

## THE VALUE OF AGGREGATION IN ENSURING THE ECONOMIC SECURITY OF ENERGY COMPANIES

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**Introduction.** In Ukraine, despite the impact of Russia's military aggression, there is a fairly active growth in the number of small electricity producers and promoters, which is explained by the ability of the decentralised system to autonomously supply energy and thereby reduce the risks of disruptions to critical energy infrastructure [1].

However, the increase in small-scale electricity generation and the active development of consumerism significantly complicate the already difficult task of balancing electricity and ensuring the economic security of energy suppliers, which, in addition to generating electricity, are responsible for providing stable, reliable and efficient operation of energy networks. Under such conditions, energy system management requires more and more coordinated actions between electricity producers, distribution system operators (DSOs) and transmission system operators (TSOs) [2].

This article seeks to answer this question. The authors focus on aggregation - a mechanism designed to balance the production and consumption of electricity, regulate its sale and purchase in the relevant market, and thus, to some extent, guarantee the economic security of energy enterprises.

**Overview of recent research and publications.** A review of recent sources of research and publications shows that both foreign and domestic scholars are actively discussing the issues of aggregation in the electricity market and its impact on the economic security of energy companies. In particular, Li S., Xu Q., Yang Y., Xia Y. and Hua K. (2024) note that aggregation in the electricity market determines the relationship between electricity generation and consumption [3]. By accumulating excess energy during high power and releasing it during low power, according to Wang Y., Wang H., Xie D. and Zhang Y. (2024), aggregation allows for optimising electricity generation consumption, thus avoiding imbalance risks [4]. According to Denysiuk S.P., Belokha G.S. and Cherneshchuk I.S. (2024), maintaining a balance between electricity generation and consumption is the most important condition for the stable operation of the electricity system. Therefore, with the increasing share of renewable energy sources in the overall generation balance (which is characterised by a variable generation schedule), there is a need to find new approaches to balancing electricity and ensuring the economic security of energy enterprises [5].

Liu Y., Luo X., Chen M. and Suo X. (2024) note that one of the threats to the economic security of energy enterprises is price fluctuations in the electricity market. It is aggregation, due to its flexibility and adaptability to changes in market conditions, that can mitigate the price risks of energy companies [6]. Lee J. and Won D. prove that aggregation is able not only to cope with price fluctuations in the electricity market but also to maximise the monetary benefits for members of the aggregated group [7]. Bai, X., Fan, Y., Hao, R. et al.

emphasise that improving monetary benefits for members of the aggregated group occurs by trading surplus-generated electricity at profitable domestic market prices determined by the energy market aggregator [8]. A market-based pricing mechanism based on the supply and demand ratio is used to determine the domestic day-ahead market prices. Thus, while constantly monitoring the price variable in the electricity market, the aggregator uses market signals to buy/sell electricity at profitable prices for the members of the aggregated group [5].

However, despite the fact that the feasibility of introducing aggregation has been proven, it has not yet become widespread in the country's electricity market. Consequently, energy companies, which are currently in a rather difficult situation (due to the geopolitical situation in Ukraine and the large-scale loss of consumers due to population migration), are losing a unique opportunity to generate additional income and improve economic security. The reason for this is the low level of awareness of electricity market participants of the value of introducing aggregation. Therefore, this study aims to transfer knowledge and understanding of the importance of aggregation in ensuring the economic security of energy companies.

**Objectives of the article.** The article aims to conduct a comprehensive study of aggregation as a mechanism designed to balance electricity production and consumption, regulate its sale and purchase in the relevant market, and thus guarantee the economic security of energy enterprises in a certain way.

**The main material of the study.** Ukraine, with the aim of becoming a member of the European Union, within the framework of the Treaty establishing the Energy Community and the EU integration action plan, has implemented Directive (EU) 2019/944 of the European Parliament and of the Council of 05.06.2019 'On common rules for the internal market in electricity and amending Directive (EU) 2012/27' [9], thus committing itself to liberalising the electricity market, introducing distributed generation with guaranteed capacity, and modernising the network infrastructure of the transmission and distribution systems.

In this regard, the Government of Ukraine has adopted a number of legislative acts designed to facilitate the implementation of distributed generation projects, including the following that deserve special attention:

The Law of Ukraine 'On Amendments to Certain Laws of Ukraine on Restoration and Green Transformation of the Energy System of Ukraine' dated 27.07.2023 No. 3220-IX [10], which amended part one of Article 1 of the Law of Ukraine 'On the Electricity Market' dated 14.07.2017 No. 2019-VIII [11] with respect to the definitions of such concepts as: aggregator, aggregation, aggregated group, aggregation unit, independent aggregator, microgrid management.

NEURC Resolution No. 1211 of 26.06.2024 [12] defines the aggregator's responsibilities. It regulates its relations in the retail electricity market, particularly related to the activities of an active consumer, operator and users of a small distribution system [12]. Thus, in accordance with [12], the aggregator is responsible for balancing all electrical installations that are part of its aggregation unit (except for electrical installations intended for consumption by consumers who purchase electricity from another market participant), as well as for the purchase and sale of electricity in the relevant market and the provision of ancillary services [12].

