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ECONOMIC COMPETITIVENESS OF GREEN ENERGY BUSINESS PROJECTS IN UKRAINE

Abstract. The article studies the economic competitiveness of a green energy business project by variations in its implementation to assess the prospects for forming a prosumer group. The use of statistical and comparative analysis has revealed that government support provides green energy development today. Most domestic renewable energy projects are uncompetitive without such assistance. The coronavirus pandemic in 2020-2021 disclosed the issues of the high price of green energy, the priority of its purchase, the interruption of renewable electricity generation, etc. Russia's full-scale war in Ukraine in 2022 has put the industry on the edge of physical and economic destruction. Today, it is critical to preserve and support remaining green energy facilities and encourage their reconstruction in the occupied territories.

The gradual convergence of green tariffs with rising energy prices improves the competitiveness of renewable energy projects and creates a basis for the formation of prosumers. To substantiate the feasibility of transforming domestic energy consumers and the economic competitiveness of the green energy business, we conducted an investment analysis of the project of an industrial photovoltaic solar power plant with a capacity of 100 kW located in the

Sumy region. 3 options for the use of generated green electricity were considered: 1) sale of electricity at a feed-in tariff; 2) partial consumption of generated electricity for own needs and sale of its surplus at the feed-in tariff; 3) consumption of generated electricity for own needs. At current electricity prices and the feed-in tariff, the best option is 100% consumption of generated electricity for own needs, i.e., the company's transformation into a prosumer. The payback period for this option is longer by almost 4 months, but its profitability increases to 75.8% compared to 62.7 and 71.7% for other options. Thus, the current conditions of the energy market contribute to the formation of the prosumer group in Ukraine.

Keywords. Business, Economic Competitiveness, Efficiency, Feed-in Tariff, Project, Prosumer, Renewable Energy, Solar Power Plant, Ukraine.

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ЕКОНОМІЧНА КОНКУРЕНТОСПРОМОЖНІСТЬ ПРОЄКТІВ «ЗЕЛЕНОГО» ЕНЕРГОБІЗНЕСУ В УКРАЇНІ

Анотація. Стаття визначає економічну конкурентоспроможність проєкту «зеленого» енергобізнесу за варіаціями його впровадження для оцінювання перспектив формування класу просьюмерів. Методами статистичного і порівняльного аналізу визначено, що розвиток «зеленої» енергетики сьогодні забезпечується за рахунок державної підтримки. Здебільшого вітчизняні проєкти відновлюваної енергетики є неконкурентоспроможними без такої допомоги. Пандемія коронавірусу у 2020-2021 роках виявила проблеми, обумовлені високою ціною «зеленої» енергії, пріоритетністю її закупівлі, переривчатістю відновлюваної електрогенерації, тощо. Повномасштабна війна Росії в Україні у 2022 році поставила галузь на межу фізичного та економічного знищення. Сьогодні критично важливим є максимальне збереження і державна підтримка «зелених» енергооб'єктів, а також стимулювання їх відбудови на деокупованих територіях.

Поступове зближення «зелених» тарифів зі зростаючими цінами на енергоринку покращує конкурентоспроможність проєктів відновлюваної енергетики, створюючи базу для формування просьюмерів. Для обґрунтування доцільності трансформації вітчизняних енергоспоживачів та економічної конкурентоспроможності «зеленого» енергобізнесу нами проведено інвестиційний аналіз проєкту промислової фотоелектричної сонячної електростанції потужністю 100 кВт, розташованої у Сумській області. Розглядалися 3 варіанти використання виробленої «зеленої» електроенергії: 1) продаж електроенергії за «зеленим» тарифом; 2) часткове споживання виробленої електрики на власні потреби та продаж надлишку за «зеленим» тарифом; 3) споживання виробленої електрики на власні потреби. За чинних ринкових цін на електроенергію і «зеленого» тарифу найкращою опцією є 100%-ве споживання згенерованої електроенергії на власні потреби, тобто перетворення підприємства на просьюмера. Строки окупності за варіантом є довшими на майже 4 місяці, але рентабельність проєкту зростає до 75,8% порівняно з 62,7 та 71,7% за іншими опціями. Отже, існуючі умови енергоринку сприяють формуванню класу просьюмерів в Україні.

Ключові слова. Бізнес, економічна конкурентоспроможність, ефективність, «зелений» тариф, проект, просьюмер, відновлювана енергія, сонячна електростанція, Україна.

Introduction. The economic competitiveness of the green energy business is the key to providing environmentally friendly and affordable energy for both business entities and the population around the world. The introduction of renewable energy (RE) technologies meets Sustainable Development Goals and decarbonizes national economies ensuring the growth of energy independence of countries, improving their environment quality, and bringing social benefits. At the same time, due to technical and technological restrictions and adverse economic conditions, the green energy projects often lose to traditional energy technologies in terms of economic efficiency without the use of state support. Therefore, it is important to study and consider current trends of the RE market development, to search for effective mechanisms for managing the competitiveness of the sector and implementation of green energy business projects, as well as the creation and expansion of the prosumer group.

Analysis of research and publications. The issues of economic competitiveness of green energy projects have been addressed in the works of many researchers, such as: S. Voytko, E. Anderson, L. V. Nefedova, S. Nilson, D. M. Rozenberg, R. Yansson, F. A. Stenford, O. Dyachuk, T. Abbasi, V. M. Kargiev, R. A. Bodali, Yu. Morozova, V. Reztsova and others. However, there are few scientific developments, which analyze and compare the competitiveness of RE business technologies depending on the options for the use of generated energy, investigate the factors of formation of such projects' competitiveness, while taking into account current trends in the RE market and sustainable development. The importance of working through these issues to improve the competitiveness of green energy technologies and boost the efficiency of mechanisms for managing the RE sector determines the relevance of this article.

The purpose of the research is to evaluate the economic competitiveness of the green energy business according to the variations of its implementation based on the analysis of current trends of the RE development, existing mechanisms of state support of the sector, the prospects for achieving sustainable development with the formation of the prosumer group.

The realization of the research purpose has determined the following **objectives**:

- to study the peculiarities of the development of RE technologies in Ukraine;
- to evaluate the current trends and state support of the sector deployment; and

- to determine the competitiveness of the industrial solar power plant (SPP) by variations in the use of generated green electricity based on calculating the economic efficiency indicators and to assess the prospects for the transformation of the SPP owner into a prosumer.

