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Alternative energy in Ukraine: the current status and possible solutions to existing problems

ABSTRACT: The Ukrainian energy sector's crucial problems, in particular, the outmoded equipment, the power infrastructure shortcoming and a significant backlog in the energy supply quality from the European one, based on the SAIDI (System Average Interruption Duration Index) indicator comparison, has been disclosed in this article. A considerable break in the energy supply quality in both rural and urban settlements has been also revealed. The current state of the alternative energy development has been described, the energy generation structure, as well as the rates of development of the renewable energy sources' usage have been analyzed. Some challenges in the imbalance of the renewable energy sources' usage and their analyzed consequences have been identified, among others, the generation volume abruptness by both SPP and WPP, requiring maneuvering with the traditional sources' employer. The negative effect of the "green" tariff as the main priming stimulus for the renewable energy facilities' construction has been proven. Generally and particularly, the

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financial influence level on the state has been analyzed, being manifested in the debts' accumulation to energy producers. The residual capability of solving the problems of alternative energy development has been considered, in particular, the "green" auctions announced by the state, the formation of the optimal predicted level of energy generation by SPP and WPP in order to prevent sharp disparities in both electricity demand and supply. The biogas plants' facilities as a ponderable choice to both solar and wind generation have been analyzed.

KEYWORDS: energy sector, alternative energy, "green" tariff, "green" vendue, biogas plant

Introduction

The energy sector in Ukraine has a variety of issues, requiring enormous investments and a good deal of time to solve. The Ukrainian economy energy efficiency is quite low, despite some improvements in recent years. The cost of both fuel and energy resources has increased, especially after a sharp drop in the hryvnia exchange rate. Geopolitical issues have sharply exacerbated the problem of Ukraine's energy independence. Suddenly, the challenge of diversifying energy supply sources appeared. Under such circumstances, maintaining the global trend for the alternative energy development has become not only a prerequisite for European integration, but also a great opportunity to reduce energy dependence. Nevertheless, both financial and legislative levers being introduced for this were not sufficient, since the renewable sources' share in total energy consumption remains low, especially in comparison with European countries. There has been active investment in both SPP and WPP in recent years, not least being due to the "green" tariff, which is one of the highest in Europe, giving an opportunity for Ukraine to enter the top ten countries in the investment attractiveness' rating of "green" energy (Ukraine took 8th place in this ranking, 2019). Notwithstanding, the active development of both solar and wind power systems, starting in 2019, has created a great deal of financial problems. It is for this reason that the "green" tariff is becoming an extremely discouraging factor.

1. The energy industry challenges in Ukraine

Energy is the very industry ensuring all the economy spheres' functioning, being in great demand, the development of which is hampered of the essence by numerous troubles. The issue of the infrastructure deterioration, its both moral and physical deterioration is especially acute. According to The National Commission for State Regulation of Energy and Public Utilities, from 75 power units of thermal power plants' generating companies, 68 power units (16,962 MW or

78.6%) are operated during the expected service, 2 power units (600 MW or 2.8%) are operated during a longer service life and 5 power units (4,000 MW or 18.6%) are operated beyond the applicable time period (NERC 2020).

Meanwhile, there is a lack of funds for both infrastructure renewal and modernization. At the same time, the energy supply quality differs from the European one substantively. It affects the Ukraine rating globally as negative. Sure, one of the indices taken into account in the Doing Business rating is the connection to power supply systems; Ukraine ranks 128th world-wide, according to this indicator. It, in turn, is based on the energy supply reliability index estimation and tariff transparency (25% of the indicator is formed by taking into account the energy supply safety). Endurance, that is, the continuity of power supply, is assessed by three indicators: the index of the long interruptions' average duration in the power supply in the system (SAIDI), the index of the average frequency of long interruptions in the power supply in the system (SAIFI) and the estimated volume of unused electricity (ENS) (NERC 2020). In Ukraine, the SAIDI indicator exceeds the indicator for European countries of the essence, due to the energy supply companies' fault (Fig. 1).

