CONSUMER DEMAND AND USAGE BENEFITS OF ELECTRICAL ENERGY STORAGE BATTERY SYSTEMS

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Abstract. *This article explores the advantages that consumers can gain from implementing electrical energy storage battery systems. It highlights benefits such as peak demand management, load shifting, backup power, and integration of renewable energy sources. The article also discusses cost savings, improved grid stability, and the role of advancing technology and supportive policies. By empowering consumers to optimize electricity usage and reduce grid dependency, energy storage systems contribute to a sustainable energy future.*
Keywords: *distribution generation, solar photovoltaic stations, accumulator batteries, grid control system.*

Introduction: As the global transition towards sustainable and renewable energy sources continues to gain momentum, Uzbekistan, a country rich in natural resources, is also embracing the shift towards a greener and more reliable energy future. With a growing emphasis on reducing greenhouse gas emissions and increasing energy efficiency, Uzbekistan is now exploring the potential of electrical energy storage battery systems to meet its energy needs while reaping numerous benefits for consumers [3; 4].

In recent years, consumer demand for electrical energy storage battery systems in Uzbekistan has been steadily increasing. This surge in interest can be attributed to several factors, including the need for energy independence, cost savings, grid stability, and environmental sustainability. As consumers become more aware of the advantages offered by these systems, their adoption is expected to play a crucial role in shaping Uzbekistan's energy landscape [5].

This article aims to delve into the consumer demand and usage benefits of electrical energy storage battery systems in Uzbekistan. We will explore how these systems are revolutionizing the way energy is generated, stored, and utilized, while empowering consumers to take control of their energy consumption and contribute to a cleaner and more resilient grid.

Throughout this article, we will highlight the specific advantages that electrical energy storage battery systems bring to Uzbekistan's energy sector. We will discuss the potential for energy cost savings, improved energy reliability, integration with renewable energy sources, and the positive impact on the environment. Additionally, we will showcase real-world examples and case studies to illustrate the successful implementation of these systems in Uzbekistan and the tangible benefits experienced by consumers.

The government has implemented a number of measures to widely introduce renewable energy sources in Uzbekistan. On February 16, 2023, the decision of the President of Uzbekistan DP-57 aimed at accelerating the introduction of renewable energy sources and energy-saving technologies was adopted [3]. In addition, on June 14 of the same year, the decision of the Cabinet of Ministers No. 247, which defines the procedure for the sale of excess electricity produced by business entities using renewable energy sources, was adopted.

Metodology and discussion: Small-scale energy storage battery systems (BESS) play an important role in solving the problems of electricity supply in developing countries [1; 10]. These systems, often based on ionic or lead-acid batteries, are used to store electricity for later use, and are installed in areas with frequent grid outages or insufficient power generation. The main features of the BESS device are:

- For consumers disconnected from the electricity grid: Many developing countries, especially in rural areas, have limited access to centralized grids. Small-power BESS can be combined with renewable energy sources such as solar panels or small wind turbines to achieve a stable and reliable electricity supply in areas without access to centralized power grids [4; 9].
- Grid stability and peak consumption period: In areas with weak or irregular grid infrastructure, BESS helps to stabilize energy supply by storing excess energy during periods of minimum demand and supplying during peak hours [2; 8]. This helps balance the load on the grid and avoid power outages or fluctuations.
- Emergency power backup: Small-scale battery systems serve as backup power during outages, which are common in many developing regions. They ensure that essential services such as hospitals, schools and small businesses continue to operate during power outages.
- Improve energy use: BESS helps to increase energy use and reduce energy shortages. By providing reliable electricity, they enable consumers to engage in economic activity, access better health services, and improve their overall standard of living.
- Reducing dependence on fossil fuels: BESS helps to reduce dependence on fossil fuels for energy production in combination with renewable energy sources. This helps reduce greenhouse gas emissions and mitigate the environmental impact of energy production in these areas.
- Disadvantages: Despite the advantages, challenges remain such as initial investment costs, maintenance and battery recycling/disposal. Ensuring proper maintenance and recycling procedures are critical to sustainability and minimizing environmental impact.

Efforts are underway to make these systems more efficient, durable, and affordable, allowing for wider implementation in various developing regions. Renewable energy sources and advances in battery technology to support solutions for consumers disconnected from the grid are driving the proliferation of small-scale battery energy storage systems in developing countries.

