e., when electricity is needed, it flows down through a turbine to generate electricity.

Recent developments have made it possible to adjust the precise power output of PHS systems, finetuning it to the electricity grid´s demand. PHS facilities can operate in a closed-loop system, and thus are able to operate without being connected to a continually flowing water source. This offers the opportunity to use this technology in more locations.

As noted above, pumped storage hydropower is a mature technology, with round-trip efficiencies ranging between 70% and 84% and a long expected lifetime between 40 and 60 years[1]. It can usually provide around 10 hours of electricity (and could be designed even larger), compared to about 6 hours for lithium-ion batteries[2]. In terms of costs, according to the Electric Power Research Institute, the installed cost for pumped-storage hydropower varies between USD 1,700 and USD 5,100/kW. Energy storage capacity costs vary from USD 10 – USD 400/kWh. The large price variation apparently stems from the site-specific nature of the PHS technology, varying components of individual projects in terms of reservoir and other construction costs, as well as engineering costs. [3]

Nevertheless, the major constraints in the deployment of PHS lie in the scarcity of available sites, the high initial investment costs, and the long construction time, accompanied with environmental concerns, complex permitting procedures and the increasing public resistance to such large projects in general. These reasons impose significant risks on investors who tend to prefer the short-term recovery of investments.

2.1.2 Compressed Air Energy Storage (CAES)

In CAES systems, electricity is used to compress air at up to 1,000 pounds per square inch and store it, often in underground caverns. When electricity demand is high, the pressurized air is released to generate electricity through an expansion turbine generator. Simply said, the energy is stored in the form of compressed air. The main requirement for CAES plants are large-volume air reservoirs placed in appropriate storage caverns, usually in former natural salt deposits or depleted gas fields. When the compressed air is released from the reservoir, it must be heated. Due to the nature of the electricity

[1] Electricity Storage and Renewables: Costs and Markets to 2030; International Renewable Energy Agency, Abu Dhabi. Link

[2] Vahid Vahidinasab, Mahdi Habib: Energy Storage in Energy Markets, 2021. Link

[3] Fact Sheet Energy Storage (2019) White Papers, EESI. Link

turbine, this must be done with natural gas. Round trip efficiencies of this technology range between 42 and 54 percent. Although CAES has witnessed a lot of attention in the past few years, there are only two large scale plants operating, one in Alabama, United States, and one in Huntorf, Germany.

Energy installation costs for CAES are estimated to be around USD 1,200/kW for power output, and USD 50/kWh for energy storage, with an expected decline to USD 44/kWh by 2030. However, costs for the CAES technology are generally difficult to be estimated adequately because especially the engineering costs can vary a lot depending on the site and the environment-related constraints. Currently, few CAES projects are developed, as other energy storage technologies have greater investment prospects.

Given the fact that Kosovo currently has no natural gas infrastructure, this technology may not be suited for the purpose of energy storage in the current circumstances. Albeit it may be considered in the future should Kosovo opt to introduce gas supply to the country.

2.1.3 Flywheels

Flywheels are another type of energy storage technology. The electricity accelerates a large wheel ("flywheel") which stores the energy kinetic rotational energy. The spinning force of the flywheel can then be used to power a generator, whenever necessary. To increase their efficiency and reduce drag, some flywheels turn in a vacuum and have magnetic bearings, thus spinning without physical contact to another object. Their speed can reach up to 60,000 revolutions per minute[4].

It is worth noting that this type of technology is not suitable for long-term energy storage, not even for medium-term applications. This is mainly attributed to its high energy installation costs ranging from USD 1,500 to 6,000/kWh, and to a high self-discharge of up to 15% an hour[5]. However, flywheels´ application is proven effective for load-levelling and load-shifting applications. Furthermore, they have a long-life cycle, high-energy density, low maintenance costs, and quick response speeds. Like other storage systems, this technology is expected to face further price decreases in the coming years, reaching price levels between USD 1,000 and 3,900/kWh[6]. Upfront costs per energy storage capacity are even higher, though, estimated at more than USD 9,000/kWh.

2.1.4 Batteries

Like common rechargeable batteries, very large batteries can store electricity until it is needed. These systems use lithium ion, lead acid, lithium iron or other battery technologies.

Stationary Battery Energy Storage Systems (BESS) have become a crucial solution to the effective integration of renewable energy sources into the power system. Battery systems are typically connected to distribution or transmission networks, or to a renewable energy generator itself. With a continuous increase of renewable energy sources, the BESS will be in even higher demand, as they are able to offer important ancillary services for system operators, such as frequency regulation, flexible

[4] K.R. Pullen, A. Dhand: Flywheel Technology. Link

[5] Electricity Storage and Renewables: Costs and Markets to 2030; International Renewable Energy Agency, Abu Dhabi. Link

[6] Electricity Storage and Renewables: Costs and Markets to 2030; International Renewable Energy Agency, Abu Dhabi. Link

ramping, or black start services. Because of this, the recent years have experienced a fast growth of these storage systems as well as rapid cost declines[7]

Battery Energy Storage Systems are available at different storage capacities ranging from a few megawatt-hours to hundreds of MWh or now even more[8]. They come in different technologies, such as lithium-ion (Li-ion), sodium sulphur and lead acid batteries. Currently, the most distinguished types of technologies from a commercial perspective are Lithium-ion (Li-ion) and Vanadium Redox Flow (Flow) batteries.