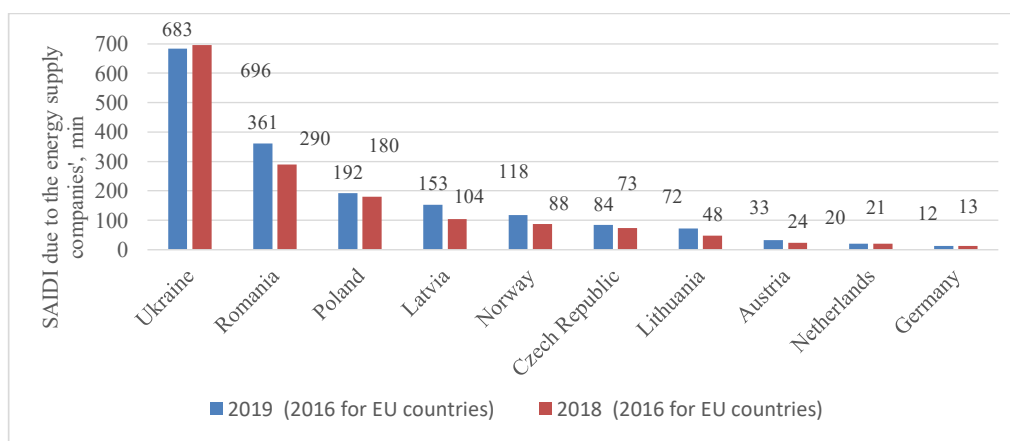


Fig. 1. SAIDI due to the energy supply companies' fault for Ukraine and a number of EU countries in 2018 and 2019 [min]

Source: based on the NERC reporting data

Rys. 1. Wskaźnik czasu trwania przerw w dostarczaniu energii elektrycznej SAIDI z winy dostawców energii na Ukrainie i w innych krajach UE w 2018 i 2019 roku [min]

Meanwhile, an imbalance in the long breaks' average duration index for both rural and urban settlements is observed in a great deal of regions – the difference between the indicators can be up to 100% (Fig. 2).

At this conjuncture, alternative energy could formidably make a difference both through the energy system modernization and renewal, and through the energy sources' formation in the same rural areas.

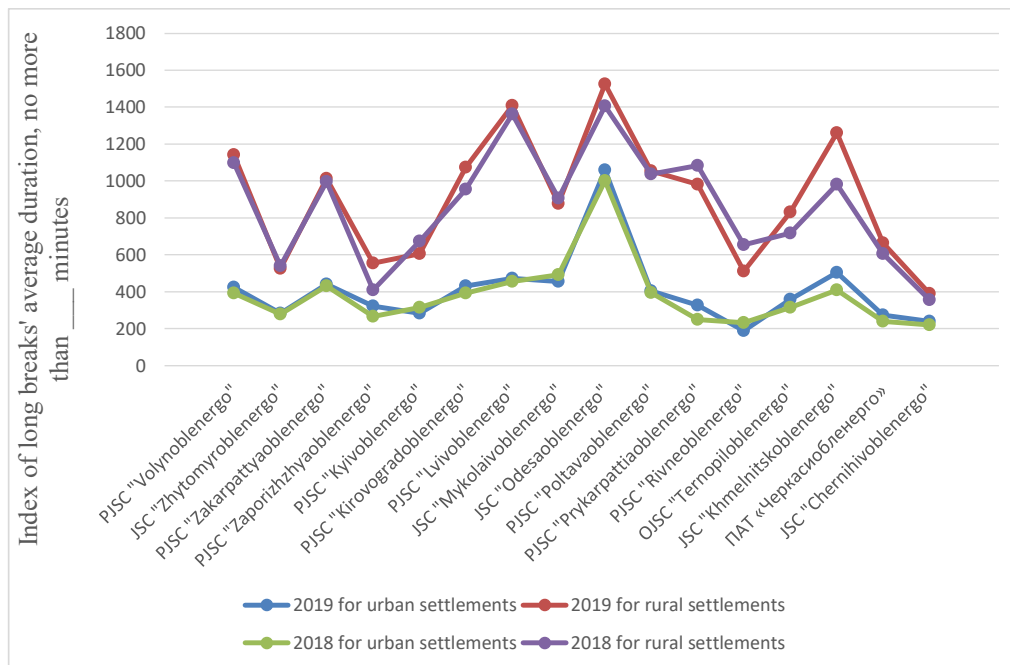


Fig. 2. Targeted indices for the long breaks' average length by selected energy supply companies for both urban and rural areas in 2018 and 2019

Source: based on the NERC reporting data

Rys. 2. Docelowe wskaźniki średniej długości długich przerw w wybranych przedsiębiorstwach dostarczających energię, w obszarach miejskich i wiejskich w 2018 i 2019 r.

The quality of the energy supply is also an important issue due to the fact that about 30% of electricity is consumed by household consumers. The urgency of the uninterrupted energy supply has increased especially due to the transition to remote work and training during the quarantine period. Thus, for 7 months of 2020, energy consumption decreased by 4.8% compared to the same period in 2019; the decline in consumption was observed in industry, agriculture and other areas. The only exceptions were household consumers – energy consumption increased by 2.6% (EnergyWorld 2020).

