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LARGE ENERGY STORAGE SYSTEMS – PROCRASTINATION IS FRAUGHT WITH LOSSES

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Key words:
energy storage systems, renewable energy sources, "green" technologies, energy system flexibility, electricity markets, recovery of Ukraine.

The latest researches on the current development and prospects for the further spread of large-scale energy storage systems were analyzed. Trends and forecasts of energy storage technology cost reducing due to an increase in production were traced. The world experience of implementing industrial energy storage systems, which are a key technology for the development of new energy system, an important direction for the advancement of high-tech sectors of the economy, as well as an important starting point for promoting «green» and low-carbon transformation of energy production and consumption was given. The current state of development of energy storage systems in Ukraine and their critical role in maintaining the stable and safe operation of the energy system was considered. Positive changes that have taken place in the field of regulation of energy storage facility operators due to the entry into force of the Law of Ukraine «On Amendments to Certain Laws of Ukraine on the Development of Energy Storages» were emphasized. A declarative nature of the Draft Plan for the Recovery of Ukraine proposed by the National Council for the Recovery of Ukraine from the Consequences of the War in the issue of the development of large energy storage systems and an absence of specific measures aimed at the introduction of such systems in Ukraine was noted. The vision of reasons preventing implementation of plans for the construction of large energy storage systems in Ukraine was drawn. A calculation of the investment payback period, when using the large energy storage facility on the balancing market of NEC «Ukrenergo» was carried out. Based on the obtained calculations the conclusion about the absence of development prospects for energy storage systems without the possibility of obtaining long-term credit resources at low interest rates was made. In this context the need to create conditions for attracting investments from private and public financial institutions of Europe and the USA was noted. The determining role of the government of Ukraine in the development and implementation of the strategy for the advancement of energy storage systems, as well as the importance of efforts to encourage the development of new and the promotion of existing projects was emphasized. Urgent actions to accelerate the introduction of energy storage systems allowing the Integrated Power System of Ukraine to cope with the challenges that will arise as a result of the recovery of industry and the return of refugees to Ukraine after the victory have been called.

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ВЕЛИКІ СИСТЕМИ ЗБЕРІГАННННЯ ЕНЕРГІЇ – ВІДТЕРМІНУВАННЯ ЗАГРОЖУЄ ЗБИТКАМИ

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Ключові слова:
системи зберігання енергії, відновлювальні джерела енергії, «зелені» технології, гнучкість енергосистеми, ринки електроенергії, відновлення України.

Проаналізовано новітні дослідження, присвячені поточному стану і перспективам подальшого розповсюдження великих систем зберігання енергії у світі. Розглянуто тенденції та прогнози зниження вартості систем зберігання енергії завдяки вдосконаленню технологій та нарощуванню обсягів їх виробництва. Наведено світовий досвід впровадження промислових систем зберігання енергії, які є ключовою технологією для розбудови нової енергетичної системи, важливим напрямком розвитку високотехнологічних галузей економіки, а також важливою відправною точкою для просування «зеленої» і низьковуглецевої трансформації виробництва та споживання енергії. Розглянуто сучасний стан розвитку систем зберігання енергії в Україні та їх критичну роль у підтримці стабільної та безпечної роботи енергетичної системи. Наголошено на позитивних змінах, що відбулись в сфері регулювання діяльності операторів установок зберігання енергії завдяки набуттю чинності Законом України «Про внесення змін до деяких законів України щодо розвитку установок зберігання енергії». Зауважено декларативність Плану відновлення України запропонованого Національною радою з відновлення України від наслідків війни, у питанні розвитку великих систем зберігання енергії, та відсутність у ньому конкретних заходів направлених на впровадження таких систем в Україні. Викладено бачення причин, що стримують реалізацію планів з будівництва великих систем зберігання енергії в Україні. Проведено розрахунок строків повернення інвестицій у промислову установку зберігання енергії, за умови її використання на балансуючому ринку НЕК «Укренерго». На підставі отриманих розрахунків зроблено висновок про відсутність перспектив розвитку систем зберігання енергії без можливості отримання довгострокових кредитних ресурсів під низькі відсотки. У зв'язку з цим, відзначено необхідність створення умов для залучення інвестицій з боку приватних та державних фінансових установ Європи і США. Підкреслено визначальну роль уряду України у розробці та імплементації стратегії розвитку систем зберігання енергії в державі, а також важливість зусиль по сприянню розробці нових та просуванню наявних проєктів. Закликано до вжиття невідкладних заходів спрямованих на прискорення впровадження систем зберігання енергії, без яких Об'єднана енергосистема України може не впоратись із викликами, які постануть внаслідок повернення біженців та відновлення промисловості, що буде відбуватися після здобуття перемоги.