Research methods. System and structural, statistical, and comparative analyses were applied to study RE technologies deployment and state support mechanisms in Ukraine in 2009-2022. Investment (project) analysis and the method of technical and economic calculations were used to estimate the economic competitiveness of the project on constructing the industrial SPP in accordance with the different options for use of green electricity generated by the SPP.

Presentation of the main material. The development of the RE sector in the country began in 2009, when the main economic incentive for the industry was introduced: the feed-in tariff (FIT) for industrial facilities on renewable energy sources (RES). In addition to the high FIT, fixed in euros, the state guaranteed 100% of the green energy purchase and a number of tax benefits, for example, zero duties when importing equipment for RES installations that have no analogues of domestic production. In 2014, FIT was extended to household wind and SPPs with a capacity up to 30 kW [i]. Generous FITs, the highest among European countries, ensured the active development of industrial and home green energy facilities in Ukraine. In 2019, the state was included in the top 10 countries in the pace of RE development, and in 2020 in the top 5 European countries in terms of solar energy development. On the one hand, despite the increase in the number of RE capacities, the current share of green energy is less than 10% and does not play a significant role in the total energy mix of Ukraine. On the other hand, the potential of RE growth is huge, so the situation may change in the coming years. Such a transformation is also planned by the National Economic Strategy for the period up to 2030, which involves the development of hydrogen energy. According to experts, unfulfilled industry potential reaches $ 1 trillion, and financial support will greatly improve the development of the sector [ii; iii].

If at first investors in the construction of industrial RE plants in Ukraine were attracted by high FITs and the opportunity to make extra profits, today the motivation has changed somewhat. On the one hand, FIT rates for new RE facilities decrease over time and reduce the profitability of such projects. At the beginning of the FIT introduction in 2009 for enterprises, its rates were 2-5 times higher than current electricity tariffs [**Помилка! Закладку не визначено.**]. It made the generated green energy extremely profitable to sell to the state at high tariffs. Today, FIT for some RE technologies is almost equal to or slightly higher than current electricity prices. Moreover, it will expire at the end of this decade and only market prices for green energy will apply. On the other hand, electricity prices are rising. Due to this fact, the generation of green energy for own needs and the sale of its surpluses under the existing FIT are often more profitable than the purchase of electricity from local energy suppliers. In particular, in Ukraine in the period from 2017 to 2020, electricity tariffs increased by more than 300% [iv]. In 2021, prices for natural gas increased by 15-20 times and coal by 3 times, which led to a sharp rise in price of electricity and heat [v]. Therefore, energy consumers are seriously considering installing RE facilities to save their own money. Industrial enterprises engaged in export have a strong additional argument for constructing own RE plants. They can avoid additional taxation in the European Union for products produced using green energy [vi]. Thus, the motivation of business entities to become prosumers, i.e. both producers and consumers of electricity, increases.

The COVID-19 pandemic has negatively affected the global RE equipment market and led to the suspension of many projects in this industry in 2020-2021. Nevertheless, in recent years Ukraine has had a gradual increase in the installed capacity on RES, in particular, by 21% during the crisis year 2020 [vii]. As of January 1, 2021, there were 1,089 solar and 55 wind generation facilities, 71 biomass / biogas facilities and 171 small hydropower plants (HPPs). The total installed capacity of the new RE facilities with FIT was 1,358 MW in 2020. It included 144 MW of wind power plants (WPPs), 1169 MW of SPPs, 42 MW of biomass / biogas power plants, and 3 MW of small HPPs [vii].

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As of the end of 2021, the RE share in the total electricity mix produced in the country was 8.1%. In 2017-2021, the production of green energy increased more than 6 times, and the total installed capacity of RE facilities at the beginning of 2022 reached 9,656 MW [viii; ix]. Of these, WPPs capacity was 17.3% (1,673 MW), industrial SPPs - 66.1% (6,381 MW), household SPPs - 12.5% (1,205 MW), biomass power plants - 1.6% (152 MW), biogas power plants - 1.3% (124 MW), and small HPPs - 1.2% (121 MW) [v].

If in 2020 the growth of the RE sector was mainly due to industrial green energy facilities, then the next year the palm was intercepted by the households. In 2021, almost 15,000 Ukrainian families installed SPPs with a total capacity of 426 MW, which is twice as many as in the previous year. The total capacity of all home SPPs exceeded 1.2 GW [x]. By comparison, in the 2021 COVID-19 pandemic, RES had 731 MW of industrial capacity that received FIT, while in 2020 that figure was nearly twice as high (1,337 MWh) [xi]. At the same time, the WPPs accounted for 359 MW, SPPs - 305 MW, biomass power plants - 43 MW, biogas power plants - 20 MW, and small HPPs - 4 MW. Therefore, in 2021, the industrial RE sector added the largest capacity in wind energy that was 2.5 times higher than in 2020 (144 MW) and 1.2 times higher than the capacity of industrial SPPs, commissioned in 2021 [v].

The slowdown in industrial RE facilities deployment during the COVID-19 pandemic was caused not only by decreasing FIT rates and a deteriorating investment climate, but also by growing government FIT debts to green power producers. Due to the decline in electricity demand caused by the 2020-2021 lockdown, RE share in energy consumption has increased significantly since the government guarantees 100% green electricity purchase. Against the backdrop of the economic crisis, this has led to a problem with payments to RE producers and the formation of a deficit in the state enterprise “Guaranteed Buyer” in 2020 and 2021. For example, as of 2021, the state debt for generated green electricity was UAH 11.3 billion. At the end of this year, the settlement rate for RE was 93% in January through April, 79% in May, 80% in June, 78% in July, 86% in August, 80% in September, 59% in October, 94% in November, and 70.5% in December (28 days) [xii]. Some power companies have filed lawsuits for the failure of the state enterprise “Guaranteed Buyer” to fulfill its obligations. Since January 1, 2021, UAH 70 billion were paid for green electricity, of which 65.7% - directly for the electricity of 2021, the rest - for the electricity of 2020 [12]. Only at the end of 2021, thanks to the issuance and placement of green Eurobonds to the amount of USD 825 billion, it was possible to pay the debt to RE producers for 2020 and partially repay the state obligations for 2021. The balance of the debt was repaid in January 2022 [v].