The use of alternative energy sources by the population could solve both the problem of quality and uninterrupted energy supply, and reduce the financial burden of paying for energy supply. The issue of raising the preferential tariff for the first 100 kWh of electricity for households from UAH 0.9 per kWh to UAH 1.68 per kWh has often been raised, and the NERC recommends gradually raising the tariff for household consumers in order to compare it with the tariff for industrial consumers.

The new electricity market would also help improve the quality of energy supply, as consumers could buy electricity from the supplier under direct contracts. Nevertheless, the motivation system for the alternative energy development in Ukraine is based mainly on the “green” tariff.

And if such a mechanism showed its effectiveness at the beginning, giving a great opportunity for the population not only to save money on utilities, but also to receive additional income from the excess electricity sale. Nowadays it is not only ineffectively, but also creates a great deal of problems.

2. Alternative energy: issues requiring urgent solutions

The alternative energy rapid development is changing the supply structure to the integrated electricity market (WEM) (Table 1).

TABLE 1. WEM energy supply installed capacity and volumes

TABELA 1. Zainstalowana moc i wielkości dostaw energii na zintegrowanym rynku energii elektrycznej (WEM)

Manufacturer	2016		2017		2018		2019	
	Installed capacity [MW]	Sales amount in WEM, million [kW/h]	Installed capacity [MW]	Sales amount in WEM, million [kW/h]	Installed capacity [MW]	Sales amount in WEM, million [kW/h]	Installed capacity [MW]	Sales amount in WEM, million [kW/h]
GC TEN	24,565	44,904	24,565	40,526	21,842	43,108	21,842	40,512
AES	13,835	76,162	13,835	80,295	13,835	79,383	13,835	83,003
HPP/ PSH	6,220.5	8,550	7,481.7	10,013	4,660.7	11,414	6,250	7,513
CHP	5,946.8	9,810	5,972.3	9,286	6,170.2	9,420	6,097	12,600
WPP	437.8	1,805	328.4	2,105	532.8	2,784	1,170	2,022
SES	530.9		758.4		1,388.3		4,925	2,932
Biofuel/Biogas Fueling Station	59.1		96.9		1,388.3		170	410

Source: based on the NERC annual reports.

A sharp increase in the energy generation share from renewable energy sources has been observed in recent years. Thus, the installed capacity of traditional power generating stations amounted to 97.8% of the total capacity in 2016, the volume of WEM supply — 98.6%, and it decreased to 88.4% and 96.4%, respectively in 2019.

The installed capacity of renewable energy facilities operating under the “green” tariff increased more than 5 times at the end of 2019 (from 967 MW to 4935 MW), and it doubled in just a year (from 2018 to 2019) from 2274 MW to 4935 MW (Lenska 2019).

In spite of the alternative energy development significant pace in Ukraine, its indicators differ significantly from European ones on the whole. Thus, the renewable energy share in the energy consumption overall structure consumption reaches more than 50% in a great deal of EU countries (Table 2).

TABLE 2. The renewable energy share in gross final energy consumption in some EU countries [%]

TABELA 2. Udział energii odnawialnej w końcowym zużyciu energii brutto w niektórych krajach UE [%]

Country	2014	2015	2016	2017	2018
EU – 28 countries	16.2	16.7	17.0	17.5	18
Norway	69.2	69.2	70.1	71.6	72.8
Iceland	70.5	70.3	70.2	70.7	72.2
Sweden	51.9	53.0	53.4	54.2	54.6
Finland	38.8	39.3	39.0	40.9	41.2
Latvia	38.6	37.5	37.1	39.0	40.3
Austria	33.7	33.5	33.4	33.1	33.4
Italy	17.1	17.5	17.4	18.2	17.8
France	14.6	15.0	15.7	16.0	16.6
Poland	11.5	11.7	11.3	11.0	11.3

Source: based on Eurostat data (Eurostat 2020).

The fundamental problem in Ukraine is that renewable energy is developing disproportionately. Solar power generation was the largest share in recent years. According to analysts, it was solar energy accounting for 54% of the total amount of renewable energy produced, while this share was 18% for the EU countries, and 24% in the whole world (Dombrovskiy 2020). The base increase rates of the SPP installed capacity are the highest (Table 3).

