In the past, the electricity generation mix relied almost exclusively on fossil fuels, nuclear and hydro, and variability of generation was not a major challenge. In that context, energy storage (essentially pumped hydroelectric storage, accounting for 96% of global installed capacity today) contributed to the operation of the electricity system based on the technical and economic grounds of arbitrage, storing electricity during low electricity demand and releasing it back into the grid during high demand, typically over a daily cycle.

Our commitment to decarbonisation will require a deep transformation of all the sectors of the EU economy. The energy sector in particular is confronted with major challenges as well as unprecedented opportunities for modernization.

With the “Clean Energy for All Europeans” package, the EU has put in place the strongest regulatory framework worldwide to enable the transition towards a clean energy system. With the 2030 EU targets for energy efficiency (32,5%) and renewable energy (32%), it is expected that the EU will actually be able to reduce its CO2 emissions by 45% by 2030, well beyond the 40% Paris agreement commitment. The share of renewables will increase more sharply in the electricity sector, where it could reach already 55% by 2030 and more than 80% by 2050, with a strong predominance of variable renewable sources, in particular wind and solar. A cost-efficient integration of growing shares of variable RES in the wider energy system will be key to a successful energy transition and economical operation of generation assets and will require several instruments of flexibility. Storage will be key in this context.
With the increasing decarbonisation and decentralisation of the energy system, energy storage will contribute also to enhance security of supply at national and at regional level.

Electricity storage would play an increasingly prominent role according to all decarbonisation scenarios modelled for the analysis supporting the EC long-term decarbonisation strategy “A Clean Planet for All”\(^1\): in 2050, the total (stationary) storage explicitly used in the power system (i.e. hydro-pumping, stationary batteries and chemical storage) ranges from some 250 TWh to 450 TWh (from approximately 30 TWh today).

Conventional storage technologies like pumped hydro but also batteries (either for stationary or mobile applications) will definitely be very important actors in the low carbon energy transition. For batteries, we have seen reduction of costs of the range of 65% over only five years. A number of analysis also anticipate a need for deploying new types of electricity storage, using in particular hydrogen and derived chemicals (ammonia, e-gas). A recent IEA study points to the fact that if we speak about curtailed electricity, compressed hydrogen storage may be competitive and avoid curtailment already for a discharge time of 20 hours. Many other studies point to the fact that for long-term storage hydrogen will be the most cost effective option. In addition, hydrogen produced from renewables through water electrolysis represents a great potential to support sectoral integration, allowing renewable electricity to be used in other sectors, including the storage of electricity also as another energy carrier (i.e. in the form of gas, liquids, heat) for later use.

Storage is anchored in different provisions under the Clean Energy Package. The definition of energy storage in the Electricity Directive\(^2\) extends the concept of energy storage from power-to-power to power-to-gas and power-to-heat, thus including the storage of electricity also as another energy carrier (i.e. in the form of gas, liquids, heat) for later use.

Other changes in the electricity market design put a higher value on flexibility mechanisms including energy storage. Energy storage is now covered both in aspects related to functioning of energy market and in relation to the planning work of Transmission System Operators (TSOs) and Distribution System Operators (DSOs). The access to grid connection should be ensured in the same way as for other flexibility solutions by the grid operator. Market, regulatory and administrative barriers to installation and operation of storage facilities should be removed. In the context of participation in the energy markets, a level playing field for storage should be established among storage operations across EU.

In terms of security of supply, the regulation on risk preparedness in the electricity sector\(^3\) requires Member States to develop measures avoiding electricity crisis situations. Such measures include also the use of the different kinds of storage. Another priority of the Clean Energy Package is to empower customers to become active in the market by generating and consuming, storing or selling electricity. The provisions in the Electricity Directive provide a general framework for all active customers (including industrial customers) that sets the general rights and obligations, whereas the recast Renewable Energy Directive\(^4\) puts in place the provisions defining for the first time in the EU legislation a specific group of active customers – the renewables self-consumers.

While the EU is technology neutral in its policies, the various energy storage technologies will provide services based on capacity and location, and would be able to compete on a level playing field on all markets, based on their respective merits. Energy storage can support a better integration of renewables and decarbonise required backup capacities, avoiding in this way lock-in effects of some fossil fuels solutions and differing the need for other investments in capital intensive and environmentally challenging infrastructures.

To tap the potential of energy storage as a key actor of the clean energy transition, it is now priority to implement the Clean Energy Package and make sure that storage is adequately addressed in all the relevant fora (such as the Madrid Forum and the Florence Forum) as an integral part of the energy market. Additional opportunities come from Member States’ integrated National Energy and Climate Plans, which should specify for example national objectives and measures with regard to increasing flexibility of the energy system and to the non-discriminatory participation in the market.

In October 2017, the EC announced the European Battery Alliance, with the aim to create a competitive, sustainable battery-manufacturing value chain in Europe. One of its main outcome was the Strategic Action Plan for Batteries (adopted on 18 May 2018), including measures on the supply of raw materials, R&I, skills, the regulatory framework.

Together with the right regulatory framework, research and innovation (R&I) is also essential to accelerate the clean energy transition and bring new promising technologies to the market. The Commission recently set up the Technologies and Innovation Platform Batteries Europe, which will consolidate the industrial basis for batteries in Europe and constitute the R&I stream of the Battery Alliance. The EU is also contributing EUR 646 million to the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) for the period 2014-2020.

\(^1\) Directive 2018/844/EU of 28 June 2018 establishing a framework for the deployment of the energy Union and amending and subsequently repealing Directives 2009/72/EC and 2013/30/EU.


\(^3\) Directive 2017/2127 of 15 December 2017 on security of supply.

supporting research, technological development and demonstration activities in hydrogen-based technologies in Europe. Other energy storage technologies are also supported by the Horizon 2020 EU framework programme.

Europe is already leading in key technologies, such as renewables and green hydrogen production. The clean energy transition is not only a commitment to invest into the future of our planet, but also an opportunity to strengthen and modernise Europe’s economy. Supporting the uptake of storage technologies will allow us to seize this opportunity.

1 COM(2018) 773
2 Directive (EU) 2019/944
3 Regulation (EU) 2019/941
SMART GRID DEMONSTRATION PROJECT WITH HYBRID BATTERY ENERGY STORAGE SYSTEMS (BESS)

WOJCIECH LUBCZYNSKI POLSKIE SIECI ELEKTROENERGETYCZNE

INTRODUCTION

The significant increase in renewable energy generation changes how the power system operates and causes numerous challenges to be solved. Network operation and security of supply are subject to new threats coming from intermittent generation. These challenges can be supported by the use of advanced grid automation, such as SPS system (Special Protection Scheme), and thus preventing overloading the network. The problem also can be mitigated due to the use of energy storage systems. The energy storage today requires high capital costs, but it should be expected that there is a tendency to constantly lower prices for energy storage installations. Energy storage technologies are developing quickly and more efficient technical parameters are expected (higher energy and power density, longer durability, higher round trip efficiency, etc.). These changes and the expected reduction in prices will result in broad implementation of energy storage in electric power systems.

PROJECT BACKGROUND

Polskie Sieci Elektroenergetyczne SA (PSE) actively supports all activities for the development of electricity storage applications. Combining energy storage and renewable generation sources will result in better management of the power system. Therefore, PSE initiated cooperation with Japanese and Polish companies as part of a demonstration project that focused on the implementation of the SPS system together with battery energy storage system installed at the BYSTRA wind farm belonging to ENERGA WYTWARZANIE SA. The demonstration project was preceded by a feasibility study that confirmed the economic justification of the designed solution in the long-term perspective.

Owing to the expansion of wind generation has been strongly concentrated in the northern part of Poland, the project partners are ENERGA-OPERATOR SA and ENERGA WYTWARZANIE SA operating in the area as indicated in Figure 1.

In the framework of cooperation in the field of energy policy between Polish Ministry of Energy and Japanese Ministry of Economy, Trade & Industry, the following parties: Hitachi, Ltd., Hitachi Chemical Co., Ltd. on Japanese side and PSE, ENERGA-OPERATOR SA and ENERGA WYTWARZANIE SA on Polish side decided to start a demonstration project that is aimed at developing a solution that would allow efficient network control under the influence of the growing share of renewable energy sources and support its balancing needs. The project will also test ancillary services supported by battery energy storage.