Lithium li-on batteries

As noted in the table below, lithium li-ion batteries have a round trip efficiency typically above 85%, and discharge times ranging from 1 min to 8 hours. They have become attractive to electricity providers as they can have a wide range of power ratings, available for toys, electric vehicles, and utility scale power systems of up to 100 MW.

Lead-acid batteries

Lead-acid batteries are characterized to have similar features to lithium li-on batteries with a round trip efficiency ranging from 80 to 90% and discharge times from 1 min to 8 hours. Although they are the oldest battery and easily recycled, they are very heavy and with relatively low energy density making them unsuited for grid storage[9].

Flow batteries

Flow batteries can also be available at maximum power ratings of up to 100 MW and have a discharge time of several hours as well, albeit with a somewhat lower round trip efficiency ranging from 60 to 85%. They are well-suited for continuous power supply and considered to be an alternative to li-on batteries[10].

2.1.5 Hydrogen

Using hydrogen as an energy storage material is again gaining momentum, after having failed to deliver on its promises in the 1930s and 1970s. This time hydrogen production and storage technology might be mature enough to sustain its usage in worldwide energy systems.

Hydrogen´s large advantage is that it can be stored over several months with only limited loss of energy. This usually is one of the main drawbacks of battery storage. However, the efficiency of turning electricity into hydrogen via an electrolyser and then back into electricity via a gas power plant or a fuel cell is quite low (between 30-40%)[11]. Also, high upfront investment costs of several thousand USD per kW of output capacity render hydrogen storage only worth financing if the attached power supply almost continuously transmits its output to the hydrogen storage facility. Costs per energy storage are

[7] Global Research UBS: Q-Series Redux Energy storage – an accelerator of net zero target

[8] Electricity Storage and Renewables: Costs and Markets to 2030; International Renewable Energy Agency, Abu Dhabi. Link

[9] Electricity Storage and Renewables: Costs and Markets to 2030; International Renewable Energy Agency, Abu Dhabi. Link: www.irena.org

[10] Fact Sheet - Energy Storage, EESI, Link

[11]Energy Storage Association, *How energy storage works*, Link

lower (USD/kWh). Yet, if electrolysers run idle, they are currently still too expensive even for wealthy countries like Germany or the US[12].

Finally, large-scale hydrogen storage of 100 GWh is theoretically feasible in large salt caverns. However, this idea has not yet been realised. Currently, only small amounts of hydrogen (a few MWh) have been stored in metal tanks[13].

2.2 Heat storage options

There are two types of thermal energy storage: one using solid materials and one using liquid materials. Solid materials can usually store far higher temperatures, but the technology is also less mature than the one using liquid materials[14]. While solid thermal storage is better suited for industrial applications requiring high temperatures, liquid storage is perfectly usable for storing heat for district heating and electricity storage purposes. Stored heat energy can be used both directly in the form of heat or for producing electricity in a small generator.

The best available technology for storing heat is the molten salt energy storage. Such facilities usually comprise two large tanks of which one stores the hot (up to 385°C) and one the cooler salt (ca 290°C). Since salt is cheap, costs for such a type of energy storage are low (between USD20-60/kWh)[15]. The first proof of concept was in Spain in 2008 in combination with a concentrated solar power plant. Since then, hundreds of similar facilities have been built. Molten salt storage systems are proven to store up to 1600 MWh of heat energy, with a maximum output rate of ca 50 MW (upfront costs ca. USD400-1,200/kW). Molten salt storage loses 1-5% of heat energy per day[16].

Thermal energy storage can both be inter-seasonal or for flexible use. It can provide bulk power of several dozen MW for many hours.

New and upcoming thermal energy storage technologies include latent heat storage (using the energy needed for the phase shift of different materials), thermochemical storage (using the chemical bonds between atoms) and new solid-state heat storage. In the latter, future thermal energy storage systems might consist of hot sands through which a liquid is sent to gather the heat and transport it somewhere else. There also exist storage systems just for storing hot water for district heating. These systems can store more than 1500 MWh.

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[12] Frink P., 2018, *Hydrogen Energy Storage Study*, US Trade and Development Agency, Link

[13] Energy Storage Association, *How energy storage works*, Link

[14] US Department of Energy, 2020, *Energy Storage Handbook, Chapter 12,* Link

[15] Brun K. et al, 2021, *Thermal, Mechanical, and Hybrid Chemical Energy Storage Systems, Chapter 3*, Academic Press, Link

[16] Riccardo Battisti, 2018, *Molten salt storage 33 times cheaper than lithium-ion batteries,* solarthermalworld.org **Link**

3. Comparison of key technology indicators

There are various aspects to consider when selecting the best-suited energy storage technology. Typically, the most relevant indicators are:

- Cost per kW (MW): the upfront ("overnight") cost of the system divided by the instantaneous output power rating of the system, or USD/kW.
- Cost per kWh (MWh): the upfront ("overnight") cost of the system divided by its projected energy output. The appropriate unit of measure is USD/kWh.
- Lifetime,
- Efficiency
- Potential storage time (seasonal vs short-term storage)

The International Renewable Energy Agency (IRENA) has developed a spreadsheet-based "Electricity Storage Cost-of-Service Tool" (available for download here). It is a simple tool that allows a quick analysis of the approximate annual cost of energy storage service for different technologies in different applications. It is not a detailed simulation for investment decisions but allows to identify some of the potentially more cost-effective options available. These could then be subject to more detailed analysis of their suitability for the specific application, their performance in given the real-world operating conditions of the application and their relative economics.