Suchwise, the solar power plants’ installed capacity has increased almost 7 times in 3 years, while wind power plants – in 2 times, small hydropower plants – no more than in 1.1 times, biomass – in 1.7 times, and biogas – in 3.5 times. The fact that the SPP “green” tariff was one of the highest contributed to this first and foremost. Meanwhile, both installation and maintenance of such a power generating plant is relatively simpler. 5.9% less electricity than in the same period in 2019 was produced by nuclear power plants in 2 months of 2020; TPP and CHPP – 5.9% less; PSP and HPP – 20.8% less; while renewable sources produced 173.6% more electricity (MENR 2020).

Nevertheless, the production of such energy is both unpredictable and uncontrollable. The rapid growth of electricity production from renewable energy sources forms its surplus. It is impossible to accumulate generated electricity reserves, therefore balancing is necessary. The latter is possible using only traditional sources. Still, nuclear power plants produce more than half of

TABLE 3. Renewable energy facilities' installed capacity operating at the "green" tariff and base rates of increase

TABELA 3. Moc zainstalowana instalacji OZE przy „zielonej” taryfie i bazowych stawkach wzrostu

	2016	2017	2018	3 quarters of 2019	Growth rate 2017/2016 [%]	Growth rate 2018/2017 [%]	Growth rate 2019/2018 [%]
SES (Taking into account SES of households)	548	793	1545	3765	144.7	194.8	243.7
WPP	438	465	533	932	106.2	114.6	174.9
SHPP	90	95	99	101	105.6	104.2	102.0
Biomass	39	39	51	67	0	130.8	131.4
Biogas	20	34	46	70	170.0	135.3	152.2

Source: based on (Lenska 2019).

the electricity in Ukraine, without having any technical opportunity to quickly maneuver energy and power plants. Moreover, TPPs are considerable environmental pollutants, but they allow the electricity production volume to be regulated, in contrast to non-traditional installations. In the case the supply of electricity exceeds the demand, it is necessary to stop generation. And even if the electricity selection from an unconventional installation is suspended, the state will still be forced to pay the tariff for the unreceived electricity in full. At the same time, Ukrainian legislation does not provide any producer's responsibility for the creation of such imbalances and incomplete production/supply of electricity to the grid. That is, in fact, the owner of a plant operating on renewable energy sources that does not bear any risks, having received his income in any case, while the state will actually incur the empty payments' costs.

The active development of solar energy generation alone creates a significant seasonal imbalance. Since solar activity is seasonal (and not always predictable within one season), in Ukraine, while maintaining the same structure of using unconventional energy sources, a need for seasonal maneuvering may arise – the suspension of traditional generation for the solar activity period and its increase in other periods. This will cause not only technical problems, but also social ones. Furthermore, the financial burden on the State Enterprise "Guaranteed Buyer" will also grow by fits and starts.

A sharp drop in the exchange rate of the hryvnia currency became an additional motivator for the solar power plant construction, since the "green" tariff rate was set in euro cents. At the same time, the "green" tariff in Ukraine is higher than in Europe. Thus, they are fixed at the level of 10–15 eurocents per 1 kW/h by 2030 (the cost of "green" energy at auctions is reduced to 4–5 eurocents per kW/h in the EU) for all renewable energy facilities that were not only commissioned, but also managed to obtain permits for the new projects' construction on December 31, 2019 (Sahajdak et al. 2020).

In 2020, green tariffs for solar power plants in the world reached, for example, the following amounts: in Denmark – 4 eurocents per 1 kW/h, in France 5.8 eurocents per 1 kW/h and in the

US – 7.8 eurocents per 1 kW/h. At the same time, Ukrainian producers of electricity from solar energy at terrestrial solar power plants, which were put into operation till January 1, 2020, were set tariffs at 11.25 eurocents per 1 kW/h (Oleniuk 2020).

This gives a great opportunity to attract investors from abroad, although it also creates a substantial financial burden not only on market operators, but also on the customer. Actually, electricity purchased by the state at high “green” tariffs is sold on the market together with cheaper “traditional” electricity.

Nowadays, electricity producers are obliged to: “1) sell 80 percent of the forecast electricity supply amount at nuclear power plants and 35 percent of the forecast electricity supply amount at hydroelectric power plants, being approved in the forecast balance of the united energy system of Ukraine for the corresponding month in each billing period to a guaranteed customer for electronic auctions in the manner prescribed by law; 2) sell up to 5 percent of the electricity forecast amount of electricity supply at nuclear power plants, which is approved in the forecast balance sheet of the unified energy system of Ukraine for the corresponding month under bilateral agreements at electronic vendues’ extra sessions” (Resolution CM 2019).