The project started in March 2017, and the project is set to end by September 2020.

It is important to emphasize that the project is supported financially by Japanese governmental agency New Energy and Industrial Technology Development Organization (NEDO), and all assets created as part of the project will be transferred to the Polish parties after the end of the project.

THE SOLUTION (ARCHITECTURE OVERVIEW)

The demonstration project consists of two parts: SPS system and Hybrid BESS.

SPS System

The SPS system is intended for use in areas with no extensive transmission and distribution network and with a significant amount of renewable energy sources.
The use of working on online SPS system allows to avoid preventive curtailment of wind farm that may be inefficient. With the SPS system, automatic reduction of wind farm generation allows to protect the network against the overloading of transmission and distribution lines during identified congestions.

The SPS system plans remedial actions for specific contingency cases in the power network based on the online measurements obtained from the SCADA system and state variables obtained from PSE’s state estimator (EMS). If the overload has been identified, the SPS system carries out automatically control orders to the wind farms in the area of the project and to BESS in order to keep power flows within secure limits. The idea of this is shown in figure 2.

Figure 2 The presentation of the operating concept of the SPS system

SPS demonstration system automatically dissolves overloads caused by grid fault by curtailing windfarms and/or charging BESS. High-speed and appropriate remedial actions based on the online analysis enhances the security and reliability of the power system. SPS is equipped with DSS (Decision Support System), which also operates in online mode but without sending control orders to wind farms. The DSS mode covers the entire area of the Polish power system and includes all types of generating units.

HYBRID BESS

The project will use a hybrid energy storage system that is intended to achieve both high-performance, thanks to the utilization of lithium-ion batteries and also cost-effectiveness through applying lead-acid technology.

The project encompasses advanced grid automation and application of hybrid (lead-acid & lithium-ion) battery energy storage (6MW, 27MWh), thus enabling testing and application of new measures that provides operators with grid flexibility and at the same time increasing its stability.

The objective of BESS installation is to demonstrate usage of lithium-ion and lead-acid batteries and to evaluate the possibilities of its wider adoption in the following scope:
- power system protection against overload on transmission and distribution lines;
- energy storage in high wind generation conditions;
- testing and provision of standardized balancing system services for transmission system operator:
  - Frequency Containment Reserve
  - Frequency Restoration Reserve
  - Restoration Reserve
- testing and provision of services for wind farm owner:
  - curtailment of short-term fluctuations in wind farm output
  - price arbitrage (electric energy time shift).

Examples of services tested in the project are shown in Figures 3, 4, 5 and 6 below.

Frequency Restoration Reserve (FRR) ancillary service (BESS functionality implemented on the basis of control orders from Load Frequency Control system transmitted via the SPS system).

Figure 3 An example of the provision of FRR service
Replacement reserve (RR) service, similar to those provided by pumped storage hydropower plants (BESS functionality on the basis of TSO dispatcher’s control orders sent from the SPS system).

curtailment of short-term fluctuations of wind farm output (BESS functionality).

Price arbitrage (BESS charging at a time when electricity prices are low and discharging at a time when electricity prices are high).

The architecture of the solution in the demonstration project is presented in Figure 7:

THE BENEFITS OF THE PROJECT

In the scope of the demonstration project:

- Gathering experience from the implementation and usage of the SPS class system and BESS;
- The possibility of a simple extension of the territorial range of the SPS system increases the security of the grid, especially in case of high wind energy generation;
- Optimal elimination of overloads, and reduction of costs of potential compensations for wind farm owners (in case of curtailments);
- The possibility of testing the BESS functionalities;
- The possibility to assess BESS technical abilities based on the ancillary services provided;
- The possibility to examine the integration of BESS with wind farm;
- The possibility to evaluate a business model for BESS application in Polish market conditions.

Despite its initial phase, the project revealed various legal, economic and technical barriers. As a result, Ministry of Energy, which supervises the project, initiated legal changes in the Energy Law. The adoption of new regulations will create legal basis for future projects involving electrical energy storage installations.

THE CURRENT STATE OF THE PROJECT

As for July 2019, the SPS system is installed and tests are underway. After successful testing, the monitoring phase of the SPS system will start.

In the case of BESS, the construction of the building has been completed and assembly work is currently underway for individual components of the battery.

The official launch of the entire SPS system and BESS is scheduled for the end of September 2019.
EUROPEAN BATTERY ALLIANCE
A EUROPEAN INDUSTRIAL POLICY CASE

DIEGO PAVÍA CHIEF EXECUTIVE OFFICER EIT INNOENERGY

The European Energy landscape and especially its electricity dimension, is undeniably going through a profound transformation characterized by several trends, namely decarbonization, which also entails electrification of some energy usages, decentralization, sector coupling, and digitalization.

Although these trends are pointing into various directions, there is a common ground: the core role to be played by flexibility in the future energy system. In addition, the rising policy, regulatory and political developments regarding CO2 emission standards for light-duty vehicles and trucks have put more and more pressure on the internal combustion engine technology.

In light of this view, the context is very prone to the development of electrified mobility and explains the fierce global competition of lead Li-ion battery storage, which is the essential technological bloc at the crossroad of electrified mobility, penetration of renewables, and decentralized energy system. Facilitated by the plummeting cost of batteries, this also explains the hockey-stick rising trend of Electric Vehicles (EVs) that have been already observed over the past few years, which seems to be at its infancy (see Figure 1).

Battery cells are sometimes considered as a commodity, implying that sourcing would be largely driven by the price. However, a battery cell is not a commodity: the performance not only depends on the type of cell (such as the chemistry or the design), as the quality of the manufacturing process and the advanced materials employed could also impact its use.

For this reason, battery cells cannot easily be sourced anywhere as commodities. For complex products like EVs, where the battery itself could represent a quarter to a third of the final commercial value of the product, there is a clear incentive for manufacturers to have, at least, a geographical proximity with their cells’ suppliers. Thus, there is no doubt about the strategic imperative to develop domestic manufacturing capacities.
of sustainable batteries in Europe in this context of unstoppable electrification of mobility. This is essential to support the European automobile industry and thus to maintain the corresponding direct and indirect jobs. It is, however, also an industrial opportunity to strengthen the competitiveness of Europe and facilitate the overall energy transition, leveraging technological excellence and a strong industrial base on the European soil.

The European Battery Alliance (EBA) officially launched by Vice-President Maroš Šefčovič, who is in charge of the Energy Union in October 11th, 2017, intends to act as a call addressed to the European industry to seize the opportunity of a technology (batteries) that will be at the core of the energy transition. The main goal of the EBA is indeed to create the necessary momentum to support the European Industry in the field of safe and sustainable batteries which could amount to €250 billion of the annual European market by 2025 (that covers the needs all along the value chain: power, transport, and industry). This is to further make European champions emerge as a credible alternative to North American and Asian players and to eventually avoid the risk for Europe to become fully dependent on foreign batteries.

Following up the political launching of the EBA, Vice-President Šefčovič gave a mandate to EIT InnoEnergy to mobilize and steer Industry towards the delivery of first recommendations by enabling framework conditions to create a pan-European and cross-sectoral batteries ecosystem, capable of converting a technological leadership into competitive products and services. These recommendations formulated by the so-called EBA@250, the industrial workstream of the EBA led by EIT InnoEnergy, notably contributed to the Strategic Action Plan on Batteries issued by the European Commission in May 2018.

In practice, this process thus gave birth to a reinforcing and growing industrial ecosystem of stakeholders coming from the entire battery value chain and driven by the shared ambition of making Europe one of the major stakeholders in the Batteries sector in the coming years (see Figure 3).