The state budget for 2022 did not provide 20% of the funds to support the RE development guaranteed by the government memorandum of 2020. Therefore, it was expected that the debt accumulation could happen again. However, Russia's full-scale invasion of Ukraine in February 2022 threatens the existence of the entire industry in the country. As of the second half of April, the situation in the national RE sector was extremely complicated and uncertain. Most SPPs and WPPs were located in the eastern and southern regions: Kherson, Mykolaiv, Zaporizhzhia, Odessa, and Dnipropetrovsk. In 2022, many of these territories were occupied by Russian invaders, under artillery shelling, or under the threat of military invasion. Some of the RE facilities were localized in temporarily occupied territories: Crimea, Donetsk and Luhansk regions. The most unfavorable situation arose with wind generation, because about 90% of WPPs were located in areas of active battles [xiii]. About 60% of SPPs were also at risk. In total, 47% of all green power capacity in Ukraine was in areas where there were hostilities [**Помилка! Закладку не визначено.**; xiv].

The constant receipt of reports about damage and destruction of facilities on RES in these territories and the lack of direct access to the latter makes it impossible to adequately assess the industry’s losses. However, it is already known about 1.2-1.5 GW of damaged SPPs capacity, i.e. about 30-40% of power plants, in the regions of the Russian invasion. Industrial RE facilities located in the Mykolaiv energy hub suffered the most damage. In the Kharkiv region, 100% of SPPs were destroyed. Experts estimate that about a quarter of the country’s household SPPs (280

MW) that ended up in the areas of hostilities were destroyed. The Russian invasion affected 10-15% of biomass facilities located in Kharkiv, Sumy, Chernihiv, Mykolaiv and Zhytomyr regions. At least 2 wind turbines were also destroyed [ix**Помилка! Закладку не визначено.**; [xv]].

For those SPPs that were not affected by the war, strict restrictions were imposed on their operation modes during the daylight period. Such conditions are related to the need to balance the United Energy System of Ukraine, which suffers from increasing inflexibility due to the discreteness of RES generation. Therefore, most of the remaining RE units do not operate at full capacity, which affects their profitability. The situation is complicated by the fact that the occupants are looting and destroying industrial and civilian energy facilities, communication nodes, transformer substations, etc., de-energizing the working capacities at RES and preventing their functioning. According to experts, more than USD 5.5 billion worth of RE assets are now in the war zone, while nearly USD 4 billion worth of investments in neighboring areas remain similarly threatened. An integral consequence of the war is a three-fold decrease in green energy generated by WPPs in Ukraine compared to the same period in 2021, and a 40% decrease in RE generated by SPPs [xiii]. In addition, according to the orders of the Ministry of Energy of Ukraine, adopted in March 2022, the actual payment for electricity generated by RE facilities is installed in the range from 15% (for SPPs) to 60% (for biomass power plants) of the weighted average FIT for 2021 [ix]. Payment of only part of the promised FIT puts owners of green power plants on the verge of bankruptcy, not allowing them to recover current costs, pay taxes and fees, and loan debts.

Thus, the significant destruction of energy capacities, technical limitations and essential economic pressure on the industry leave little chance for the independent survival of RE sector in modern conditions. Therefore, it is extremely important to preserve and support the existing green power facilities, as well as to stimulate their restoration in the de-occupied territories. Further development of the industry after the end of active hostilities is practically without alternative. Given Ukraine's focus on joining the European Green Deal and reducing dependence on natural gas and coal [[xvi]], the expansion of the RE sector together with the introduction of energy efficient technologies will significantly contribute to sustainable energy development of the country. To implement these plans, it is advisable to maintain FITs at least for new SPPs and WPPs of households, increase financial and investment support for construction of new facilities and the restoration of damaged RE capacities. In the near future, the Ukrainian government plans to introduce new levers such as green bonds to raise capital in the domestic market of Ukraine, contracts for differences instead of fixed payments for FIT, creating legal conditions for energy storage and offshore wind market development [v**Помилка! Закладку не визначено.**]. In our opinion, additional mechanisms for RE deployment should be Feed-in Premium, corporate PPAs (Power Purchase Agreements), green auctions, Guarantees of Origin, Net Billing or Net Metering.

The application of the above-mentioned economic incentives will ensure the restoration and expansion of RE capacity in Ukraine, as the relevant investment projects will be highly competitive against the background of rising prices for electricity generated from fossil fuels. To confirm this, we will study what options for the generation and use of green electricity will encourage Ukrainian industrial enterprises to become prosumers while maintaining current FIT rates. To do this, we will calculate the *Net Present Value (NPV)* for the three options of the use of green electricity generated by an industrial photovoltaic (PV) SPP within its life cycle [xvii; xviii]. Given the high risks of doing business in Ukraine, we will additionally assess the *Discounted Payback Period (DPP)* of the project [xviii; xix]. The calculations will be conducted on the example of an industrial PV SPP with a capacity of 100 kW, located in the Sumy region, Ukraine.

The geographical location of Ukraine provides sufficient annual surface insolation, which is equal, and in some places exceeds indicators of Germany that actively develops solar energy. On average, the value of solar insolation throughout Ukraine is more than 1000 kWh by 1 m^2 of surface per year. But this does not mean that from 1 m^2 of solar panel can be obtained 1000 kWh per year, as there are significant losses when converting the energy that can reach 30% [xx; xxi]. Consequently, each project of green energy business should be estimated considering the performance of different options for power generation.

NPV calculations can be performed by the formula:

$$NPV = \sum_{t=t_n}^{T} Д_t \times (1+r)^t - \sum_{t=0}^{t_з} B_t \times (1+r)^t, \quad (1)$$

where $Д_t$ – incomes of the project in the *t*-th year within its life cycle;

B_t – investment costs for the project in the *t*-th year within its life cycle;

t_n – the year of receipt of the first income;

$t_з$ – the year of end of investment;

r – discount rate that provides income and investment to a single moment of time;

T – life cycle duration of the project, years [xvii; xviii].

NPV helps determine the profitability of a particular project. If $NPV > 0$, the project's income exceeds its life-cycle costs, i.e., the project is profitable and should be implemented. If the *NPV* value is negative, the project is unprofitable. If $NPV = 0$, the project is break-even, that is, the invested funds are paid back but do not provide a profit. At the same time, given the increased risk of implementing investment projects in Ukraine, owners are usually not inclined to support break-even decisions. The reason is that these projects do not have financial capacity reserves and at the slightest deviations they completely lose their competitiveness. On the other hand, the life cycle of RE projects can last several decades, and the situation regarding government economic incentives and electricity prices is complicated. Consequently, an additional argument for implementing such measures is the possibility for the investors to switch to energy self-sufficiency in the long term. Sometimes this circumstance encourages owners to implement even break-even RE projects.