Namely, the guaranteed customer sells it at market rates, having compensated all the “green” tariff payments due to the profit received by purchasing electricity at the minimum tariffs from NNEGC “Energoatom” and “Ukrhydroenergo”. Notwithstanding, NNEGC “Energoatom” and “Ukrhydroenergo” are interested in increasing tariffs for electricity in such a way, therefore, the end consumer – both population and industry – may be adversely affected.

The “green” tariff, on the one hand, attracts investors, and therefore, alternative energy is developing, jobs are being created, and a replacement for traditional outdated power generating plants is being formed. Nevertheless, solar energy takes on most of the payments due to the imbalance in alternative energy generation. According to Table 1, the electricity supply amount was about 2% to the WEM from SES (or about 2.1% excluding HPPs and PSPPs), while it received 61% of payments under the “green” tariff. And when the power generation of both biomass and biogas plants is relatively predictable and stable, they receive only 7% of payments (Table 4).

TABLE 4. Payments’ distribution for the “green” tariff by renewable generation type in Ukraine, 2019

TABELA 4. Rozkład płatności za „zieloną” taryfę według rodzaju energii odnawialnej na Ukrainie, 2019

		WPP	Biomass	Biogas	SES	SHPP	Total
Basic „green” tariff, 4 quarters, 2019	kopecks per kWh	280.8	341.8	341.8	414.6	321.0	
The level of payments on the „green” tariff	million UAH	5,677	554	845	12,156	775	20,010
Payments’ distribution on the „green” tariff	%	28.0	3.0	4.0	61.0	4.0	100.0

Source: Dombrovskiy 2020.

Although the “green” tariff for SES and WPPs in Ukraine is the highest in Europe, for biogas it is one of the lowest. For example, in Germany it is 13.32 eurocents/kWh, in Bulgaria 20.42–24.8 eurocents/kWh, while in Ukraine it is 12.39 eurocents/kWh.

Challenges with timely profits’ payments to manufacturers were evidenced back in 2019. Debts to manufacturers amounted to UAH 2 billion in January-February 2020. In 2020, the amount of required financing will exceed UAH 30 billion, according to the Ministry of Energy forecasts, and the debt of the State Enterprise “Guaranteed Buyer” will amount to about UAH 19 billion (Orzhel 2020). Producers have already been paid UAH 6,770,000,000 for January–June 2020 (SE “GB” 2020).

In early 2020, it was announced that the Ukrainian energy sector was in crisis due, in particular, to a fall in energy consumption following a slowdown in industrial production, a warm winter in 2019–2020 and then the COVID-19 lockdown (Yaremko 2020). Despite the fall in industrial production and demand for electricity, SE “Guaranteed Buyer” is still forced to buy electricity at a “green tariff”.

Thereby, the active, but uneven development of alternative energy does not solve the prevailing problems of the Ukraine energy sector, but in concurrence with this, it forms a great deal of risks, causing imbalances in the state energy system and creating a cost loading on the state (on customers in prospect).

3. Problem-solving aid

The first decision calling a contradiction was the “green” tariff reduction for SPP. Thereby, the reduction of the load on the State Enterprise “Guaranteed Buyer” is planned to ensure that it fulfills its obligations to pay for the purchased electricity. Nevertheless, a great deal of experts consider that this will contribute to the investors’ outflow, since, firstly, their profits will decrease, and secondly, a precedent is being created for the “reverse” action of the government’s promises, which may reduce its attractiveness for investment.

The next step that would allow replacing the “green” tariff should be a “green” auction. In accordance with the Law of Ukraine, the auction for the support quota distribution is a way to determine business entities acquiring the right to support in the production of electricity from alternative energy sources (except for blast furnace and coking gases, with the hydropower usage – produced only by micro-, mini- and small hydroelectric power plants) (Law of Ukraine 2019). The government annually sets the number of support quotas for the next 5 years, distributed according to the reverse auction principle – it will be received by the entity suggesting the lowest tariff for electricity generation.

A further increase in the renewable energy share (as provided for by the energy strategy of Ukraine) only at the expense of SES can cause an increase in imbalances and cost loading on the state. It is an extremely important task to form a methodology for the power generation optimal

level estimation for each installation type. It is also necessary to secure responsibility for the shortfall in the planned electricity volumes at the level of state acts. This will make it possible to plan the power system possibilities for the electricity supply more accurately, balancing its needs and making payments at the “green” tariff only in accordance with the actually purchased electricity amount.

Changing the focus from wind farms and solar power plants to using the agriculture potential in the energy generation sphere may be an optional version to dispose of a problem. The biogas plants’ construction is more complex and expensive than the solar power plant construction, but it will make it possible to use the significant potential of the agro-industrial complex, creating jobs in rural settlements and improving infrastructure in the regions. The fact that large agricultural holdings (for example, MHP) have their own biogas plants plays in favor of biogas. The number of biogas plants is constantly growing, despite the pace of their commissioning, compared to both SPP and WPP (Fig. 3).