On their side, European car manufacturers have made clear their strategic move towards EV. Among the various statements, e.g. Daimler, which will electrify 25% of its fleet by 2025; BMW will electrify 15% to 25% of its fleet by 2025, Volkswagen expects to sell 2 to 3 million EVs by 2025, Peugeot wants to shift 80% of its models to electric by 2023, and Jaguar expects to sell 50% of EVs by 2020. All in all, while more than 4 million EVs were sold in 2018, BNEF forecasts that 28% and 55% of global annual sales of light-duty vehicles will be EVs by 2030 and 2040 respectively. From a globalized economy’s perspective, although Asian players seem to dominate the market with companies like LG Chem, Samsung or Panasonic from the manufacturing side, and OEMs such as BYD, Europe is quickly ramping up, with new European (like Northvolt) and foreign (like LG Chem, Samsung or CATL) investments being announced at a quick pace.

Beyond the positive signal, these investments are sent to the outer world. It will also probably contribute by creating domestic jobs, as manufacturing has indeed become a fairly high labor intensity (21 jobs per m€ of Value Added for manufacturing in general, and 19 for manufacturing of motor vehicles1). Analysts and observers forecast more than 1100 GWh of global manufacturing capacity of Li-ion battery by 2028, with 207 GWh (around 18.8%) in Europe (versus 13.4% in the USA), which is a different picture compared to the situation a few years ago (see Figure 2). According to analysts, the European manufacturing capacity of Li-ion battery (207 GWh by 2028) may be insufficient to match the EV battery demand from Europe, which is forecasted at 400 GWh by 2027. So, there is room for massive industrial investments that will create related jobs, with no tangible risk of over-capacities in Europe.

The EBA initiative has also remarkably helped to identify the main efforts made in Europe. It has created a suitable condition to align, mobilize, orchestrate and provide extra visibility to the full set of EU tools and instruments in the hands of the European institutions, from regulation, such as via the eco-design and battery directives, to Research & Innovation activities (i.e dedicated calls in H2020, creation of a European Technology and Innovation Platform (ETIP) on Batteries, partnerships of European regions active in batteries R&I, etc.) or even skill-related activities such as the Erasmus+ Sector Skills Alliance dedicated to Batteries for electro-mobility. It can also leverage tools in the hands of the European Investment Bank that is ramping up on energy transition and notably batteries with the InnovFin EDP product.

In addition, national and multilateral initiatives are also on-going in a very timely manner, as illustrated by the recent

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declaration from France and Germany on a joint strategic plan to develop battery manufacturing capacities and corresponding expertise in Europe. In this perspective, Germany’s economy minister Peter Altmaier made bullish declarations about the longer-term prospects for both EVs and European cell production, announcing that the goal was to cover around 30% of global demand for battery cells from German and European production by 2030, and demonstrating this ambition by stating that Germany alone would set aside €1 billion to support battery cell production. France has also launched on January 2019 a call aiming to mobilize the national competencies on batteries, in the frame of the Franco-German initiative. Many other Member States, like Poland, Slovakia, Czech Republic, Sweden, The Netherlands, Spain, etc. have also expressed a strong interest for batteries and are developing strategies to support industrial initiatives and attract investments.

All these intergovernmental and cross-sectoral initiatives could be catalyzed by the existence of a dedicated instrument, as put by Vice-President Maroš Šefčovič: (...) our EU accelerator – the EIT InnoEnergy – is setting up together with the EIB support an Investment Platform. This match-making platform should create an additional flow of 70 bn EUR into EU-based projects.

The main purpose would be to achieve a fully functional market through a tailor-made business investment platform, thus bridging the supply-demand gap.

The mechanism also worth mentioning, as it allows to potentially benefit from State Aid exemptions, is an Important Project of Common European Interest (IPCEI). This demonstrates the complementarity and mutually reinforcing nature of the various initiatives supporting battery Industry in Europe taken at different levels and by various types of stakeholders, both from the public and the private sectors.

To conclude, acknowledging that the electrification of mobility is not an option and that car manufacturers have clearly announced their ambition to move towards a new technology of powertrain, for competitiveness and employment reasons, Europe should host the largest share of car and battery manufacturing capacities. All in all, the coming years are decisive to ensure that this impressive political impetus created in 2017 by the creation of the EBA is effectively translated into an industrial momentum, leading to socio-economic benefits for Europe.

In these unsettled times, beyond the case of batteries, this political initiative kick-started at the EU level was outstanding and could be echoed to tackle an even broader challenge involving additional economic sectors: the energy transition. The raison d’être of EIT InnoEnergy is to precisely accompany the energy transition, and we will keep on supporting these ambitions with enthusiasm and determination.
On 20 June 2019, European Commission, Poland and representatives of three Baltic States signed the Political Roadmap on implementing the synchronisation of the Baltic States’ electricity networks with the Continental European Network via Poland (‘Political Roadmap’). The document clearly states the commitment to continue at full speed the implementation of synchronisation of the Baltic States’ electricity system with the Continental European Network via Poland in 2025 at the latest.

The Political Roadmap mandated TSOs of the Baltic States and Poland to implement all necessary measures under the Agreement on the Conditions of the Future Synchronous Interconnection of power system of the Baltic States and power system of Continental Europe containing the Catalogue of Measures (‘Connection Agreement’).

Connection Agreement was adopted and entered into force on 27 May 2019 following the endorsement of the ENTSO-E Regional Group Continental Europe defining formal rights and obligations with respect to the steps and measures for the synchronisation process of the Baltic States with the Continental European Network. Before that, three TSOs of the Baltic States and Polish TSO together with Institute of Power Engineering (Gdansk Division) performed several studies, including extended Dynamic and Frequency Stability assessment of the Baltic States after synchronous connection to Continental European Network.

One of the main conclusions of the studies concerning frequency stability is related to frequency control capabilities of HVDC links – “The goal of avoiding or minimizing UFLS after islanding and loss of up to 700 MW infeed can only be achieved with the use of the frequency regulation capabilities of HVDC links. Such actions have an impact on the Nordic SA and/or CESA and need to be agreed upon.” Therefore, one of the most important strategic decision is about which amount of regulating power will be made available from HVDC links. Limitation of HVDC capacities for the market has been eliminated from the deeper analysis as it is too expensive, however, additional measures such as cUFLS (contractual Under-Frequency Load Shedding) or BESS (Battery Energy Storage Systems) can be used to ensure the frequency stability after severe (out of range) incidents. BESS is an effective means to support frequency control. BESS, being permanently available sources of continuous regulating power, offer a quick availability of regulating power and a very good dynamic response. Moreover, they can provide other services that were not subjects of the study. Summarizing the main findings of the first study could state that BESS can offer comparable control characteristics to HVDCs as far as frequency control is considered. Besides, BESS can constitute an alternative or a back-up to HVDCs overload capabilities (if HVDC is specially designed for overload) instead of using UFLS. The advantages of using BESS instead of HVDC overload capability are higher reliability and availability due to dispersed installation. In summary, BESS of large rated power will support HVDC links in frequency control and will decrease the amount of the necessarily available capacity on the HVDC links by the value equal to its rated power.

However, any final investment decisions related to purchasing and installation of a higher amount of BESS should be postponed by a few years due to a lack of unambiguous, confirmed results about the practical application of BESS on a large scale in power systems. The rapid development of storage technologies can lead to solutions that better fit the Baltic States. Moreover, a possible significant decrease in the cost of BESS can be expected in the forthcoming years.

Taking this into account the additional studies in cooperation with suppliers of BESS have been required in Annex II Additional Technical Requirements of the Connection Agreement:

- Technical and economic analysis of the possibilities and purposefulness of a multi-variant use of BESS in Baltic System
- Development of assumptions for the information exchange of BESS with the FSAS (Frequency Stability Assessment System) system
- Electromagnetic transient analysis of Baltic System with regard to grid stabilization by the converter control of BESS
- Analysis of synthetic inertia by grid forming converter control

LITGRID AB, realizing the importance of stable system operation and in order to be properly prepared for high amounts of BESS installation in Lithuania by 2025, initiated a pilot project of 1 MW BESS installation in Vilnius. The goal of the project is to check the possibilities of using BESS under real operating conditions of the Lithuanian power system, identify the areas and functions for the use of high-capacity battery storage systems in Lithuania, establish requirements for the batteries that would provide different types of services. As a minimum, the operation of BESS will be tested for delivering frequency control reserves including Frequency Containment, Restoration and Replacement capabilities.
The Synthetic or Digital inertia capability that will react to Rate of Change of Frequency (RoCoF) will be checked as well as Emergency Power Control (EPC) and Fast Frequency Regulation (FFR) functions will be integrated in special protection schemes, which provide external control signals from central control systems such as FSAS, DSAS (Dynamic stability assessment system), AGC (Automatic Generation Control) or others. The grid voltage control function will also be implemented in order to check the effect of voltage regulation from BESS and to improve the quality of energy supply.