DPP (years) is determined by the formula that outlines the period for which the initial investment of the project will be covered by its current incomes:

$$DPP = m + \frac{В_{\Sigma} - SД_m}{Д_{m+1}} \cdot (1+r)^{m+1}, \quad (2)$$

where B_{Σ} – the total amount of discounted project investment costs given to the moment of investment start;

$SД_m$ – total discounted incomes calculated cumulatively until inequality is performed: $SД_m < B_{\Sigma} < SД_{m+1}$;

m – the number of full years in which the amount of discounted incomes calculated cumulatively is less than the amount of discounted investment costs;

$(m+1)$ – the year in which the amount of discounted incomes calculated cumulatively will exceed the amount of discounted investment costs;

$Д_{m+1}$ – the project incomes in the $(m+1)$-th year [xviii; xix].

Along with the initial investment, formula (2) considers all the investments for the project that were made in other than zero years and affect its payback period. The shorter the payback periods of projects, the more profitable and attractive the latter are for investors [xxii]. The longer the *DPP*, the riskier the project is, even if the *NPV* values are attractive, because the risks associated with the instability of the political, economic and social environment of the project are much greater than those indicated by *NPV* and *DPP* calculations.

So, applying *NPV* and *DPP* values, let us estimate the different options for use of RE generated by the mentioned PV SPP, namely:

1) selling all of the generated green electricity by the FIT;

2) partial consumption of the generated renewable electricity for own needs and selling the surplus by the FIT to the grid;

3) consumption of the generated electricity solely for own needs.

For option 2, assume that the volume of consumption for the enterprise's own needs is 50% of the annual amount of electricity generation, regardless of the monthly volume of electricity generation. Thus, when making calculations, we will be guided by the annual indicators of electricity generation, not taking into account the different volumes of energy transmission on a monthly basis. The industrial PV SPP will be built and put into operation on July 1, 2022. Let us assume that PV SPP will operate under the basic conditions of taxation and the FIT payment [i; [xxiii]], without considering the peculiarities of martial law introduced in Ukraine in February 2022. Let us assume that in the second half of 2022 50% of the annual volume of green electricity will be produced. Calculations of project competitiveness will be made in euros (EUR), firstly, to avoid the negative impact of fluctuations of the national currency, and secondly, to compare the income received under the project from the sale of electricity by the FIT, fixed in euros.

The contract for the construction of the industrial PV SPP is planned to conclude with the Lviv engineering company "Correct Power Supply", which offers turnkey installation of household and industrial PV SPPs and since 2012 has launched more than 1000 SPPs and more than 80 solar systems [xxiv]. The main characteristics of the project for the construction of the industrial PV SPP with a capacity of 100 kW are presented in Table 1.

Table 1

The main characteristics of the industrial PV SPP project

Indicator	Indicator characteristic
Type of the power plant	Industrial ground connected to the grid photovoltaic solar power plant
Solar panel capacity	100 kW
Number of phases	3
Installation area required	530 m²
Panel / inverter manufacturer	China / China
Panel / inverter warranty	30 years
Number of panels	228 pcs.
Panel capacity	440 W
Ratio of annual solar panel capacity decline	0.8%
Availability of batteries:	not available
Type of solar panels	monocrystalline
Annual electricity generation (first full year of operation)	116,946 kWh
Volume of consumption for own needs by options: 1 2 3	 0 50% of the annual electricity generation 100% of the annual electricity generation
Year of commissioning of the power plant (July 1 – December 31)	2022
FIT amount (without VAT)	0.122 EUR/kWh
Electricity price for an enterprise	0.98 EUR/kWh

Source: compiled by the authors based on [i; xxiii; xxv; xxvi; xxvii].

Given the guarantee on the panels of at least 25-30 years and considering the data [[xxviii]], we assume that the lifecycle of the project is 30 years. When calculating the income for the project to assess its competitiveness in accordance with the various options for the use of

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electricity generated, we take into account the FIT of 3.78 UAH/kW (excluding value-added tax (VAT)). It equals 0.122 EUR/kWh at the National Bank of Ukraine exchange rate of 30.9 UAH for 1 EUR [xxix] as of January 1, 2022. This FIT corresponds to industrial PV SPPs with a capacity of up to 150 kW and commissioned in 2022 [i; xxiii]. The FIT is valid until December 31, 2029 [i]. After this period, during the rest of the project lifecycle, electricity will be sold at the usual price (generation price) in the market. We conventionally assume it at the level of 3.05 UAH/kWh (excluding VAT) [xxv] as the minimum tariff for industrial consumers for December 2021, or 0.098 EUR/kWh at the National Bank of Ukraine exchange rate. The income from green electricity sale is subject to corporate income tax at the rate of 18% [xxx]. According to Table 1, each year, due to the decline in solar panel performance, electricity generation will decrease along with revenues from its sales.

Investments in the project are presented in Table 2. The cost of connecting to the grid has already been factored into the construction cost of the PV SPP. During the project lifecycle, defined above at the level of 30 years, there will be additional costs for maintenance (operating) of the PV SPP and its disposal after the end of its service term. According to [xxii], we will assume annual operating costs of 1% of the investment cost or 533.94 EUR / year, and an end-of-life decommissioning cost of 5% of the investment cost or 2,670 EUR. Thus, the total undiscounted lifecycle costs of the industrial 100-kW PV SPP will be 53,394+533.94*30+2,670=72,081.9 EUR.

Table 2

Costs of construction and turnkey legal registration of an industrial ground PV SPP with a capacity of 100 kW

Name of cost component	Model	Quantity, pcs.	Price per 1 pc., EUR	Amount, EUR
Solar panel	Risen RSM110-8-540M (440 W, monocrystal, Half-Cell, PERC, 10 bb, Tier 1, 30 years of warranty)	186	183	33,964
Grid inverter	Huawei Sun 2000 - 50KTL-M0 (China, 6 MPPT trackers, 10 years of warranty)	2	4,234	8,469
Aluminum profile mount	Aluminum rail, connector, pin, T-shaped bolt with a nut, inter-panel Z-shaped clamp	186	23	4,266
Electric fittings	6-mm solar cable (1000 m), MC4 connectors, DC and AC fuses, surge suppressors, circuit breakers, and consumables	1	1,764	1,764
Generation limiter	Smart meter Huawei DTSU666-H	1	256	256
Installation and commissioning	Work on the installation and start-up of the solar power plant on a turnkey basis	1	4,499	4,499
Total construction costs				53,218
Legal registration of FIT	Paperwork for FIT	1	176	176
Total investment costs				53,394

Source: compiled by the authors based on [xxvi].