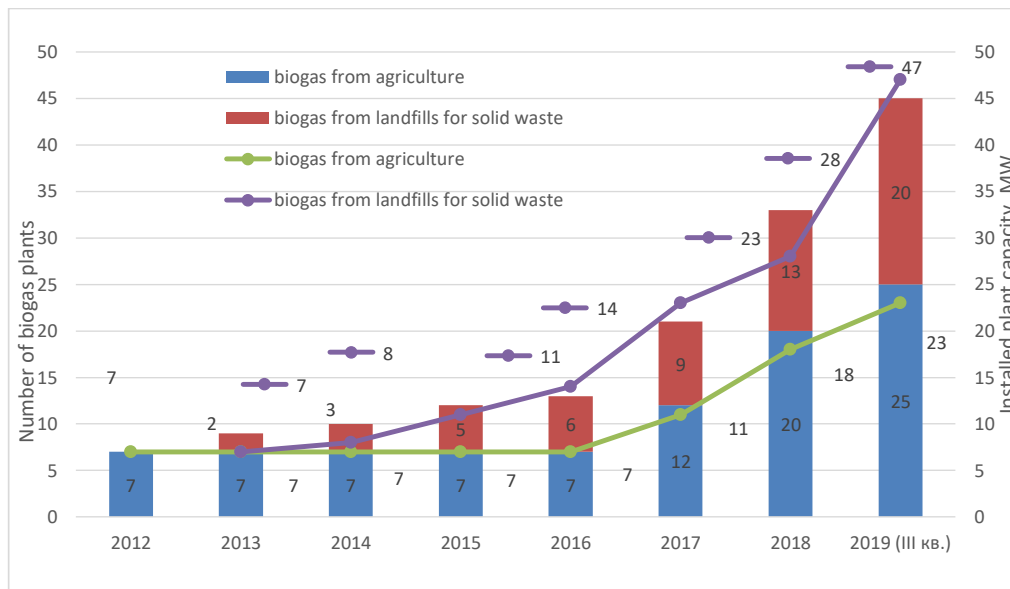


Fig. 3. Biogas plants’ number and capacity in Ukraine, 2012–2019 (3 quarters)

Source: based on SAEE (Lenska 2019)

Rys. 3. Liczba i moc biogazowni na Ukrainie w latach 2012–2019 (3 kwartały)

The output capacity of such power generating plants is more predictable. Furthermore, biogas plants can generate both electricity and heat, and a by-product of their operation is environmentally friendly fertilizer.

To stimulate the development of biogas plants, as well as the alignment of the structure of energy generation from renewable sources, the rate of “green” tariff for biogas plants will not

change until 2030 and will be 12.39 eurocents per 1 kW/h (provided that they will be put into operation until January 1, 2023).

It is even possible to replace gas imports' significant volumes by just this type of animal husbandry, even taking the rather negative trend towards a decrease in the number of cattle in Ukraine into account (Table 5).

TABLE 5. Projected potential for substituting natural gas imports through biogas production on cattle farms, 2018–2022

TABELA 5. Prognozowany potencjał zastępowania importu gazu ziemnego produkcją biogazu w gospodarstwach hodowlanych, 2018–2022

Year	Biogas production potential, billion cubic meters			Gas price forecast [USD/thousand cubic meters]			Substitution potential at different gas prices, upside case [USD billion]			Substitution potential at different gas prices, average case [USD billion]			Substitution potential at different gas prices, downside case [USD billion]		
	Upside case	Average case	Downside case	Hub+	Hub–	Hub0	Hub+	Hub–	Hub0	Hub+	Hub–	Hub0	Hub+	Hub–	Hub0
2018	3.61	2.07	0.92	341.5	261.0	301.2	1.23	0.94	1.09	0.71	0.54	0.62	0.31	0.24	0.28
2019	3.53	2.03	0.90	346.2	265.6	305.9	1.22	0.94	1.08	0.70	0.54	0.62	0.31	0.24	0.28
2020	3.12	1.79	0.80	350.8	270.2	310.5	1.09	0.84	0.97	0.63	0.48	0.56	0.28	0.22	0.25
2021	3.01	1.73	0.77	355.4	274.9	315.1	1.07	0.83	0.95	0.61	0.48	0.55	0.27	0.21	0.24
2022	2.89	1.66	0.74	364.7	284.1	324.4	1.05	0.82	0.94	0.61	0.47	0.54	0.27	0.21	0.24

* Price calculation based on the World Bank Commodities Price Forecast data for gas prices in Europe using pessimistic (Hub+), optimistic (Hub–) and neutral (Hub0) options for calculating the price of imported gas. For 2025–2045, we will take the gas price in 2020.