Statement of the problem

Implementation of the energy storage system is a strategically important task for our country. This is a way to increase the flexibility of the Integrated Power System of Ukraine, which in the future will make it possible to increase the amount of generation of clean electricity from renewable energy sources.

Ukraine is consistently moving towards the European Union and integrating its own network with ENTSO-E. The Fourth Energy Package, also called the Clean Energy for all Europeans package is one of Ukraine's benchmarks in restoring and ensuring reconstruction based on the principles of energy efficiency and decarbonization. The Fourth Energy Package is aimed among other things at developing renewable energy sources.

Intensification of efforts aimed at decarbonization of the Ukrainian energy sector, in particular due to the increase in the share of electricity produced by renewable energy sources and the development of distributed generation requires not only measures to stimulate these segments, but also measures to increase the flexibility of the energy system. The ultimate goal is to put into operation highly maneuverable capacities and storage systems that will provide balancing of unstable power output of solar and wind power plants, and will be a tool for guaranteeing uninterrupted and reliable electricity supply for all categories of consumers.

On June 8, 2023, the first decision to issue a license for energy storage activities was made at National Commission for State Regulation of Energy and Public Utilities meeting. On the one hand, this is a significant event, because energy storage is very important and useful for the energy system, but on the other hand, it is a rather dubious achievement, because at a time when the energy storage systems is being

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intensively increased all over the world, the implementation of such installations in Ukraine is at an initial stage.

The purpose of the article is to highlight the role of large energy storage systems in the energy system and the reason for their today's low development level in Ukraine.

Analysis of latest research and publications

The benefits of large energy storage systems and the flexibility they bring to power grids are easy to understand, but often quite difficult to measure. However, the need for their accelerated deployment is obvious. It was confirmed by a study conducted by Frontier Economics [1].

In December 2023, the German government launched a strategy for the development of energy storage systems. In this context, the mentioned study offers important evidence for the future role of energy storage for the German energy system.

According to the study, the volume of industrial storage systems in Germany could increase to 60 GW / 271 GWh by 2050, which proves their great importance for the energy system in the future. The capacity of large storage systems in Germany is forecast to increase to 15 GW / 57 GWh by 2030 caused by battery storage sharply falling costs and an ever-growing demand for energy system flexibility. This corresponds to a forty-fold increase in the storage capacity compared to today's 1.4 GWh [1].

Due to the decrease in cost and speed of diffusion, storage systems are expected to make significant progress similar to photovoltaic systems in recent years. But the difference is that large-scale storage facilities are built without support from the government and they are purely market-based.

Storage systems can create significant economic value by shifting the time of electricity production from periods of excess to periods of shortage. According to estimates by Frontier Economics, by 2050 the added value from savings in the wholesale market alone is estimated at approximately 12 billion euros. This includes in particular fuel savings and lower costs due to lower CO^2 emissions. This figure also includes the use of storage facilities to provide system services necessary for the stable operation of the electricity system and participation in intraday electricity markets [1].

The study presents a graph showing the impact of energy storage on reducing price volatility in wholesale markets. Reducing the cost of electricity during periods of high prices leads to an overall reduction in electricity costs for end-users, even though energy storage slightly increases the cost of electricity during periods of low prices.