To calculate *NPV* and *DPP*, we will accept the discount rate *r* in formulas (1)-(2) at 11% according to [xxii] and based on the fact that the project investment costs are formed by 50% of own resources and 50% of the attracted (credit) ones.

The important components of formulas (1) and (2) are the project incomes. They will vary depending on the chosen option of electricity use.

Option 1: If all the electricity generated is sold upon the FIT, the project income in the *t*-th year will be calculated as follows:

$$Д_t = ЗТ \cdot Г_t \cdot (1 - k_{под} /100\%), \quad (3)$$

if *t* corresponds to years 2022–2029, when the FIT scheme is valid;

$$Д_t = k \cdot Г_t \cdot (1 - k_{под} /100\%), \quad (4)$$

if *t* corresponds to years 2030–2052, when the FIT scheme is not valid;

where $Г_t$ – green electricity generation volume in the *t*-th year, considering the ratio of annual solar panel capacity decline, kWh/year;

$ЗТ$ – FIT, EUR/kWh;

$k_{под}$ – the rate of the corporate income tax, %;

k – electricity market price, EUR/kWh per year.

Option 2. If 50% of electricity generated is sold upon the FIT and 50% of electricity is consumed for own needs, the project income in the *t*-th year will be calculated as follows:

$$Д_t = ЗТ \cdot 0{,}5 \cdot Г_t \cdot (1 - k_{под} /100\%) + k \cdot 0{,}5 \cdot Г_t, \quad (5)$$

if *t* corresponds to years 2022–2029, when the FIT scheme is valid;

$$Д_t = k \cdot 0{,}5 \cdot Г_t \cdot (1 - k_{под} /100\%) + k \cdot 0{,}5 \cdot Г_t, \quad (6)$$

if *t* corresponds to years 2030–2052, when the FIT scheme is not valid.

The sum components in formulas (5) and (6) present the company's taxable income from sale of the generated green electricity at FIT (in 2022-2029) or at a market price (in 2030-2052), as well as savings in own costs resulting from the generation and consumption of electricity for own needs.

Option 3. In the case of 100% electricity consumption for own needs, the project income in the *t*-th year will be calculated as follows:

$$Д_t = k \cdot Г_t. \quad (7)$$

Detailed calculations of electricity generation by years and annual discounted incomes for different options of energy use are presented in Tables 3-5. Total investment costs include initial investments and decommissioning costs at the end of the PV SPP’s lifecycle. Their discounted value is as follows: 53,394+2,670/22.8923 = 53,510.62 EUR.

Table 3

Annual revenues and expenses of a 100-kW industrial PV SPP for option 1 (sale of all generated electricity upon FIT scheme)

Year	PV SPP generation volume, kWh	Discount rate, *r* =11%	Price of electricity sale (excluding VAT)*, EUR/ kWh	Investment costs for the construction and decommissioning of the PV SPP, EUR	Operating costs, EUR	Annual income from electricity sales, minus operating costs and income tax, EUR	Discounted annual income from electricity sales, minus operating costs and income tax, EUR

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1		2	3	4	5	6	7	8
0	2022	58473.0	1	0.122	53,394.00	266.97	5,630.72	5,630.72
1	2023	116,478.2	1.11	0.122		533.94	11,214.65	10,103.29
2	2024	115,546.4	1.2321	0.122		533.94	11,121.43	9,026.40
3	2025	114,622.0	1.3676	0.122		533.94	11,028.96	8,064.28
4	2026	113,705.0	1.5181	0.122		533.94	10,937.22	7,204.69
5	2027	112,795.4	1.6851	0.122		533.94	10,846.22	6,436.70
6	2028	111,893.0	1.8704	0.122		533.94	10,755.95	5,750.57
7	2029	110,997.9	2.0762	0.122		533.94	10,666.40	5,137.56
8	2030	110,109.9	2.3045	0.098		533.94	8,410.60	3,649.58
9	2031	109,229.0	2.5580	0.098		533.94	8,339.81	3,260.24
10	2032	108,355.2	2.8394	0.098		533.94	8,269.59	2,912.42
11	2033	107,488.4	3.1518	0.098		533.94	8,199.93	2,601.70
12	2034	106,628.5	3.4985	0.098		533.94	8,130.83	2,324.12
13	2035	105,775.4	3.8833	0.098		533.94	8,062.28	2,076.15
14	2036	104,929.2	4.3104	0.098		533.94	7,994.28	1,854.63
15	2037	104,089.8	4.7846	0.098		533.94	7,926.82	1,656.74
16	2038	103,257.1	5.3109	0.098		533.94	7,859.91	1,479.96
17	2039	102,431.0	5.8951	0.098		533.94	7,793.53	1,322.04
18	2040	101,611.6	6.5436	0.098		533.94	7,727.67	1,180.96
19	2041	100,798.7	7.2633	0.098		533.94	7,662.35	1,054.93
20	2042	99,992.3	8.0623	0.098		533.94	7,597.55	942.35
21	2043	99,192.3	8.9492	0.098		533.94	7,533.27	841.78
22	2044	98,398.8	9.9336	0.098		533.94	7,469.50	751.94
23	2045	97611.6	11.0263	0.098		533.94	7,406.24	671.69
24	2046	96,830.7	12.2392	0.098		533.94	7,343.49	600.00
25	2047	96,056.1	13.5855	0.098		533.94	7,281.24	535.96
26	2048	95,287.6	15.0799	0.098		533.94	7,219.48	478.75
27	2049	94,525.3	16.7387	0.098		533.94	7,158.22	427.65
28	2050	93,769.1	18.5799	0.098		533.94	7,097.46	382.00
29	2051	93,019.0	20.6237	0.098		533.94	7,037.17	341.22
30	2052	46,322.7	22.8923	0.098	2,670.00	266.97	3,503.58	153.05
							Total	**87,071.43**

* FIT is used up to and including 2029; since 2030, the market price of electricity is used.
Source: calculated by the authors.