The list below provides information on technologies that can currently provide large storage capacities (of at least 20 MW).

Table 1: Key energy storage indicators of different energy storage technologies

	Typical power ratings (MW)	Typical storage size (MWh)	Lifetime	CapEx: USD/kW	CapEx: USD/kWh	Round-trip efficiency	Seasonal or short-term
Pumped Hydro	50-3,000	500-20,000	30 – 60 years	500-3000	10-400	70 – 85%	Both
Compressed Air	1,000	500-2,500	20 – 40 years	1,218	22-29	40 – 70%	Both
Flywheel	1-20	0.1-5	20 - 30 years	2400	9600	70 – 95%	Short-term
Li-Ion Battery	1-100	10-1000	< 15 years	196	338	85 – 95%	Short-term
Lead-acid Battery	1-20	10-100	6 – 40 years	300-600	200-500	80 – 90%	Short-term
Flow Battery	0.5-20	5-120	5 - 30 years	1,717	252	60 – 85%	Short-term
Hydrogen & Fuel Cell	< 50	100s of MWh (Practice until now: <10 MWh)	10 - 15 years	3,000-7,500	100-200	30-40%	Both
Molten Salt Thermal Energy Storage	50-100 (thermal or electric)	1,500 MWh	20 years, 10,000 cycles in total	400-1200 (USD/thermal kW)	20-60 (USD/thermal kWh)	Heat to electricity: 40% As CHP: 80-90% Roundtrip electricity to electricity: 25%	Both

Sources: Energy Systems and Energy Storage Lab, Lazard, U.S. Department of Energy; Multidisciplinary Digital Publishing Institute (MDPI)

4. Regulatory and policy framework

Even though energy storage systems have gained in popularity, particularly battery energy storage systems, they have not yet reached their full potential as key components in the energy transition. The wide support for their deployment in light of the growing integration of intermittent energy sources into the grid has been countered and somewhat weakened by the inconsistent regulatory framework arrangements among the EU Member.

The new legislation within the framework of the "Clean Energy for All Europeans" package aims to settle the confusion and enhance the use of the energy storage systems. More specifically, the so-called "Fourth Energy Package" around EU Directive 2019/944 aims to remove obstacles and barriers pertaining to energy storage systems in the EU. It establishes common rules for the generation, transmission, distribution, energy storage and supply of energy with a view to creating truly integrated competitive, fair and transparent energy markets in the EU[17].

Kosovo, on the other hand, has adopted its energy primary legislation in 2016 in compliance with the Third Energy Package, and as a signatory party to the Energy Community will now need to implement the requirements set in the Fourth Energy Package. However, the current primary legislation covering the energy sector does not contain any stipulations or provisions in relation to energy storage systems. Furthermore, the Energy Regulatory Office (ERO) is not legally able to approve pertinent rules and regulations.

Under these circumstances, Kosovo can only rely on the Energy Community Secretariat's Policy Guidelines issued in September 2020, which among others, provide recommendations for all Contracting Parties: It recommends that all parties should remove any technical barriers to non-discriminatory connection and access of self-consumer installation to the grid, including those with energy storages[18].

In going forward, the relevant provisions and measures will need to be embedded into the primary Kosovar legislation. As the path towards transposing the Clean Energy for All Europeans could be considered long under the given circumstances, it might be appropriate to include special provisions for energy storage systems in the framework of the upcoming Renewable Energy Sources Law.

Once this is accommodated into the national policy level, the regulatory body, the Energy Regulatory Office (ERO) will be able to start drafting and implementing a clear set of rules and responsibilities to incentivize the greater use of energy storage systems.

These rules will need to address technical and financial aspects. For instance, on the level of self-consumers with energy storage installations, the Energy Regulatory Office should ensure that all of them are allowed to be connected at all voltage levels in line with the pertinent connection rules and after the technical conditions have been met. Secondly, network tariffs should factor in the long-term support which storage systems offer to the grid. In this regard, the regulator should ensure that self-consumers with an energy storage installation cannot be double charged, e.g., by issuing network charges for stored electricity remaining within their premises. These and many other aspects, including

[17] DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, Link

[18] Energy Community Secretariat, 2020, Policy Guidelines on Integration of Renewables Self-Consumers, 2020

ownership issues at the level of the utility-scale energy storage systems, must be treated properly and thoroughly by the Regulator[19].

[19] DIRECTIVE (EU) 2019/944