The construction of new gas-fired power plants in Germany has been faltering for several years and depends on public funding as part of the federal government's power plant strategy. The modeling by Frontier Economics shows that if large storage systems are not built, in addition to the 26 GW of already planned new gas-fired power plants, a further 9 GW will need to be built by 2030. Although large energy storage systems will not be able to make the construction of gas-fired power plants unnecessary, but they can make a significant contribution to reducing the investment pressure on their financing. However, gas-fired power plants are still needed to ensure supply in the 2030s and should be considered as part of an efficient fleet of time-limited power plants [1].

Until recently, for German politicians the issue of energy storage has been mostly irrelevant. The strategy for the development of energy storage systems released by the German government in December 2023 was the first important step that underlines the serious attitude of the state to the role of storage systems in the context of the energy transition. The strategy aims to support greater

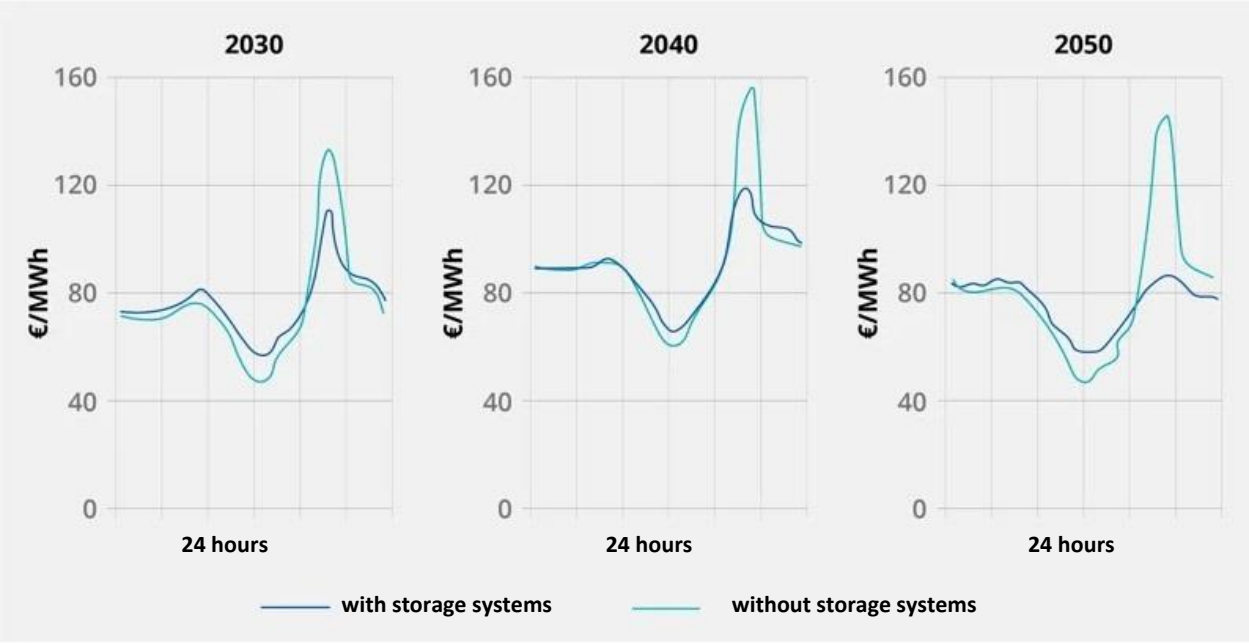

Fig. 1 – Predicted fluctuations in the price of electricity during the day with and without stationary storage systems
Source: Frontier Economics

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deployment of energy storage systems. However, its current version has no clear legislative timetable. Straightforward policy decisions must be made to encourage long-term investment while reducing costs, enhancing energy security and promoting the energy transition in Germany.

An illustrative example of how powerful could be the development of energy storage systems under the condition of attention from the state is China, where energy storage systems are increasingly becoming a key technology for the development of the country's new energy system, an important direction for the advancement of high-tech sectors of the economy, as well as an important starting point for promoting "green" and low-carbon transformation of energy production and consumption.

According to the National Energy Administration of the People's Republic of China by the end of 2023 total installed capacity of energy storage projects completed and put into operation throughout the country reached 31.39GW/66.87GWh with an average energy storage time of 2.1 hours. Installed capacity of projects put into operation in 2023 reached 22.6GW/48.7GWh, which is 260% more than at the end of 2022.