Table 4

Annual revenues and expenses of a 100-kW industrial PV SPP for option 2 (selling 50% of electricity at FIT; consumption of 50% of electricity generated for own needs)

Year		**PV SPP generation volume, kWh**	**Volume of electricity consumption for own needs, kWh**	**Surplus of generated electricity sold to the grid, kWh**	**Discount rate, *r* =11%**	**Purchase (market) price of electricity (excluding VAT), EUR/kWh**	**Price of electricity sale (excluding VAT)*, EUR/ kWh**	**Investment costs for the construction and decommissioning of the PV SPP, EUR**	**Operating costs, EUR**	**Annual savings from the electricity purchase, income from the electricity sale minus operating costs and income tax, EUR**	**Discounted annual savings from the electricity purchase, income from the electricity sale minus operating costs and income tax, EUR**
1		2	3	4	5	6	7	8	9	10	11
0	2022	58,473.0	29,236.5	29,236.5	1	0.098	0.122	53,394.00	266.97	5,571.08	5,571.08
1	2023	116,478.2	58,239.1	58,239.1	1.11	0.098	0.122		533.94	11,095.84	9,996.25
2	2024	115,546.4	57,773.2	57,773.2	1.2321	0.098	0.122		533.94	11,003.57	8,930.75
3	2025	114,622.0	57,311.0	57,311.0	1.3676	0.098	0.122		533.94	10,912.04	7,978.79

4	2026	113,705.0	56,852.5	56,852.5	1.5181	0.098	0.122		533.94	10,821.24	7,128.29
5	2027	112,795.4	56,397.7	56,397.7	1.6851	0.098	0.122		533.94	10,731.17	6,368.43
6	2028	111,893.0	55,946.5	55,946.5	1.8704	0.098	0.122		533.94	10,641.82	5,689.55
7	2029	110,997.9	55,498.9	55,498.9	2.0762	0.098	0.122		533.94	10,553.18	5,083.03
8	2030	110,109.9	55,055.0	55,055.0	2.3045	0.098	0.098		533.94	9,381.77	4,071.00
9	2031	109,229.0	54,614.5	54,614.5	2.5580	0.098	0.098		533.94	9,303.21	3,636.86
10	2032	108,355.2	54,177.6	54,177.6	2.8394	0.098	0.098		533.94	9,225.29	3,249.00
11	2033	107,488.4	53,744.2	53,744.2	3.1518	0.098	0.098		533.94	9,147.98	2,902.50
12	2034	106,628.5	53,314.2	53,314.2	3.4985	0.098	0.098		533.94	9,071.29	2,592.95
13	2035	105,775.4	52,887.7	52,887.7	3.8833	0.098	0.098		533.94	8,995.22	2,316.40
14	2036	104,929.2	52,464.6	52,464.6	4.3104	0.098	0.098		533.94	8,919.76	2,069.34
15	2037	104,089.8	52,044.9	52,044.9	4.7846	0.098	0.098		533.94	8,844.90	1,848.62
16	2038	103,257.1	51,628.5	51,628.5	5.3109	0.098	0.098		533.94	8,770.63	1,651.44
17	2039	102,431.0	51,215.5	51,215.5	5.8951	0.098	0.098		533.94	8,696.97	1,475.29
18	2040	101,611.6	50,805.8	50,805.8	6.5436	0.098	0.098		533.94	8,623.89	1,317.92
19	2041	100,798.7	50,399.3	50,399.3	7.2633	0.098	0.098		533.94	8,551.39	1,177.34
20	2042	99,992.3	49,996.1	49,996.1	8.0623	0.098	0.098		533.94	8,479.48	1,051.74
21	2043	99,192.3	49,596.2	49,596.2	8.9492	0.098	0.098		533.94	8,408.14	939.54
22	2044	98,398.8	49,199.4	49,199.4	9.9336	0.098	0.098		533.94	8,337.37	839.31
23	2045	97,611.6	48,805.8	48,805.8	11.0263	0.098	0.098		533.94	8,267.17	749.77
24	2046	96,830.7	48,415.4	48,415.4	12.2392	0.098	0.098		533.94	8,197.53	669.78
25	2047	96,056.1	48,028.0	48,028.0	13.5855	0.098	0.098		533.94	8,128.45	598.32
26	2048	95,287.6	47,643.8	47,643.8	15.0799	0.098	0.098		533.94	8,059.92	534.48
27	2049	94,525.3	47,262.7	47,262.7	16.7387	0.098	0.098		533.94	7,991.94	477.45
28	2050	93,769.1	46,884.6	46,884.6	18.5799	0.098	0.098		533.94	7,924.50	426.51
29	2051	93,019.0	46,509.5	46,509.5	20.6237	0.098	0.098		533.94	7,857.60	381.00
30	2052	46,322.7	23,161.4	23,161.4	22.8923	0.098	0.098	2670.00	266.97	3,912.14	170.89
										Total	**91,893.63**

* FIT is used up to and including 2029; since 2030, the market price of electricity is used.
Source: calculated by the authors.

Table 5

Annual revenues and expenses of a 100-kW industrial PV SPP for option 3 (consumption of 100% of electricity generated for own needs)

Year		PV SPP generation volume, kWh	Discount rate, *r* =11%	Purchase (market) price of electricity (excluding VAT), EUR/kWh	Investment costs for the construction and decommissioning of the PV SPP, EUR	Operating costs, EUR	Annual income (savings) from 100% generation and consumption of electricity for own needs, minus operating costs, EUR	Discounted annual income from 100% generation and consumption of electricity for own needs, minus operating costs, EUR
1		2	3	4	5	6	7	8
0	2022	58,473.0	1	0.098	53,394.00	266.97	5,463.38	5,463.38
1	2023	116,478.2	1.11	0.098		533.94	10,880.93	9,802.64
2	2024	115,546.4	1.2321	0.098		533.94	10,789.61	8,757.09
3	2025	114,622.0	1.3676	0.098		533.94	10,699.02	7,823.03
4	2026	113,705.0	1.5181	0.098		533.94	10,609.15	6,988.58
5	2027	112,795.4	1.6851	0.098		533.94	10,520.01	6,243.11
6	2028	111,893.0	1.8704	0.098		533.94	10,431.58	5,577.15
7	2029	110,997.9	2.0762	0.098		533.94	10,343.85	4,982.20
8	2030	110,109.9	2.3045	0.098		533.94	10,256.83	4,450.71
9	2031	109,229.0	2.5580	0.098		533.94	10,170.51	3,975.90
10	2032	108,355.2	2.8394	0.098		533.94	10,084.87	3,551.73
11	2033	107,488.4	3.1518	0.098		533.94	9,999.92	3,172.81