The Contractor will prepare the concept of multi-variant BESS and will make detailed technical specification. After this, technical and detailed design work will be carried out, resulting in BESS installation in Vilnius. And then BESS operation will be tested by providing different services mentioned above and tests reports will be prepared. After the tests, technical requirements for the BESS will be established for the provision of each of the services.

The pilot project will be implemented for a period of three years and public procurement will be announced.
The European energy system is experiencing rapid changes, as we transition to an increasingly decentralised and decarbonised energy system powered by variable renewables such as wind and solar. While for a long time, the focus of policymakers has been solely to increase the deployment of renewables. In recent years, it has become clear that the energy transition also requires a host of new technologies that can offer flexibility to the system.

Energy storage has emerged as one of the key technologies that will be needed to support the transition to the decarbonised energy system in the future. However, in a system and regulatory framework built around the traditional assets of generation, transmission/distribution and consumption, energy storage has faced significant hurdles. In the past, there was no EU regulatory framework for energy storage. In fact, the Third Energy Package that entered into force in 2009 did not mention energy storage.

EASE – the European Association for Storage of Energy – was founded in 2011 for precisely this reason: key players in the storage sector recognised the need to advocate for a level playing field and regulatory clarity regarding energy storage devices. Since then, both the storage markets and regulatory framework have changed significantly.

In particular, the EU regulatory framework for storage has advanced in leaps and bounds with the “Clean Energy for All Europeans” package of legislative and non-legislative proposals, finalised in 2019. By establishing a binding renewables target of 32% by 2030 - as well as targets for renewables in transport, heating, and cooling – the package creates a high level of ambition that can only and it with the deployment of flexible solutions such as storage.

DEFINITION OF ENERGY STORAGE

There are also many aspects of the package that specifically address storage. In particular, the Electricity Market Design files (the recast Electricity Directive and Regulation) tackle some of the most pressing challenges for storage technologies. First of all, they establish a definition for energy storage that covers all of the different technologies: pumped hydro storage, power-to-gas, power-to-heat, liquid air, batteries, supercapacitors, flywheels, and others. This technology-neutral definition ensures that both current technologies and those that may be developed in the future are covered by the legislative framework.

OWNERSHIP OF STORAGE BY REGULATED ENTITIES

Second, the Clean Energy Package clarifies the important issue of regulated entities (TSOs and DSOs) owning and operating storage devices. As a general rule, TSOs and DSOs should not own and operate storage facilities, unless they are considered fully integrated network components. However, in situations where there is no market party willing to build a storage device, the National Regulatory Authority (NRA) may introduce a derogation to allow TSOs and DSOs to own and operate an energy storage facility. Prior to the Clean Energy Package, the lack of clarity on ownership of storage held back the development of storage devices; clarifying this point, therefore, represents an important step forward for the industry.

This point is part of the evolving role that is envisaged for system operators. The Clean Energy Package clearly states that TSOs and DSOs must consider energy storage in their network planning and it encourages them to move towards market-based tendering of flexibility services as an alternative to grid extension. This will allow energy storage to access more revenue streams, building a more robust business case and creating a level playing field between the different flexibility options.

THE ROLE OF CONSUMERS

The Clean Energy Package also contains several key points on the role of consumers. They are no longer assumed to be passive players in the energy system. Rather, they can choose to play an active role, deploying renewables and storage and even actively participating in different electricity markets. The Package formally recognises the right of ‘active customers’ and ‘citizens energy communities’ to own and operate energy storage devices. These customers and communities should be able to offer the flexibility of their storage devices to the grid, including via aggregators.

REGULATORY CLARITY AND INVESTMENT CERTAINTY FOR A CENTRAL PLAYER IN THE ENERGY SYSTEM

The Clean Energy Package clearly establishes energy storage as a central player in the energy system. The market design files emphasise the need for a level playing
field between storage and other flexibility options and seek to ensure access of energy storage devices to different markets.

These provisions provide the regulatory clarity and investment certainty needed to kick-start storage deployments around Europe. However, there are further issues that still need to be addressed in order to ensure that storage can build a robust business case and be rewarded for the services it provides to the grid.

For instance, energy storage deployments will require at least some investment certainty in the form of long-term contracts (up to 3 years). The Clean Energy Package limits the duration of balancing services, which could reduce investment certainty, without which storage facilities may not be built. Another key issue is that grid fees, taxes, and tariffs applied to energy storage may be higher than on other devices, as storage is sometimes taxed when ‘consuming’ electricity and then again, when ‘generating’ electricity. This point is not adequately addressed in the Clean Energy Package.

LOOKING AHEAD
Policymakers and industries must now work together to ensure rapid implementation of the Clean Energy Package and to discuss further measures that can support the high levels of storage deployment needed to achieve the 2030 and 2050 targets. As the Commission recognised in its 2050 Long-Term Decarbonisation Strategy, there is simply no way to achieve a stable, secure, and efficient decarbonised energy system without significant increases in storage capacity. Now is the time to seriously rework regulatory frameworks to incentivise investment in clean energy and storage deployments, while also increasing the funding for energy storage research, development, and deployment.
ENERGY STORAGE PROGRAM IN POLISH ENERGY GROUP (PGE)

PGE Capital Group is developing energy storage projects that may play a significant role as well as become a profitable part of the whole energy system. Currently, PGE is focusing on eight projects of about 40 MW total power and assumes further development within the group-wide framework called Energy Storage Programme.

Energy storage is currently one of the most developing branches of the electric power industry. Energy storage facilities allow to store energy in different ways: in physical form, electrochemical form, mechanical form, etc. and deliver it according to certain parameters. The most common energy storage facilities in the world are pumped-hydro units. In this area, PGE Group is the leader with ownership of about 85% of total power installed in Poland, in four pumped-hydro energy storage plants. Under conditions of increasing generation from renewable energy sources, balancing the supply and demand becomes a serious challenge, because the generation of renewables is intermittent and not always demand-driven. In this context, energy storage can’t be limited to only pumped-hydro facilities.

Energy Storage Programme launched in PGE Group is comprehensive and also pertains to conventional power units. A part of the Programme is, inter alia, the construction of the first energy storage facility integrated with a conventional unit in Poland.

PGE is strongly involved in the analysis of technical and economic context of construction of the first energy storage facility integrated with the conventional power unit in Poland, to test its different functionalities. Storage unit with the power of 1 MW will be potentially constructed in Belchatow Power Station, the world’s largest lignite-fired power plant, and could provide a variety of applications. The basic purpose of the facility will be to increase the power supply for transmission system operator during the peak demand period due to the reduction of power reserve for TSO’s needs. Moreover, the storage facility will be tested to provide back-up power supply for defined ancillary equipment and devices like supervisory and control systems of the conventional unit during lack of primary energy supply. The pilot project will allow to test the storage facility in terms of capacity market, frequency response reserve as well as price arbitrage. If the tests of the 1 MW storage unit are successful, PGE will consider integrating a more powerful facility with the conventional unit, taking into account the pilot results, preferred functionalities and business profitability of the project.

Energy Storage Programme also integrated R&D projects that are connected with our renewables assets: energy storage facility integrated with a renewables assets: energy storage facility integrated with wind farm Karnice I. Both of these projects are carried out by PGE Energia Odnawialna, one of the key business lines of PGE Group.

The first one, mentioned above, concerns the construction of 500 kW power and 750 kWh capacity storage plant to be built in Li-ion technology. The project is co-financed using public funds governed by The National Centre for Research and Development. The aim of this project is to test the cooperation between the storage unit and the existing 600 kW power photovoltaic farm as well as cooperation between medium-voltage distribution grid and whole integrated system consisting of PV farm and storage unit. Similar aspects will be the object of the research program for storage facility integrated with wind farm Karnice I. The storage unit of about 2 MW power and 2MWh capacity will be built next to the wind farm and will be the object of several tests.