** The cost according to the statistical data of 2015.

Source: Dergachova and Koleshnia 2018.

The potential of agriculture is not limited to the use of livestock waste for biogas and electricity production. Thus, agriculture is a source of production:

- ◆ biofuels (growing energy plants on low-yielding lands; use of crop waste (corn stalks, straw) and forestry for fuel production;
- ◆ bioethanol from biomass (which will allow to replace the import of gasoline).

The Institute of Renewable Energy of the National Academy of Sciences of Ukraine has created an Atlas of Energy Potential of Renewable Energy Sources in Ukraine, which shows the total annual technically achievable potential of renewable energy: 68.9 million toe, of which wind energy is 15.0 million toe; solar energy – 4.2 million toe; large hydropower – 4.9 million

toe; small hydropower – 2.1 million toe; bioenergy – 21.7 million toe; geothermal energy – 8.4 million toe; environmental energy – 2.65 million toe (Kudrya 2015).

According to the Energy Strategy of Ukraine for the period up to 2035, bioenergy will predominate in the structure of the total supply of primary energy of Ukraine among renewable sources (Table 6).

TABLE 6. The structure of the total supply of primary energy of Ukraine [%]

TABELA 6. Struktura całkowitej podaży energii pierwotnej Ukrainy [%]

Name of primary energy supply sources	2015	2020 (forecast)	2025 (forecast)	2030 (forecast)	2035 (forecast)
Coal	30.4	22	16.1	14.3	12.5
Natural gas	28.9	29.3	31	30.8	30.2
Petroleum products	11.6	11.5	9.2	8.2	7.3
Atomic energy	25.5	29.3	32.2	29.7	25
Biomass, biofuels and waste	2.3	4.9	6.9	8.8	11.5
Solar and wind energy	0.1	1.2	2.4	5.5	10.4
HPP	0.5	1.2	1.1	1.1	1.0
Thermal energy	0.6	0.6	1.1	1.6	2.1
Total	100	100	100	100	100

Source: KМУ 2017.

Both small and medium-sized businesses can contribute to the active growth in the popularity of the agricultural waste and municipal solid waste usage as well. The author's research has shown that small or medium-sized agricultural enterprise can pay off the biogas plant construction in 6–8 years, provided there is a sufficient livestock population. However, the crop waste usage was not taken into account.

To calculate the payback period of the biogas plant, take the enterprise PLAE “PEREMOHA”, which is located in the Chernihiv region. The number of cattle at this enterprise is 962. The annual capacity for biogas production will be 1,028.5 thousand cubic meters. The installation of such capacity costs about UAH 39.91 million (about EUR 1.2 million).

1 kWh of biogas produces 2 kW of electricity, so the annual electricity generation will be 2,057 thousand kW.

For its own operation, the biogas plant uses about 10% of electricity production, ie the useful generation capacity (and that can be sold) will be about 1,851.3 thousand kW. The annual company's own electricity consumption is 145.5 thousand kW. Thus, the company can sell 1,705.8 thousand kW of electricity at a “green” tariff. Due to the instability of the hryvnia exchange rate, all payments are made in euro. The “green” tariff for biogas plants until 2030 remains unchanged and will be 12.39 eurocents/kWh. According to the bank's loan offer, part of the cost of the equipment is paid by the customer (initial investment). The amount of annual credit payments is

provided by the bank, according to them we will calculate the forecast income from the sale of electricity at the “green” tariff (Table 7).

TABLE 7. Projected income from the sale of electricity at the “green tariff”

TABELA 7. Prognozowany dochód ze sprzedaży energii elektrycznej po „zielonej taryfie”

Year	Electricity production [kW]	„Green” tariff [EUR]	Income [EUR]	Credit payments by position [EUR]	Income/loss of the enterprise from the sale of electricity [EUR]	Income/loss of the enterprise from the sale of electricity accumulated as a result [EUR]
Initial investment [EUR]						-12,010,00
2021	1,705,800	0.1239	211,348.6	406,886.6	-195,538	-555,550
2022	1,705,800	0.1239	211,348.6	351,410.1	-140,061	-695,611
2023	1,705,800	0.1239	211,348.6	304,296.8	-92,948.1	-788,560
2024	1,705,800	0.1239	211,348.6		211,348.6	-577,211
2025	1,705,800	0.1239	211,348.6		211,348.6	-365,862
2026	1,705,800	0.1239	211,348.6		211,348.6	-154,514
2027	1,705,800	0.1239	211,348.6		211,348.6	56,834.87
2028	1,705,800	0.1239	211,348.6		211,348.6	268,183.5
2029	1,705,800	0.1239	211,348.6		211,348.6	479,532.1
2030	1,705,800	0.1239	211,348.6		211,348.6	690,880.7

Source: own calculations.