The commissioning of these energy storage projects directly contributed to economic investment of more than 100 billion yuan (USD13.9 billion) promoted the expansion of the industrial chain of related industries and became a "new driving force" of the country's economic development [2].

The huge scale of production and participation in the entire value chain from processing materials to finished products, as well as taking advantage of early adopters in terms of technology and know-how development, enable battery manufacturers from China to offer their products at the lowest prices in the world.

The development of technology and the growth of production capacity around the world will lead to a further decrease in prices within the segment. In this context, attention should be paid to the updated forecast of costs for long-term lithium-ion battery energy storage systems (BESS) until 2050 published by the US National Renewable Energy Laboratory (NREL) in June 2023 [3].

In its study, «Cost Projections for Utility-Scale Battery Storage: 2023 Update», NREL provides a projection of how the cost of capital expenditures for lithium-ion battery energy storage systems will change from 2022 to 2050. The report is based on collected data and forecasts from 16 other publications and uses the example of a four-hour lithium-ion BESS.

The most important conclusion of the study is that costs for energy storage systems from lithium-ion batteries will start to fall in 2023 under the "low" and "medium" cost scenarios, or increase over the next few years under the "high" scenario.

Compared to 2022, NREL estimates that BESS costs will drop by 47%, 32%, and 16% by 2030 under the low, medium, and high cost scenarios, respectively. By 2050, costs could fall by 67%, 51%, and 21%, respectively, under the three scenarios. A significant factor in the decline in the cost of BESS will be the decrease in the cost of the battery cells and units themselves, which can be half the cost of lithium-ion BESS [3].

Current state of development of energy storage systems in Ukraine

The Law of Ukraine "On Amendments to Certain Laws of Ukraine on the Development of Energy Storages" which entered into force on 16th of June 2022, defined the concept of energy storage activities, introduced licensing requirements for such activities and outlined the types of services connected with it [4].

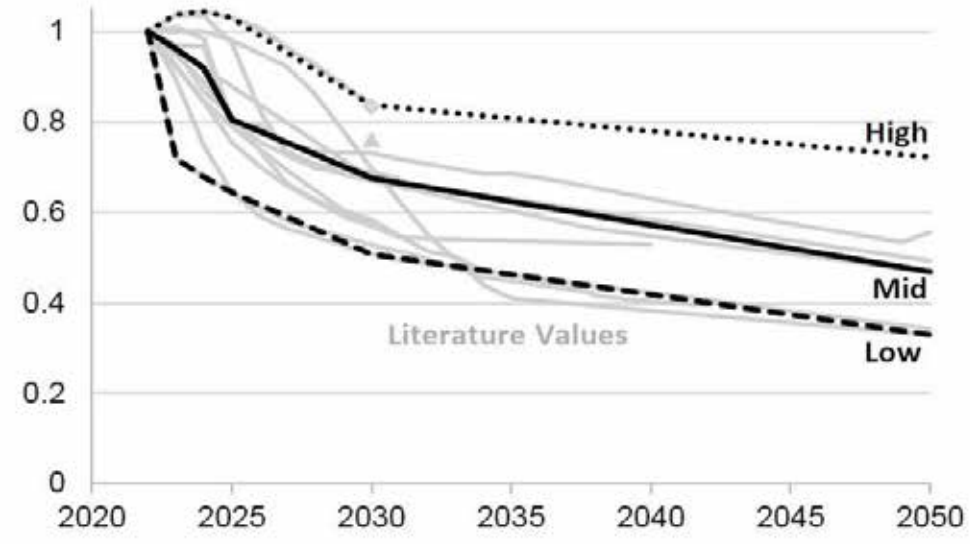

Fig. 2 – Battery cost projections for 4-hour lithium-ion systems, with values normalized relative to 2022.
The "high", "medium" and "low" scenarios are shown as black lines.
Data from publications used during the research are shown as gray lines.
Source: NREL

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The law defines that energy storage is an activity related to the collecting of electricity with the purpose of postponing its final use to a later time than when it was produced.