Energy storage facilities can help to integrate renewable energy sources, thus enabling the energy generated in them to be used during the peak demand period. In addition, they can serve as a backup power supply for the end user, energy arbitrage, as well as a system for managing the current demand.

Energy storage is also a very important issue in the context of distribution grid stability. PGE Dystrybucja, another key business line of PGE Group, is currently formulating concepts of energy storage facilities in four locations. These potential projects are generally focused on: improvement of electricity quality in distribution grid due to the intermittent generation of renewables, ability to coordinate the activity of substantial, chimeric renewable sources, management of electric power flows, reduction of grid losses as well as the ability for periodical off-grid operation in case of emergency. PGE Group is also involved in microgrid projects, where the energy storage facility is planned to be built. PGE is continuously monitoring all legislative activities at EU and national level. The role of distribution system operator in ownership, management, and development of energy storage facilities has been limited in Clean energy for all European package, which was adopted in June 2019 by European Parliament and the Council of European Union. The stage of transposing the provisions of the directive into the national legal system will allow PGE to develop appropriate paths for the implementation of projects for the DSO.
The main objective of the PGE Group’s Energy Storage Programme is to integrate highly unstable renewable energy sources, improve the quality parameters of electricity in the grid, increase security of energy supply, enable island operation (to independent selected grid area from external energy supplies) as well as price arbitrage, which is based on the possibility of charging storage units with cheaper electricity during the so-called night valleys and selling it during peak demand. Following the appropriate legal regulations in this area in future, it would also be possible to provide frequency ancillary services to transmission and distribution system operators, which could potentially be an additional source of revenue for the PGE Group.
ENERGY STORAGE FACILITY COMMENCES OPERATION IN HUNGARY

ATTILA CHIKAN CEO OF ALTEO

ALTEO GROUP – SUSTAINABLE ENERGY PROVIDER IN HUNGARY

Since the 1990s, it has become clear that renewable energy sources need to have a greater role in electricity generation in order to achieve sustainable and efficient energy production.

After the millennium, this perspective has started to spread all over Central Eastern Europe, including Hungary. As one of the leading representatives of the impact investment strategy (the company sees both itself and its shareholders impact investors), ALTEO has been committed to supporting sustainable development and renewable energy since the establishment of the company in 2008.

As a result, power plants utilizing renewable energy sources have a prominent role in the company’s energy mix. The capacity of ALTEO’s renewable power plant portfolio has reached 55 megawatts, produced by four solar power parks and five wind farms. In addition to that, the company also has two hydropower plants and four renewable gas generating plants.

Although the utilization of renewable energy has been through a significant development over the past years, renewable energy sources – mostly wind and solar energy – do depend on the weather conditions. Since it is difficult to plan the production of weather-dependent energy sources, operating these types of power plants is a business challenge. ALTEO provides complex energy services to industrial companies (who highly value the security of supply). So, to effectively serve them with renewable energy solutions, it was necessary to solve the issue of storing energy.

CREATING AN ENERGY STORAGE – THE BEGINNING

ALTEO’s goal was to find a solution for the global issue of storing energy in 2017, it started to work on an innovative model within a research and development project. The model was unique not only in Hungary, but in the CEE region as well.

To implement the project, ALTEO gained over EUR 1.5 million support from Hungary’s National Research, Development and Innovation Office, to start developments that can contribute to the renewal of the energy production system, and thus lead to sustainable development. The execution of the project cost approximately EUR 3.4 million in total.

As a result of the R&D program, a uniquely diverse and autonomous system was created, which has a significant positive impact on the Hungarian electricity system. “The capacity of ALTEO’s system is 6 megawatts, meaning that it is capable of covering 21% of the Hungarian market demand in terms of frequency containment reserve.”

RETURN TO THE LIST OF CHAPTERS
Currently, in Hungary, the demand for primary regulation is 28 megawatts.

The Li-ion battery energy storage facility and its integration in the electricity system make a significant contribution to the efficient and profitable operation of ALTEO’s renewable energy based production as well.

The complex energy service systems with the energy storage, renewable energy sources, and Virtual Power Plant by now have become a gradually evolving industry segment with great potentials.

However, a great amount of data and experience is still needed in order to use ALTEO’s energy storage facility effectively. The scope of the technology covers a wide spectrum including balancing the peak periods and frequency control. Since each case has different requisitions, various technical specifications and operation strategies are needed. According to the analysis of ALTEO’s specialists, the installation of an electricity storage system with a capacity of 4 MWh and performance of 6 MW was advised, as it has the needed amount of capacity and efficiency to provide the services. In addition, it has the capacity to monitor the impact of the operational factors that affect its lifetime. The storage unit is located in Budapest, at the heating power plant of ALTEO.

THE PURPOSE AND THE OPERATION OF THE SYSTEM

The project aimed to develop a complex system and as a result, execute the goals of the R&D project. The central element of the project was the establishment of a battery depot and its operation. It also included the development of the existing Virtual Power Plant and the integration of weather-dependent producers.

The electricity storage architecture basically carries out two tasks in parallel: it provides a Frequency Containment Reserve (FCR) for the electricity system and supports the operation of the ALTEO Virtual Power Plant that provides Automatic Frequency Restoration Reserve (aFRR).

The storage is able to provide FCR in a much higher quality and at a lower price compared to the technologies used previously. Thus, it has a beneficial effect on the operation of the system and the financial burden of electricity users by reducing the maintenance cost. Moreover, making the Virtual Power Plant more flexible allows less flexible, weather-dependent power generation units to be integrated into the Virtual Power Plant. Therefore, those units can be involved in providing services. Consequently, there is a higher chance of establishing new renewable (weather-dependent) energy generators in Hungary or the sustainability of the current capacities may increase.

Elements of the energy storage project
- Improvement of ALTEO’s Virtual Power Plant
- Establishment, integration, and optimization of a battery storage facility
- Establishment, integration, and optimization of an electricity-based heat generating equipment
- Adjustment of the weather-dependent units (wind turbines) to become controllable, analysis and optimization of the system operation
- Development and implementation of an algorithm predicting the status of the system.

The battery energy storage system was delivered in August 2018. Later on, while the system was running, developments of algorithms for the optimal operation were continued.

ALTEO plans to publish the results of the research and development program as it could help to spread the pioneering technology in the region. The successful application of this technology marks a milestone as this project allowed the company to engage better with the idea of sustainable and efficient energy usage.
MAIN FACTORS BEHIND THE RISE OF THE ENERGY STORAGE MARKET

DELOITTE REPORT

The global market for energy storage is poised to grow rapidly. According to projections, the global storage market could reach more than $26 billion in annual sales by 2022, a compound annual growth rate (CAGR) of 46.5 percent. More conservative estimates envisage growth at a more modest - but still robust, pace - expanding at a compound annual growth rate of 16 percent and reaching $7 billion annually by 2025. This process is fuelled by several market tendencies:

COST AND PERFORMANCE IMPROVEMENTS
The main driving factors are declining costs and improved performance, particularly relating to lithium-ion batteries, since expanding electric vehicle markets are promoting manufacturing economies of scale. As illustrated in Figure 1, costs for lithium-ion batteries are declining at a steep trajectory.

![Figure 2 Lithium-ion battery prices fell 80% from 2010-2017 ($/kWh)](image)

GRID MODERNIZATION
Grid-modernization programs aim to boost resilience in the face of severe weather events, reduce system outages linked to aging infrastructure, and improve the overall efficiency of the system. These programs often involve deploying smart technologies and energy storage within established electric grids to enable two-way communication and advanced digital control systems, along with integrating distributed energy resources (i.e., renewables, fuel cells, diesel or natural gas generators, storage assets, and microgrids).

GLOBAL MOVEMENT TOWARD RENEWABLES
Broad support for renewables and emissions reduction is also driving adoption of battery storage solutions. The critical role that batteries can play in offsetting the intermittency of renewables and reducing curtailment is well known, but the strength and pervasiveness of the desire for clean energy among all types of electricity customers are growing.

DESIRE FOR SELF-SUFFICIENCY
A growing desire for energy self-sufficiency among residential customers emerged as a somewhat surprising force behind storage deployment. This desire is fueling behind-the-meter markets to some extent, suggesting that the motivations for purchasing storage systems are not purely financial.