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12	2034	106,628.5	3.4985	0.098		533.94	9,915.65	2,834.30
13	2035	105,775.4	3.8833	0.098		533.94	9,832.05	2,531.89
14	2036	104,929.2	4.3104	0.098		533.94	9,749.12	2,261.75
15	2037	104,089.8	4.7846	0.098		533.94	9,666.86	2,020.42
16	2038	103,257.1	5.3109	0.098		533.94	9,585.25	1,804.83
17	2039	102,431.0	5.8951	0.098		533.94	9,504.30	1,612.24
18	2040	101,611.6	6.5436	0.098		533.94	9,423.99	1,440.20
19	2041	100,798.7	7.2633	0.098		533.94	9,344.33	1,286.51
20	2042	99,992.3	8.0623	0.098		533.94	9,265.30	1,149.21
21	2043	99,192.3	8.9492	0.098		533.94	9,186.91	1,026.57
22	2044	98,398.8	9.9336	0.098		533.94	9,109.14	917.01
23	2045	97,611.6	11.0263	0.098		533.94	9,032.00	819.13
24	2046	96,830.7	12.2392	0.098		533.94	8,955.47	731.71
25	2047	96,056.1	13.5855	0.098		533.94	8,879.56	653.61
26	2048	95,287.6	15.0799	0.098		533.94	8,804.25	583.84
27	2049	94,525.3	16.7387	0.098		533.94	8,729.54	521.52
28	2050	93,769.1	18.5799	0.098		533.94	8,655.43	465.85
29	2051	93,019.0	20.6237	0.098		533.94	8,581.92	416.12
30	2052	46,322.7	22.8923	0.098	2,670.00	266.97	4,272.65	186.64
							Total	**94,051.66**

Source: calculated by the authors.

According to the results of the formula (1) calculations, the net present value of the project, as the difference of discounted incomes and costs, for 3 options is

$NPV_{project\ B1}$ = 87,071.43 – 53,510.62 = 33,560.81 EUR;

$NPV_{project\ B2}$ = 91,893.63 – 53,510.62 = 38,383.01 EUR;

$NP_{project\ \ B3}$ = 94,051.66 – 53,510.62 = 40,541.04 EUR;

that is, all the project options are profitable, ensuring a discounted profit from 33,560.81 to 40,541.04 EUR for the entire project lifecycle. At the same time, the most profitable is option 3, for which the company generates green energy solely for its own needs. This is explained by two reasons:

- first, by small gap between the purchase price of electricity generated by the company (0.098 EUR/kWh) and its sale to the grid under the FIT (0.122 EUR/kWh);
- second, by taxation of the enterprise income for the green electricity sale at the rate of 18%, which reduces the actual income of the company from the energy sale. Instead, the savings of electricity obtained due to its consuming for own needs are not taxed.

Thus, taking into account the considered conditions of generation and purchase of electricity from the grid, as well as the cost of its own generation, the FIT as a stimulating factor for the RE development loses its economic importance. To be a prosumer becomes more profitable for the enterprise. This proves the high economic competitiveness of the green energy business. Given that the lifecycle of the PV SPP is 30 years, the profitability of the various project's options is quite high, namely 62.7% for option 1, 71.7% for option 2, and 75.8% for option 3 of the total amount of initial investment and decommissioning costs.

Next, we calculate the discounted payback period of the project, using the formula (2). At first, we need to process the value of $SД_m$, $SД_{m+1}$ and m. According to the data of Tables 3-5:

Option 1: $SД_m$=52,216.65 EUR; $SД_{m+1}$=57,354.21 EUR; m=6.5 years. Hence: DPP=6.75 years.

Option 2: $SД_m$=51,663.14 EUR; $SД_{m+1}$=56,746.17 EUR; m 6.5 years. Hence: DPP=6.86 years.

Option 3: $SД_m$=50,654.98 EUR; $SД_{m+1}$=55,637.18 EUR; m=6.5 years. Hence: DPP=7.07 years.

Therefore, the payback period for all project options is about 7 years, but the first option (100% of the generated electricity sale via FIT scheme) demonstrates the lowest payback period. The reason for this is the FIT, which during the first years of the project implementation provides higher incomes. At the same time, the disadvantage of the payback period is that the indicator does not consider the income received beyond the payback period. So, the decision to choose the best option should be made based on both *NPV* and *DPP*.

Since all options have approximately the same payback periods, the most competitive is the variant with the maximum *NPV* value. This is the option 3, which provides for the 100% use of generated electricity to the enterprise's own needs, that is, the transformation of the company into a prosumer. The choice of this option will not only maximize the project profit, but also contribute to the enterprise's energy independence, decarbonization of production, the formation of a green business image among consumers, and optimization of energy and environmental costs.

Conclusions. Prospects of further research. Decarbonization of the national economy and the transition to sustainable energy development arise the issues of further RE deployment and economic competitiveness of green energy projects. In Ukraine, as well as worldwide, traditional fossil fuels still dominate in the country's energy mix, although in recent decades there are noticeable trends of the RE share growth. The government supports the expansion of green energy technologies using FITs, green auctions, soft financing, etc. For the most part, domestic RE projects are still uncompetitive without such assistance, but this trend is already changing amid rising prices for conventional electricity and other fossil fuels. At the same time, the coronavirus pandemic in 2020-2021 revealed problems caused by the high price of green energy and the priority of its purchase, interruptions in renewable electricity generation, the emergence of the "green-coal paradox" and debts for payment for generated RE in the country. In addition, the full-scale Russian war in Ukraine in 2022 negatively influenced on the slowdown of the domestic RE sector. It brought the industry to the edge of physical and economic destruction. To avoid a collapse in the sector, it is crucial today to preserve the state's support of existing facilities on RES, as well as to stimulate their reconstruction in deoccupied areas. In the future, after hostilities, it will be vital to attract serious investment in the sector and introduce new, more effective levers to regulate the industry development.