Therefore, aggregators should be recognised as an important link in the electricity distribution system, as they manage the production, storage and balancing of energy, which allows electricity market participants to generate additional revenues, and for TSOs – more balancing capacities and simplification of the dispatch management structure [13].

Thus, the aggregator has two main roles, and therefore the following functions (Fig. 1).

With regard to the function of a flexibility expert, it should be noted that each of the electricity market participants is a balance sheet responsible party (hereinafter referred to as the BRP). However, according to the Market Rules approved by the Resolution of the National Commission for State Regulation of Energy and Public Utilities of 14.03.2018 No. 307 [14], as well as in accordance with part 2 of Article 70 of the Law of Ukraine 'On the Electricity Market' [11], electricity suppliers are the IBP of their consumers, any electricity market participant may transfer its responsibility for the balance to another party, provided that it is a member of an aggregated group. Under such conditions, the settlement of imbalances, according to the Law [10], is assigned to the aggregator, but only if it generates units that include supply units with a total capacity of more than 1 MW. [15, p. 119].

As for the function of a market expert, it looks like this: several power plants (RES) are combined into an aggregated group administered by an aggregator. The association is carried out on the basis of a relevant agreement on participation in the aggregated group. The aggregator is an alternative to the Guaranteed Buyer

for RES producers; it buys the electricity produced, resells it, and is the party responsible for the balance. The aggregator also provides ancillary services to National Energy Company “Ukrenergo” and executes dispatch commands. Profits from such activities will be received by both the aggregator and the members of the aggregated group [16].

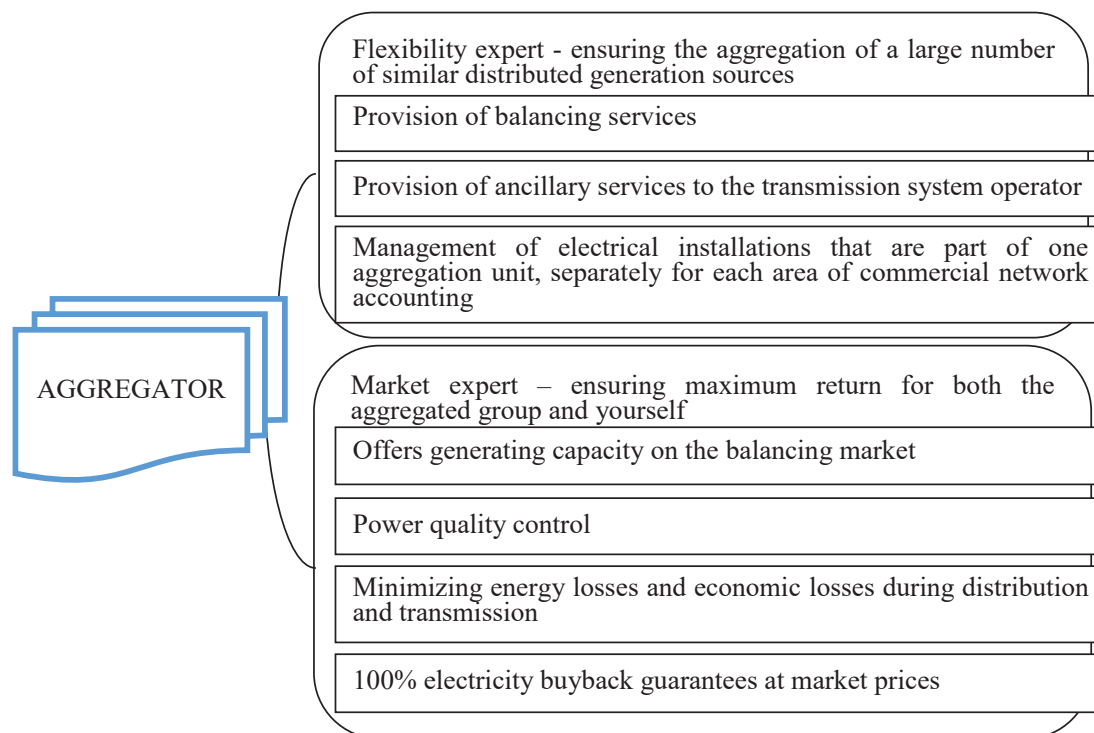


Figure 1. Roles and functions of the aggregator in the electricity market

Source: [10]

An aggregated group is an association of small and medium-sized power producers (up to 20 MW) for joint generation and sale of electricity. By combining their capacities, the group members operate as a single ‘virtual power plant’ managed by the aggregator company. Such consolidation creates a number of benefits for small producers that they cannot obtain if they operate independently [17].

In particular, JSC Energy Company of Ukraine (hereinafter referred to as ECU), a national energy trading company, has launched one of the first aggregation groups in Ukraine that offers operational and commercial management services for distributed generation facilities. Services for electricity producers include load planning, dispatching, purchase/sale of electricity and imbalance optimisation. At the same time, the aggregator represents the interests of participants in the electricity market, including the day-ahead market, the intraday market, the balancing market, and the ancillary services market. Therefore, if small producers previously did not have the opportunity to optimise their imbalances in balancing groups, the aggregated group of the ESO creates such an opportunity, increasing their income by guaranteeing the purchase of 100% of electricity at market prices [17].