PARTICIPATION IN WHOLESALE ELECTRICITY MARKET
Though renewables and batteries are often mentioned in the same sentence, battery storage can help balance the grid and improve power quality regardless of the generation source. This points to a growing global opportunity for batteries to participate in wholesale electricity markets.

FINANCIAL INCENTIVES
The widespread availability of government-sponsored financial incentives further reflects policymakers’ growing awareness of the range of benefits battery storage solutions can deliver throughout the electricity value chain. Such incentives range from a percentage of battery system costs being refunded directly or through tax rebates, to capital support through grants or subsidized financing. These incentives appear to be particularly generous in countries that have energy security concerns.

PHASE-OUTS OF FITS OR NET METERING
Low or declining feed-in-tariffs (FITs) or net metering payments additionally emerged as a driver of behind-the-meter battery deployments, as consumers and businesses seek ways to obtain greater returns from their solar photovoltaic (PV) investments. While this is not yet a global trend, it is reasonable to think it may become one as FITs phase down in more nations and as the owners of solar PV installations adopt batteries as a means of self-consumption of the electricity they produce. As a result, there’s a shifting of their loads to avoid peak charges, and/or providing grid-stabilization services by allowing a utility or an aggregator to charge or discharge their batteries when needed.
NATIONAL POLICY

Additional opportunities for battery storage providers are arising from national policies aimed at furthering a variety of strategic objectives. Many countries see renewables plus storage as a new way to lessen their dependence upon energy imports, fill gaps in their generation mix, enhance the reliability and resiliency of their systems, and move toward environmental goals and de-carbonization targets. Some nations, such as Italy and Japan, are actively subsidizing and promoting energy storage as part of broad restructuring efforts, aimed at ensuring reliability and reducing dependency on international energy companies and foreign imports.

Based on a report "Supercharged: Challenges and opportunities in global battery storage markets", Deloitte Center for Energy Solutions, 2018
The main aim of the project was to investigate the possibilities of storing the energy coming from renewable energy sources as hydrogen gas, in salt caverns. Additionally, the project also explored the possibilities of using hydrogen for processes in refinery, the production of electricity and for the supply of fuel cells. One of the important aspects was the determination of the economic conditions, in order to assess the profitability of the project. The project was implemented by a consortium of the following companies and institutions: Grupa LOTOS S.A., AGH University of Science and Technology, Research and Development Center CHEMKOP Ltd., Silesian University of Technology, Warsaw University of Technology, and Gas Transmission Operator GAZ-SYSTEM S.A.

The hydrogen that will be generated and stored in a salt cavern will be usable for:
- energy purposes, by using it as a fuel for gas turbines during periods of peak demand for electricity,
- technological processes at the refinery, reducing the need for natural gas, used for its production, and allowing a rationalization and optimization of the hydrogen economy,
- road transport purposes.

The basic assumption that had to be verified was the availability of inexpensive surplus energy from renewable energy sources (RES). Inexpensive energy should be the result of a grid's limited intake possibilities, due to an excessive energy production from renewable energy sources during favourable weather conditions. The conducted analysis led to the following results:
- currently, a surplus of RES energy occurs only on a few days during a year;
- the availability of surplus energy that could be used to supply electrolysers will occur, according to the reference scenario, only for 275 hours in 2020 and 1,350 hours in 2036; the growth rate of installed capacity in RES and power demand could make the project feasible, but only in the distant future (2030 onwards).

Another aim of the project was to choose the best available locations for salt caverns leaching. The maximum version of such a cavern (the largest possible for leaching in a given location) will have a capacity ranging from 190,000 m³ to 350,000 m³, storing between 2,000 and 3,000 tonnes of hydrogen, which could allow to produce between 33 and 43 GWh of electricity. Leaching such a cavern takes about two years.
The performed work has allowed to determine the optimal shape and maximum capacity of a cavern, depending on the minimum and maximum storage pressure, and meeting the criteria of stability and tightness, as well as to identify the maximum cavern capacity depending on the type of the analysed cavern, the depth of its foundation, and the thickness of the deck.

An important element of the project was to investigate the phenomenon of hydrogen degradation and, subsequently, the selection of appropriate materials for pipelines and fittings. These tests have allowed to verify the intensity of hydrogen interaction with the selected materials and to characterize the degradation processes that may occur during the operation of components in contact with hydrogen.

Regarding the project’s objective of determining the characteristics of hydrogen generators, the researchers’ attention was focused on the two most commonly used types of electrolysers, namely alkaline and PEM-type electrolysers. Based on the performed tests, the efficiency level of alkaline electrolysers was of 78%, and that of PEM electrolysers was of 50%.

To enable an optimization of hydrogen use in electricity production, a research was necessary to define the characteristics of the GE LMS100TM gas turbine, powered by hydrogen and a mixture of hydrogen and natural gas. The turbine’s work characteristics with a partial load have been determined. The conducted tests led to the conclusion that a turbine operating at a 50% load will perform an efficiency drop of about 6 percentage points in relation to the nominal value.

The increase in the share of hydrogen in fuel was associated with an increase in efficiency by 1 percentage point and a decrease in power by 1.4%. Additionally, preliminary simplified economic calculations were performed and compared to the results of the technology of gas-steam systems. Due to the technological maturity, availability of systems, capital expenditures and energy efficiency, the use of a gas turbine for converting hydrogen to electricity was selected as the one most likely to be used. Additionally, an assessment has been prepared for the possible use of by-products in the water electrolysis process, namely oxygen, for refining purposes. Oxygen is used by the refinery to increase the efficiency of the desulfurization processes. The preliminary analyses performed under the HESTOR project have shown that the oxygen obtained in the process of hydrogen production may be an important contribution to the balance sheet of the refinery in Gdańska.

As part of the project, a number of technical, technological and economic conditions that have a decisive impact on the profitability of the project were also defined. The calculations were based on the current technical and economic parameters and energy prices. We assume that, as commercial technology continues to develop and mature (e.g. the construction of electrolysers), the CAPEX per unit will gradually decrease. This will have a positive impact on the project’s economic and financial results. For an economic analysis, a technical description was created, containing the most important elements from the previously performed analyses, and technical and technological research, for which CAPEX, OPEX and revenue levels were determined. Appropriate economic models were developed depending on the adopted scenario. A multivariate economic analysis was performed for periods of 20 years and 50 years. Forecasts of electricity and natural gas prices were also used. As part of the feasibility study, the following scenarios were analysed:

- use of hydrogen for the refinery and storage at the facility in Mechelinki;
- use of hydrogen for the production of electricity in a gas turbine and storage at the facility in Bialogarda;
- use of hydrogen for the production of electricity in fuel cell and storage at the facility in Bialogarda.

These variants were supplemented with the possibility of using hydrogen in transport, as a complementary option. The basic CAPEX of the investment ranges, depending on the variant, as follows:

- the technological use of hydrogen: USD 82.7 – 145.3 million USD;
- the use of hydrogen for energy USD 135.6 - 141 million.

Capital expenditures related to the construction of a hydrogen refuelling station were estimated at around USD 5 million. The economic efficiency of the investment was determined using the NPV method, providing negative values for each basic option. The following factors are considered the most important for the success of the project electricity prices in 20 - 30 years,

- the amount of surplus energy from RES and from conventional sources: electricity balance, taking into account the time-varying source of energy supply,
- volatility of hourly / daily / monthly / quarterly electricity (produced and received). Given the above-mentioned results of the HESTOR project, the key factors for increasing the efficiency of the projects of energy storage as hydrogen gas were defined as follows:

- building a system of financial incentives, such as a partial exemption from transmission charges, lowering taxes and other charges,
- introducing legislative incentives, such as a system of relevant ‘green’ hydrogen certificates, given that hydrogen from electrolysis has a low or almost zero carbon footprint,
- establishing a clear regulatory framework for the use of surplus energy from renewable energy sources,
standardizing the hydrogen injection to the natural gas grid and establishing appropriate tariffs for such an activity.