Figure 1 shows how to equip electricity consumers with energy storage battery systems and increase the reliability of their electricity supply. BESS usually consumes excess electricity during daytime off-peak hours and transmits power to consumers at night when there are no solar photovoltaic stations, defined by the following expressions [3; 5; 7].

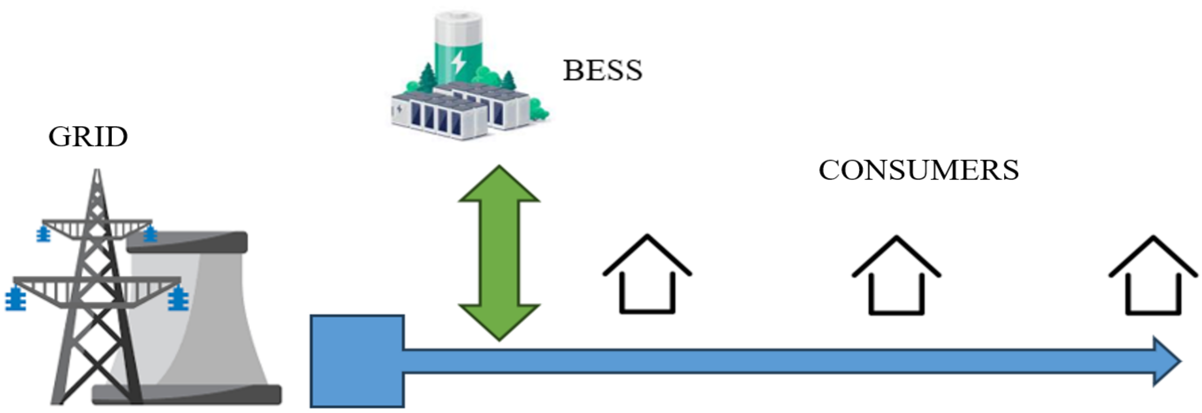

Fig. 1. Consumers with BESS in the electricity network

$$W_{bess} = \max(W_{ist} - (W_{qtem} + W_t)) \quad (1)$$

where W_{bess} - the electrical energy that the battery pack must receive, W_{ist}- the demand for electricity from consumers that is needed during off-peak times, W_{qtem}- electricity from distributed generation sources, W_t electricity supplied through central power networks. If the distributed generation sources consist of wind and solar photovoltaic stations, then the expression will look like.

$$W_{bess} = \max(W_{ist} - (W_{sh} + W_q + W_t)) \quad (2)$$

where W_{sh}, W_q- electricity from wind and solar photovoltaic stations.

The battery stops receiving power after it is fully charged. At the same time, the battery discharge process is also determined by the above expressions.

We use the following expression to determine the ability of the accumulator battery to receive or transmit power [6]:

$$W_{bess} = \max\left(\frac{|P_{besmak}|}{S_{bess} * H * \mu}, \frac{|P_{bessmin}|}{S_{bess} * H * \mu}\right) \quad (3)$$

where $P_{besmak}, P_{bessmin}$- able to receive or transmit maximum and minimum power per unit time, S_{bess}- the value of the battery backup, μ- the useful duty factor of the accumulator battery, H-battery life at specified capacity.