However, in order for electricity market participants to take advantage of aggregation opportunities, an appropriate digital infrastructure should be created to allow for intensive exchange of digitised data on the state of energy markets, electricity prices, and technical parameters of the grid, which is an important prerequisite for the spread of aggregation and ensuring the economic security of energy companies.

**Conclusions.** Thus, in order to achieve this goal, an attempt has been made to transfer knowledge about the value of introducing aggregation in the electricity market for market participants, especially for energy companies. The author emphasises the technical and economic benefits of electricity market participants by introducing aggregation in the electricity market.

It is emphasised that creating an aggregator and an aggregated group allows for solving the most important issues in the electricity sector, namely, balancing the supply and demand for generated electricity and ensuring the economic security of energy enterprises.

It is noted that with the full-scale invasion of Ukraine by the Russian aggressor, energy enterprises suffered the most, as enemy attacks were primarily aimed at destroying critical infrastructure. Therefore, ensuring the economic security of energy companies requires new approaches to managing electricity generation and consumption, electricity pricing, and incentives for the further development of small-scale electricity generation facilities.

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JEL G21

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The study attempts to transfer knowledge on the importance of introducing aggregation in the electricity market for both energy sector enterprises and other market participants. The main technical and economic advantages of introducing an aggregation mechanism are identified. It is emphasised that creating aggregators and aggregated groups allows solving key problems in the electricity sector. This, in particular, contributes to a more efficient

balancing of electricity supply and demand, a prerequisite for the stable functioning of energy systems. Additionally, it is noted that aggregation allows for optimising the load on the grid, reducing the risk of overload and increasing the efficiency of the use of generated resources. In addition, aggregated groups can use modern technologies for monitoring and forecasting consumption, which allows them to respond quickly to market changes and increase the level of adaptability of energy companies. Particular attention is paid to the impact of hostile attacks on Ukraine's energy sector. The large-scale invasion of Russian troops led to significant losses of energy companies due to targeted attacks on critical infrastructure, which caused interruptions in electricity supply and complicated the functioning of the country's economy. In this context, the need for new approaches to managing electricity generation and consumption, improving pricing mechanisms and developing small-scale generation, which will help strengthen the country's energy security, is substantiated. Another important aspect is stimulating investment in decentralised energy sources, which will help increase energy independence and market flexibility. Using renewable sources in aggregated groups will reduce dependence on traditional energy sources and contribute to the environmental sustainability of the energy sector. At the same time, aggregation will balance electricity production and consumption, regulate its sale and purchase in the relevant market, and thus, to some extent, guarantee the economic security of energy companies.

**Keywords:** economic security of energy enterprises, economic losses, guaranteeing economic security, aggregation, aggregator, aggregated group, electricity balancing, market price for electricity, additional income.

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JEL G21

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У межах проведеного дослідження здійснено спробу трансферу знань щодо важливості впровадження агрегації на ринку електроенергії як для підприємств енергетичного сектору, так і решти учасників ринку. Визначено основні технічні та економічні переваги запровадження механізму агрегації. Наголошено, що створення агрегаторів та агрегованих груп дозволяє вирішити ключові проблеми у сфері електроенергетики. Це, зокрема, сприяє ефективнішому балансуванню попиту та пропозиції електроенергії, що є необхідною умовою для стабільного функціонування енергетичних систем. Додатково зазначено, що агрегація дозволяє оптимізувати навантаження на мережі, зменшуючи ризики перевантаження та підвищуючи ефективність використання генерованих ресурсів. Крім того, агреговані групи можуть використовувати сучасні технології моніторингу та прогнозування споживання, що дозволяє оперативно реагувати на зміни ринку та підвищувати рівень адаптивності енергетичних підприємств. Особливу увагу приділено впливу ворожих атак на енергетичний сектор України. Масштабне вторгнення російських військ призвело до значних втрат підприємств енергетики через прицільні атаки на критичну інфраструктуру, що спричинило перебої в електропостачанні та ускладнило функціонування економіки країни. У цьому контексті обґрунтовано необхідність нових підходів до управління генерацією та споживанням електроенергії, удосконалення механізмів ціноутворення та розвитку малої генерації, що сприятиме посиленню енергетичної безпеки країни. Важливим аспектом є також стимулювання інвестицій у децентралізовані джерела енергії, що допоможе підвищити енергетичну незалежність та гнучкість ринку. Використання відновлюваних джерел у складі агрегованих груп дозволить зменшити залежність від традиційних енергоносіїв та сприятиме екологічній стійкості енергетичного сектора, а агрегація забезпечить балансування виробництва та споживання електроенергії, регулювання її купівлю-продажу на відповідному ринку, а отже, і певним чином гарантування економічної безпеки підприємств енергетики.

**Ключові слова:** економічна безпека підприємств енергетики, економічні втрати, гарантування економічної безпеки, агрегація, агрегатор, агрегована група, балансування електроенергії, ринкова ціна на електроенергію, додатковий дохід.