Further growth of electricity prices in Ukraine significantly increases the competitiveness of RE projects due to the gradual convergence of the FIT size with the prices on the energy market. This creates the basis for the formation of prosumers, both among enterprises and households. To substantiate the feasibility of domestic energy consumers' transformation and to evaluate the economic competitiveness of green energy businesses, we calculated *NPV* and *DPP* indicators on the example of an industrial 100-kW PV SPP, located in the Sumy region, Ukraine. We considered various options for the use of green electricity generated by the RE facility: 1) selling all generated electricity under the FIT; 2) partial consumption of generated electricity for own needs and sale of the generated surplus under the FIT to the grid; 3) consumption of generated electricity exclusively for own needs. The results of the calculations indicated that at the current market electricity prices and established FITs, the best option in terms of competitiveness is the 100% use of generated green electricity for the own needs of the enterprise, that is, the transformation of the business entity into a prosumer. This option is characterized by the maximum *NPV* value and acceptable payback period compared to other options of the project implementation. Although the payback period of the option is longer by almost 4 months, the profitability of the RE project increases to 75.8% compared to 62.7 and 71.7% for other options. Thus, we can conclude that FIT in Ukraine is losing its stimulating effect on the RE development and can be replaced by other levers. The existing conditions of the energy market contribute to the formation of prosumers in Ukraine. In this context, areas for further research are the development of state mechanisms to create a favorable investment climate in the domestic RE sector at the end of hostilities, as well as financial support to increase the number of prosumers.

References

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1. On the electricity market: Law of Ukraine No 2712- VIII dated April 25, 2019. URL: http://surl.li/agkjz (accessed: January 08, 2022)

2. On approval of the National Economic Strategy for the period up to 2030: Resolution of the Cabinet of Ministers of Ukraine No. 179 dated March 03, 2021. URL: http://surl.li/betch (accessed: January 11, 2022)

3. Impossible to refuse, continue: Why the transition to green energy is inevitable. http://surl.li/betcj (accessed: January 12, 2022).

4. Sotnyk I., Kurbatova T., Dashkin V., Kovalenko Ye. "Green" energy projects in households and its financial support in Ukraine. *International Journal of Sustainable Energy*. 2020. Vol. 39 (3). P. 218–239.

5. "Betrayal and Victories" – 2021 and an indefinite future of the Ukrainian RES-generation. UE, January 28, 2022. URL: https://ua-energy.org/uk/posts/zradoperemohy-2021-ta-nevyznachene-maibutnie-ukrainskoi-vde-heneratsii (accessed: April 28, 2022).

6. RES Market. The results of the year and prospects for 2022. NV, January 18, 2022. URL: http://surl.li/bwirn (accessed: April 28, 2022).

7. Report on the results of the activities of the National Commission for State Regulation in the fields of Energy and Utilities in 2020. URL: http://surl.li/betcc (accessed: January 09, 2022).

8. More and more private households are choosing solar energy. Solar System, 2022. URL: https://solarsystem.com.ua/ru/vse-bil%CA%B9she-pryvatnykh-domohospodarstv-obyrayut%CA%B9-sonyachnu-enerhetyku/ (accessed: April 28, 2022).

9. Green energy in Ukraine on the verge of bankruptcy. What's next? Ekonomichna Pravda, April 10, 2022. URL: https://www.epravda.com.ua/columns/2022/04/10/685513 (accessed: April 28, 2022).

10. In Ukraine, a record number of domestic SPPs has been installed per year. Business Censor, January 18, 2022. URL: http://surl.li/bwiyo (accessed: April 28, 2022).

11. growth rates of green energy in Ukraine almost halved last year. Terminal, 14.01.2022. URL: http://oilreview.kiev.ua/2022/01/14/tempi-rostu-zeleno%d1%97-energetiki-v-ukra%d1%97ni-v-minulomu-roci-vpali-majzhe-vdvichi/(accessed: April 28, 2022).

12. Ukrainian alternative energy: December 27, 2021 – September 9, 2022. Enerhodzherela, 2022. URL: http://surl.li/bwzbp (accessed: April 28, 2022).

13. The extent of the damage to the power system of Ukraine caused by the war and the development of alternative energy sources. Ukrinform, April 14, 2022. URL: http://surl.li/buugq (accessed: April 19, 2022).

14. Chaika O. Sun, wind and water. How the green energy survives during the war. Focus, April 06, 2022. URL: https://focus.ua/uk/economics/511487-kak-vyzhivayushchiy-zelena-energetika-vo-vremya-voyny (accessed: April 19, 2022).

15. Energy sources: April 1-17, 2022. Enerhodzherela, 2022. URL: https://enerhodzherela.com.ua/novyny (accessed: April 19, 2022).

16. European Green Deal and green transition of Ukraine: common goals and transformation challenges. VK, December 9, 2022. URL: (accessed: April 29, 2022).

17. NPV (Net Present Value) – formula, meaning & calculator. URL: https://cleartax.in/s/npv-net-present-value (accessed: January 09, 2022).

18. Business Economics: Textbook / L. G. Melnyk (Ed.). Sumy: University Book, 2012. 864 p.

19. . Discounted payback period: definition, formula, example & calculator. Project-Management.info, 2021. URL: https://project-management.info/discounted-payback-period-dpp/ (accessed: January 05, 2022).

20. Research of operation modes of solar power plants in Matlab Simulink. URL: http://surl.li/betcw (accessed: January 05, 2022).

21. Current trends and potential for the development of green energy in Ukraine. URL: https://t.ly/Kuse (accessed: January 08, 2022).

22. Report on research work “Formation of economic mechanisms of sustainable development of renewable energy in the conditions of global and local threats to the energy security of Ukraine” (Intermediate) / Head: I. M. Sotnyk. Sumy: SumDU, 2021. 130 p.

23. The regulator has set feed-in tariffs for 2022. Ekonomichna Pravda, 2021. URL: https://t.ly/xodd (accessed: January 06, 2022).

24. Solar Energy, 2022. URL: https://sun-energy.com.ua/about_us (accessed: January 08, 2022.

25. Convenient calculator to calculate the base price and detailed information about business tariffs. URL: https://tek.energy/electricity/prices (accessed: January 04, 2022).

26. 100-kW grid solar power plant for own consumption and business. Solar Power, 2022. URL: https://sun-energy.com.ua/solar-power/solar-power-plants/ses100kwt (accessed: January 08, 2022).

27. Solar power plant calculator. Rentechno, 2022. URL: https://rentechno.ua/ua/solar-calc.html (accessed: January 13, 2022).

28. Trypolska G., Kurbatova T., Prokopenko O., Howaniec H., Klapkiv Y. Wind and solar power plant end-of-life equipment: prospects for management in Ukraine. *Energies*. 2022. № 15(1662). DOI: 10.3390/en15051662.

29. The official hryvnia exchange rate on foreign currencies. National Bank of Ukraine, 2021. URL: https://t.ly/ZBjO (accessed: January 03, 2022).

30. Tax Code of Ukraine. 2011. URL: http://zakon3.rada.gov.ua/laws/show/2755-17 (accessed: January 08, 2022).