As a main conclusion of the HESTOR project, it should be noted that hydrogen storage in salt caverns is technically feasible, safe and possible, using the technologies and knowledge of consortium members. The technical, technological and economic conditions, which have a decisive impact on the profitability of the project, were defined. The performed analyses indicate that, under the current conditions, the possibility of a profitable use of hydrogen produced in the electrolysis process, its storage in salt caverns and further use, according to certain purposes, is unprofitable and burdened with many conditions.
In February 2019, the European Commission has launched BatteRies Europe, a new €1 million Technology & Innovation Platform aimed at driving forward research, innovation and knowledge transfer in battery technology across Europe. First stakeholder meeting in Brussels was held on 25 June 2019.

BatteRies Europe is bringing together all relevant stakeholders in the European batteries research and innovation (R&I) ecosystem in order to develop and support a competitive battery value chain in Europe. Its aim is to be the driving force behind Europe’s ambitions in the field of batteries.

BatteRies Europe will be a forum for setting strategic research and innovation agenda throughout the whole value chain and an important cooperation platform on batteries research and innovation. It will not be a funding instrument but will bring together different funding schemes, such as Horizon 2020 and its successor Horizon Europe, Regional-ERDF funding, and Member States-funded Projects of Common Interest. It thus becomes an important linking structure in batteries research and innovation landscape and ensures one-stop access to all involved Commission structures and beyond.

In line with the European Commission’s priority to accelerate the establishment of a competitive European battery industry, the forum will also empower the Implementation Plan of the SET-Plan Action 7 and act as coordinator of several initiatives already in place, such as: European Battery Alliance, ETIP SNET, EIT Raw Materials, EARPA (European Automotive Research Partners Association), ALISTORE, BATSTORM, and NAMEC.

In parallel, a new matchmaking platform bringing together battery projects promoters and investors will also soon be inaugurated under the auspices of the European Battery Alliance. There will be a strong link between the two platforms: sufficiently ripe innovative ideas coming from members of BatteRies Europe technology and innovation platform will be able to find easier access to the market through the matchmaking platform.

By enhancing support for research and innovation on all types of battery technologies, the new platform will consolidate the industrial basis for this sector in Europe, creating new growth opportunities and new jobs.

BatteRies Europe will be the “one-stop shop” for the battery-related R&I in Europe. The ambition is to make the ETIP a place where relevant stakeholders (Research community, Industrial actors, Commission services and Member States, -including their regional governments) will not only exchange and coordinate their efforts on Batteries R&I, but also mobilize resources to implement R&I activities in the field.
Contribution of CRE within EU Projects WiseGRID and CROSSBOW with energy storage components.

WISEGRID PROJECT
WiseGRID is an EU Project looking to develop specific tools (solutions and technologies) which shall increase the smartness, stability and security of an open, consumer-centric European energy grid, with an enhanced use of storage technologies and a highly increased share of RES. Within WiseGRID, there are 9 tools to be considered and one of them is related to the storage approach, which is considered as a major part of the project to facilitate the integration of renewable energy storage systems in the network. The figure below is a comprehensive image about the variety of services that can be provided by energy storage systems, according to WiseGRID findings.

Day-ahead/Intraday portfolio optimization; Self-balancing; Generation optimization, Services to DSOs: Load frequency control; Grid capacity management; Voltage support; Power quality support.

The WG StaaS/VPP developed under WiseGRID Project, allows the integration of prosumers in the energy market offering demand response services by means of an optimal combination of production from distributed renewable energy sources, charge or discharge of energy storage systems and management of loads, such as peak shaving or load displacement. WG tool represents a key development for the integration of Energy Storage resources in the electricity markets, providing an added value for the power systems., Nnot only in economic terms, but also in efficiency and sustainability, since the available capacity from a (usually) renewable energy source is used to contribute to the balance of the power grids.

CROSSBOW PROJECT
Crossbow project is continuing continuation further continues the WiseGRID project by that is addressing the tools for integrating new renewable energy into the DSO grid, being more focused for on cross border tools and procedures helping that help TSO to integrate their assets in a European wide grid. Also, Crossbow includes a set of work packages focused on storage and clustering storage units in Virtual storage plant in order to provide stability to the grid and reduce congestions on the lines crossing borders used for energy changes between the EU states.

Large energy storage plants are getting an important role in the modern power system, which includes the high penetration of renewable energy sources (RES). Continuously increasing the share of RES have changed the dynamics of the power system because of the non-controllable RES, i.e. solar and wind.

Virtual Storage Plant (VSP) is an entity able to improve what improves the power system operation. The EC’s project CROSSBOW of sharing the large storage assets also include the virtual storage plants by connecting them in a coordinated way to increase their utilization and promoting the RES’ share in of the power system. The project demonstrator systems will be located in Greece and Croatia.
Energy storage technologies like Li-ion battery are still new for SEE market. Greece is already undergoing the development of a 0.8 MW, Romania is undergoing the testing of a wind energy, supported by, 1 MW Li-ion technology- based energy storage plant in Cobadin 26 MW Wind Park, while in Slovenia, under Sincro.Grid project, ELES (Slovenian TSO) is planning to install two 5 MW battery energy storages.

The Romanian battery storage unit from Cobadin (picture below) is still in under testing and has 1 MW power and 1 MWh energy. The purpose of this storage unit is to improve the market integration of the wind park by decreasing the imbalances due to wind unpredictability. The control of the storage unit is in this phase on of the owner, and currently, there is no control from National Dispatch in order to provide system services, while this can be an option in the future.

The Virtual Storage Plants (VSPs) are comparatively small or medium scale energy storage plants, which are spread geographically across several different locations in the SEE region. There could be a combination of energy storage technologies like batteries, super capacitors, flywheels, superconducting magnetic energy storages, compressed air, etc. In CROSS-BOW, such storages will be used in a coordinated way with STO-CC in the region to support grid stability at the regional level. VSP provides a platform capable of sending charge, discharge, and controlling control commands. It will provide energy producers with a highly independent platform with and an optimal coordination with STO-CC using various algorithms for better utilization of their surplus energy and storages, to enhance their profit as well as system performance. Virtual energy storage system aggregates various controllable components of energy systems, which include conventional energy storage system, flexible loads, distributed generators, Micro grids, microgrids, local DC networks, and multi-vector energy systems. Through each unit works in a coordinated way to form a single high capacity energy storage system. It is integrated with power network operations and is able to vary its energy exchange with the power grid in response to external signals. The project investigates several potential applications such as: facilitate the integration of RES in the distribution networks, defer transmission networks reinforcements, provide local regulations in the network, provided provide ancillary services.

Obstacles of VSP: VSP has several obstacles, which which makes it difficult to bring it online in full swing. VSP are vulnerable to cyber-attacks which and may lead to serious problems in the power system. Secondly, high level of distributed energy resources may affect local voltage unless a smart voltage control scheme is implemented. Lastly, incentives need to be managed wisely to implement VSPs to help operators bring their benefits to the system. As one of the additional challenges is the compatibility of VSP with the European connection code, which asks for conditions for each component, but does not provide instead steady solutions for aggregated entities, and thus requiring specific regulations which that may partially be in conflict with the existing ones.
Overcoming such challenges in VSPs can build a strong support to for large power plants. For example, in Germany, a network of more than 1,000 biogas, solar, wind, and water plants are located across four transmission grids, which which provide up to 796 MW of clean energy that boosts grid stability. VSPs can also provide demand response automatically and attenuate the requirement of day-ahead energy planning. They are usually fast in response to price signals and, shifting load. In addition, they may also support in load shedding, capacity relief, and frequency regulations.

THE CHALLENGE FOR FUTURE LARGE-SCALE ENERGY STORAGE

While different storage related services are considered in both European projects, the testbeds are still small comparing with with the future needs to prepare for a fully decarbonized economy. For instance, new short time reaction for rapid primary fast frequency regulations (10, 2 or 1 second) have has been already acquired through bids in the UK (200 MW)¹, while different smaller projects for grid stabilization appeared in Germany², and all have been supported by battery- based solutions. Thus, the battery systems can also be a useful support for synthetic inertia as well, as results have been found in the Reserve Project. Recent studies for Romania showed that a high level of VSP and distributed storage are needed to address a 100% CO2 target in Romania. Figure The figure below shows a need between 40 and 100 GWh of short-to-medium term storage needed to make compatible stochastic RES production with consumption in Romania in based on selected days or weeks of the year⁴️⁵.