The law envisages the appearance of a new participant in the electric energy market – the operator of an energy storage facility, and regulates its legal status. The operator of an energy storage facility can be a natural or legal entity (except hydro-accumulating power plants) that uses the energy storage facility for the further sale of electricity, provision of auxiliary services or balancing services.

It is important that according to the law the operator of the energy storage facility pays the fee for the services of transmission of electric energy, distribution of electric energy, fee for the services of dispatch management, only for the amount of the absolute value of the difference between the monthly collection and the monthly release of electric energy by the energy storage facility, which ensures no double billing for these services.

Unfortunately, there is no electricity storage strategy in Ukraine. The project of the Recovery Plan of Ukraine proposed by the National Council for the Recovery of Ukraine from the Consequences of War envisages the construction of pilot projects of energy storage units with a capacity of 50-200 MW in 2023-2025 to ensure balancing of the system and fulfillment of climate obligations. During 2026-2032, it is planned to increase the capacity of energy storage systems to 750 MW – 1 GW [5]. However, there is no plan of measures to implement these goals, as well as sources of their financing. That is, the state expects that it will be carried out by private investors.

But despite loud statements from both government officials and business representatives about the great potential of the energy storage market, as well as the availability of few projects for the construction of large energy storage systems announced by DTEK, MHP and OKKO groups, the implementation of none of them has yet started. The main obstacle in this is the lack of companies' own funds for the realization of such projects, and difficulties in attracting financing from foreign creditors. Undoubtedly, there is a war going on in Ukraine which increases credit risks but investors may be confused by the project payback terms. Let's try to calculate these terms.

Due to the fact that no project for the construction of a large energy storage system in Ukraine has yet been realized there are no data on its cost, while estimated value of the planned projects is a commercial secret. But there is a possibility to make calculations based on the cost of foreign projects.

As the basis for these calculations was chosen the project of South Australian energy infrastructure company Epic Energy, which ordered an energy storage complex from the manufacturer e-STORAGE, which is a subsidiary of the Canadian Solar company. E-STORAGE will deliver a 110 MW / 220 MWh DC system based on lithium-iron-phosphate (LFP) battery cells and start construction of the project in the second quarter of 2024. Epic Energy reported in a separate release that the amount of investment in the specified project will be about USD 130 million [6].

Storage systems can be used for operations on intraday electricity markets, but their maximum efficiency is achieved when working precisely on the NEC "Ukrenergo" balancing market, where the electricity purchase price is the lowest (from UAH 0.01/MWh), and the sale price is the highest (up to UAH 9000.00 /MWh). However, it should be noted that the volume of electricity trades on the balancing market sometimes, in particular on weekends, would not allow to fully use the installed capacity of the system chosen as an example, and the difference in the price of purchase and sale is not significant, so such periods were not included in calculation.

Below is a table of results of possible electricity purchase and sale operations on the balancing market of the system with an installed capacity of 110 MW / 220 MWh at the auctions of the balancing market of NEC "Ukrenergo" in the directions of unloading and loading, for the period from November 1 to November 30, 2023 [7].

The financial result is given taking into account the efficiency factor of 90%, specified in the characteristics of LFP batteries on the manufacturer's website [8].

If we assume that one dollar is converted at the rate of UAH 38.00, the cost of a similar LFP system in Ukraine could be UAH 4.94 billion. Thus, it will take about 124 such periods, i.e. more than 10 years just to return the initial investment. And this is not taking into account payment for electricity transmission and distribution services, payment for dispatching management services, operating costs, loan servicing, taxes, etc. One of the factors that can improve the situation may be the regulator's permission to enter into agreements on the balancing market at negative prices, in which case the power generation will have a choice, either to limit its own capacity, or to pay extra for the produced electricity to the consumer. But this will be possible only when a sufficient amount of storage systems is already put into operation.

It should be understood that the state of affairs in Ukraine is not unique. Given the current prices on the world market of energy storage systems, it is not worth counting on a quick return on investment, but this does not stop European companies, because for them funding for such a long term is not problematic. As for Ukraine, taking into consideration the military risks, it can be quite difficult.