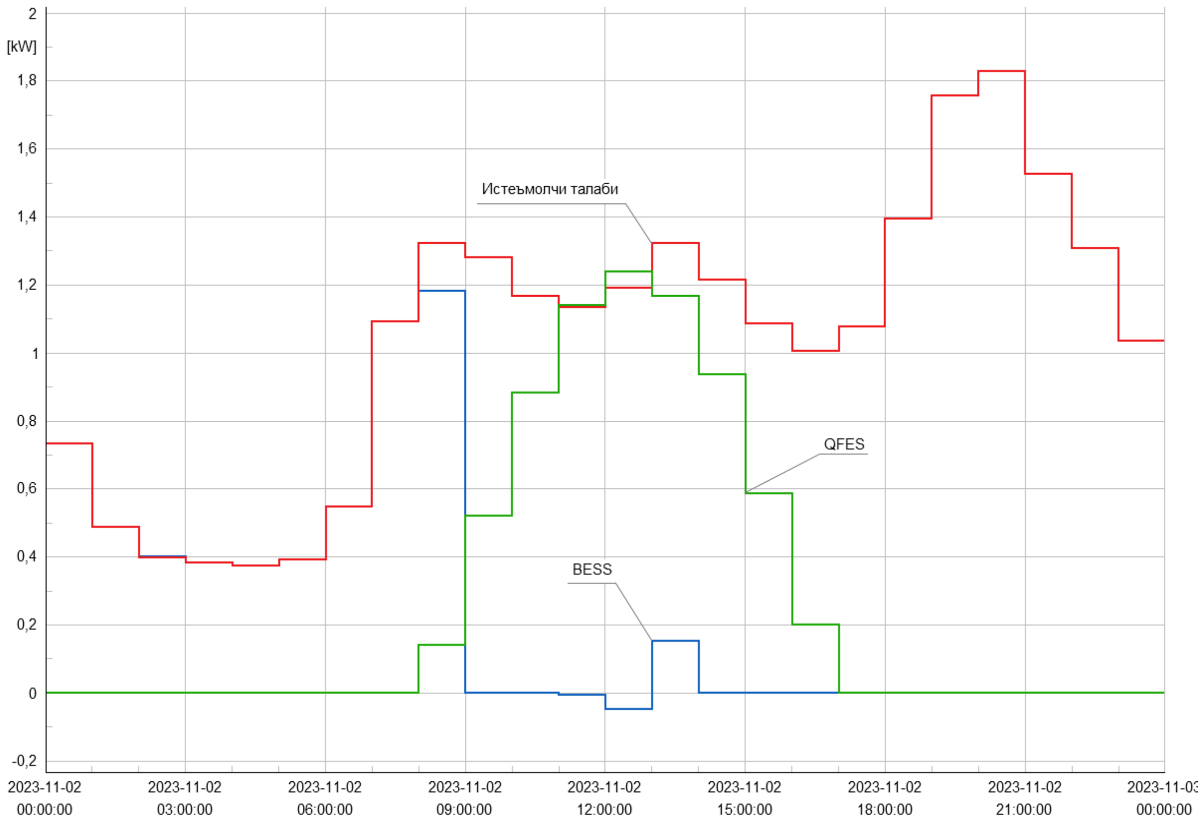

Fig. 2. Demand of consumers with BESS in the power grid

Figure 2 shows the customer demand satisfaction of a 1.3 kW solar PV plant installed in a house and a BESS device, according to which the full customer demand of the BESS is satisfied at night. During the daytime, PV plant meets a certain consumption demand and the rest of the electricity demand is provided by the grid.

Table 1 shows that the consumer's demand for electricity is between 10^{00} and 13^{00} during the day, when both BESS and PV plant cover the consumption almost completely, but between

17^{00} and 23^{00} in the evening, it was observed that the consumer receives power entirely from the low voltage distribution network. This is due to the fact that the BESS cannot accumulate enough charge after transmitting its full energy to the consumer.

Table 1.

Provision of household electricity consumption by BESS and PV plant

02.11.2023 Time	Consumer demand kW	BESS generation kW	PV plant generation kW
00.00	1,38	1,38	0,00
01.00	1,16	1,16	0,00
02.00	1,02	1,02	0,00
03.00	0,97	0,97	0,00
04.00	1,06	1,06	0,00
05.00	1,29	1,29	0,00
06.00	1,40	1,40	0,00
07.00	1,82	1,82	0,00
08.00	2,77	2,40	0,37
09.00	4,40	3,04	1,36
10.00	4,67	2,36	2,31
11.00	4,78	1,80	2,97
12.00	4,84	1,60	3,24
13.00	4,17	1,12	3,05
14.00	3,53	1,08	2,45
15.00	3,58	2,05	1,53
16.00	4,02	3,50	0,52
17.00	4,09	0,00	0,00
18.00	4,08	0,00	0,00
19.00	2,94	0,00	0,00
20.00	2,12	0,00	0,00
21.00	1,86	0,00	0,00
22.00	1,61	0,00	0,00
23.00	1,52	0,00	0,00

Conclusion: In conclusion, electrical energy storage battery systems provide significant benefits to consumers. By integrating peak demand management, backup power, and renewable energy sources, these systems increase reliability, efficiency, and flexibility in meeting electricity needs. Additional benefits include cost savings, modern grid stability, and reduced energy storage adoption issues. Also, with advanced technologies, consumers have the opportunity to optimize their use of electricity, reduce grid dependency and contribute to a sustainable energy future. The deployment of electric energy storage battery systems is an important step towards achieving a more sustainable and environmentally friendly energy landscape.

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