In However the same time, recent investments decided in California, (a USA US state aiming for 100% free CO2 free in by 2045), has recently chosen battery systems instead of new peak power plant⁵, with battery projects with having a capacity of more than 2000 MWh.

Our project studies and international new direction show shows that battery storage is a new and highly promising domain, which needs further developments.

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The Polish Chamber of Energy Storage Association has presented a report on the electricity storage market in Poland. This is the first comprehensive study of this type with characteristics of the power system needs, a description of energy storage technologies and their recommendations for the Polish market as well as the most important regulatory issues related to electricity storage in Poland against the background of the changing internal electricity market in the European Union. The report was prepared in the form of conclusions from workshop discussions conducted in 2017-2019 as part of the Polish Chamber of Energy Storage Association ("PIME"), in which professionals involved in the development of the electricity storage market in Poland participated - representatives of investors, network operators and solution providers. Although in the public space for several years there is a consensus on the legitimacy and a need to develop electricity storage - in particular in the context of network security, power quality and generation balancing from renewable energy installations, experts have repeatedly noted that current regulations are not well designed and give space to various - often contradictory - interpretations and regulatory practices, thus increasing investment risk and business costs, hampering the development of large-scale commercial storage projects.

Summary of the main problems related to the current regulation of electricity storage and directions of the proposed changes

The first important regulation regarding the storage of electricity appeared with the Polish law with the entry into force of the Act of 20 February 2015 on renewable energy sources (the RES Act), which in Art. 2 point 17) introduced into the Polish legal system a legal definition of the concept of electricity storage. Further electricity storage regulations were introduced by the Act of 8 December 2017 on the Power Market (Act on the Power Market) and the Act of 11 January 2018 on Electromobility and Alternative Fuels (Act on Electromobility), which as of 22 February 2018 amended the provisions of the Act of 10 April 1997 - Energy Law in the scope regarding energy storage. Unfortunately, the changes to Polish energy storage regulations outlined above still do not constitute a comprehensive regulation of electricity storage, are not sufficiently precise and do not remove the main regulatory barriers in the access of electricity storage to the electricity market. What’s more, legal definitions of "energy storage" and "electricity storage" that differ from each other, as well as uncertainty regarding the status of energy storage on the basis of concession obligations, unbundling or charging for using the network, they create significant risks in undertaking investments in energy storage and imply that currently conducted ones are mainly part of research and development projects carried out with the participation of network operators.

It seems that the further development of energy storage technologies and the use of large-scale energy storage in Poland are conditioned by the adoption of legislative actions in the following areas:
1. Area I - clarifying the status of energy storage on the energy market;
2. Area II - elimination of barriers to the construction of energy storage;
3. Area III - reducing the costs of energy storage and creating incentives for their construction.
AREA I - CLARIFYING THE STATUS OF WAREHOUSES ON THE ENERGY MARKET

It is assumed that the determination of the position and function of energy storage in Poland should be largely derived from regulations adopted at the EU level within the so-called Clean Energy Package for All Europeans, to ensure consistency of national rules with the EU’s internal electricity market regulations. In this respect, the following solutions can be postulated today:

- Introduction of uniform definitions of legal “energy storage system” and “electricity energy storage” in order to avoid interpretation doubts limit the admissible functions of energy storage only to support unstable generation of RES. It seems that the broad definition of storage (i.e. technologically neutral and including all potential applications of energy storage) should ultimately be included in the Energy Law and should serve the purpose of interpreting other acts, including the Power Market Act and the RES Act. In turn, more detailed regulations concerning various energy storage functions can be implemented at the level of the Transmission Network Code / Distribution Network Operation Manual. These documents may provide for a varied regime of storage operations depending on the functions performed, e.g.
  - warehouses integrated with renewable energy sources serving the needs of a single prosumer or manufacturer,
  - individual warehouses serving the needs of the energy recipient,
  - warehouses for balancing local networks (on a small scale),
  - system stores used to support the operation of the power system on a larger scale,
  - batteries for electric cars,
  - batteries supporting the infrastructure for charging cars,
  - fuel cells producing energy from hydrogen, etc.

- Ensuring the priority in the construction of energy storage for entities other than distribution system operators. This objective can be achieved by statutory specification of premises, after which TSOs and DSOs will be entitled to build their own energy storage. These premises should take into account the final shape of regulations and take into account the availability of system services offered by non-DSO energy storage operators. The fulfilment of the premises should be verified each system on a larger scale, battery for electric cars, batteries supporting the infrastructure for charging cars, fuel cells producing energy from hydrogen, etc.

However, in the case of warehouses operated by the DSO, you can consider:

- Allowing inclusion in the warehouse development plan as an alternative to the least viable network investments. If the DSO/ TSO meets the statutory prerequisites for building its own energy storage, the operator could present a project for the construction of such a warehouse as a less expensive option to ensure stability and security of supply, especially in small towns with a small number of inhabitants.

AREA II - ELIMINATION OF BARRIERS TO THE CONSTRUCTION OF ENERGY STORAGE

Facilitating the construction of energy storage facilities by entities other than the DSO could include:

- Exclusion or limitation of the concession obligation in relation to the activity consisting in the introduction of energy from storage to the network.
- Developing favorable conditions for connecting energy storage to the grid, i.e. working out clear rules for connecting warehouses to the network and possible preferences within the scope of the maximum processing time for applications and connection fees, as well as ensuring storage priority for connection before other production installations. The preferential treatment mechanism could function similarly to RES installations but should ensure neutrality of energy storage technologies.
- Enabling the use of electric vehicles as energy storage, from which energy could be transferred to the network. Aggregating power from individual vehicle owners and offering their DSOs could be implemented, for example, by charging service providers.

At the operational level, the following solutions should be considered lowering the operating costs of energy storage, at least in the initial period of storage infrastructure development in Poland:

- Exemption of electricity introduced into the energy storage from distribution fees or even the application of full exemption in the scope of variable charges and the application of reduction coefficients in the scope of fixed charges (e.g. based on the efficiency level of the warehouse). The release of energy entering the warehouse from distribution fees allows to avoid double charging the energy.
- Release of electricity introduced into energy storage from fees associated with the financing of aid programs, including renewable energy charges, a capacity charge, or a cogeneration charge, etc. In this context, it is worth noting that the very essence of energy storage operates in the objectives for which it is charged the RES fee, or the power fee. The warehouse allows you to take full advantage of the RES potential,
ensure the availability of energy from RES and increase the share of energy from RES in the national energy mix, as well as supports the provision of an appropriate level of generation in the system. The functioning of warehouses also contributes to achieving the goals for which a fee will be charged. It seems that the introduction of energy into the energy store during rush hours will be limited due to energy prices during these hours, and the possible loading of the warehouse in the hours for which the charging is expected will be limited to the situation when this energy will be necessary to support network continuity or there will be surplus available power in the system. Consequently, the calculation of the aforementioned fees in the case of energy entering the warehouse cannot be justified. The release of energy entering the warehouse from these fees will avoid double charging this energy with these charges.

- Exclusion of electricity entering energy stores from the obligation to submit certificates of origin for redemption, including certificates of origin of energy from a renewable energy source and energy efficiency certificates. The exclusion of energy entering the warehouse from the obligation to submit certificates of origin and energy efficiency certificates for redemption allows to avoid the double burden of this energy duties.
- Exemption from excise tax on electricity entering the warehouse and electricity consumed in connection with the storage process. The exemption of energy introduced into the excise warehouse allows to avoid double charging this energy with excise duty, and in the part related to consumption for storage purposes - it will provide an additional incentive for the implementation and operation of warehouses.
- Expanding the offer of the National Fund for Environmental Protection and Water Management (“NFOŚiGW”) to non-returnable forms of investment support for the construction of energy storage regardless of the storage technology used (i.e. mechanical, electrical, biological, electrochemical, thermal, chemical, etc.). Currently, NFOŚiGW provides support mainly for the research & development phase. Depending on the scale, the proposed action could require prior notification to the European Commission of the intention to provide state aid.