In the current situation, the role of the state comes to the forefront, it has to either create attractive conditions for private investors or build the necessary facilities on its own – and this may be the right decision, because it should be considered as an investment in the development of infrastructure, similar to the construction of highways.

The Ukrainian energy system is unbalanced, the commissioning of two nuclear power units, announced by the Ministry of Energy, will add basic load to the energy system, but not only will not solve the problem of its balancing but rather increase it. Balancing the energy system by increasing or decreasing the load of coal-fired TPP units impacts negatively on their operational capabilities, while the construction of highly maneuverable gas capacities requires time and large amounts of funding.

The state could motivate private investors by approving at the legislative level tax credits for energy storage systems, but unfortunately as long as hostilities continue on the territory of Ukraine, and there is a threat of missile

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Table 1

Date	Balancing energy weighted average price for downward, UAH/MWh	Balancing energy weighted average price for upward, UAH/MWh	Financial result, UAH
01.11.2023	11,56	8 281,20	1 637 388,72
02.11.2023	11,89	8 042,42	1 590 044,94
03.11.2023	0,01	8 843,75	1 751 060,52
04.11.2023	499,00	6 249,94	1 138 686,12
05.11.2023	0,01	6 749,90	1 336 478,22
06.11.2023	0,01	7 112,00	1 408 173,03
07.11.2023	0,01	7 135,74	1 412 874,54
08.11.2023	12,37	8 868,45	1 753 502,85
09.11.2023	9,25	8 923,91	1 765 102,68
10.11.2023	2,65	8 542,99	1 690 987,32
11.11.2023	12,35	6 886,36	1 361 053,98
13.11.2023	0,01	8 935,53	1 769 231,97
15.11.2023	2,61	7 249,98	1 434 980,25
16.11.2023	2 585,00	8 931,21	1 256 548,59
17.11.2023	2 689,50	7 899,32	1 031 543,37
18.11.2023	925,01	8 060,00	1 412 729,01
19.11.2023	1 400,00	7 171,09	1 142 675,82
20.11.2023	322,50	7 900,62	1 500 467,76
21.11.2023	1 750,00	7 921,25	1 221 907,50
22.11.2023	0,01	6 924,50	1 371 048,03
23.11.2023	0,01	6 922,49	1 370 650,05
24.11.2023	687,50	8 337,88	1 514 774,25
25.11.2023	675,01	8 276,05	1 505 006,91
26.11.2023	480,00	8 934,94	1 674 077,13
27.11.2023	0,01	7 750,00	1 534 497,03
28.11.2023	2 766,50	8 928,82	1 220 139,36
29.11.2023	2 550,00	8 910,02	1 259 283,96
30.11.2023	2 270,00	7 000,00	936 540,00
		In general	40 001 453,91

Source: Energy Map

attacks in any region, even in the case of adopting such a legislative decision a massive influx of investments it's unlikely to be expected.

Another way of funding could be grants, both from the EU and from financial funds, such as Denmark IFU or Netherlands FMO. But it requires the government's hard work to develop a strategy for the implementation of energy storage systems, as well as the development of new projects and the support and promotion of existing projects, including private ones.

The recovery of industry and the repatriation of Ukrainian refugees after the victory will cause an overload on the power system which simply cannot be able to cope with new challenges. That will lead to massive blackouts and huge losses. In any case, there are no simple and most importantly cheap ways to solve the problem of the imbalance of the energy system of Ukraine. It is necessary to act and find sources of financing now because procrastination in solving this problem will cost much more in the future.

Conclusions

- intensification of efforts aimed at decarbonization of the Ukrainian energy sector requires among other things, putting into service of energy storage systems which have to increase the flexibility of the Integrated Power System of Ukraine;
- the latest studies prove the need to boost the installed capacity of energy storage systems, which will provide balancing of the unstable power output of solar and wind power plants and become a tool for guaranteeing continuous and reliable electricity supply for all categories of consumers;
- implementation of projects for the construction of energy storage systems in Ukraine is hindered by long payback periods and a lack of cheap financing;
- the state must play a key role in the development and implementation of the strategy for the advancement of energy storage systems in Ukraine.

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