Provided that the enterprise will keep the number of cattle at the same level, the payback period of the biogas plant will be 7 years. After 2030, the company will be able to sell the produced electricity to the wholesale market or directly to consumers (under direct contracts). It is worth noting that the company can save money on its own energy consumption. According to the tariff of UAH 2.85/kWh, the annual savings will be about UAH 415 thousand.

The discounted payback period of the equipment will be slightly higher. If we accept the discount rate at the level of the NBU discount rate (currently it is 6%), the payback period will increase to 8 years (Table 8).

The payback period will be shorter and the level of profitability will be higher for biogas plants of large enterprises.

The biogas plants’ construction in rural areas will definitely improve the energy infrastructure, providing the population with a great opportunity to choose an electricity supplier. In addition, enterprises, ensuring their energy consumption by their own production, will increase the level of energy independence and ensure the stability and continuity of production processes.

TABLE 8. Projected discounted income from the sale of electricity at the “green tariff”

TABELA 8. Prognozowany zdyskontowany dochód ze sprzedaży energii elektrycznej po „zielonej taryfie”

Year	Income [Euro]	Discount rate	Discounted income [EUR]	Discounted credit payments [EUR]	Income/loss of the enterprise from the sale of electricity [EUR]	Income/loss of the enterprise from the sale of electricity accumulated as a result [EUR]
Initial investment [EUR]						-12,010,00
2021	211,348.6	0.94	199,385.5	383,855.3	-184,470	-544,482
2022	211,348.6	0.89	188,099.5	312,753.7	-124,654	-669,136
2023	211,348.6	0.84	177,452.4	255,493.4	-78,041.1	-747,177
2024	211,348.6	0.79	167,407.9		167,407.9	-579,769
2025	211,348.6	0.75	157,932		157,932	-421,837
2026	211,348.6	0.70	148,992.4		148,992.4	-272,845
2027	211,348.6	0.67	140,558.9		140,558.9	-132,286
2028	211,348.6	0.63	132,602.7		132,602.7	316,897.8
2029	211,348.6	0.59	125,096.9		125,096.9	125,413.8
2030	211,348.6	0.44	93,792.15		93,792.15	219,206

Source: own calculations.

Conclusions

Alternative energy is considered as a great opportunity to minimize the negative effect on the environment in the global dimension, ensuring the natural resources' safety. Nevertheless, for a great deal of countries, including Ukraine, this is a chance to ensure energy independence (being, in turn, an important element of economic independence) and improve the electricity supply quality. Subject to proper market reform, the active construction of power plants operating on renewable sources will create a truly competitive market, increasing supplier competition in the regions (especially in rural areas), where there are no alternatives for now.

The main issue essence is the very fact that the major method of stimulating the alternative energy development are “green” tariffs. Based on the research, they have become a justifiable threat in recent years, creating a significant financial burden on the state, which can eventually be transferred to the customer. Alternative energy is becoming a source of high income, while creating imbalances and adversely affected traditional electricity producers, as they are forced

to compensate for the “green” tariff at their own expense. Energy producers are not motivated to enter the market as suppliers, as they will not be able to sell all the generated electricity at a similarly high tariff. While the state, represented by the “Guaranteed Buyer” SE, pays for energy generation in full, despite its surplus in the energy system, and a decrease in green tariffs will entail an outflow of investors and their industry discredit.

Hereby, it is necessary to take more multipurpose approach to issues of concern, including expanding the mechanisms’ list for the alternative energy development promotion, focusing on the successful experience of other countries, as well as promoting the potential usage of the agro-industrial complex in the energy generation sphere. The volume of electricity production by biogas plants is predictable and independent of external uncontrolled factors, in contrast to solar and wind plants. The change in the size of the “green” tariff rates for SES and WPPs and their preservation for biogas plants is justified given the complexity of the implementation of these projects, their reliability and ensuring uninterrupted energy supply. Ukraine remains an agrarian country, and the potential of agriculture in the field of energy generation is quite high.

Traditional electricity generation in Ukraine is cheaper than renewable energy. However, the wear and obsolescence of power units poses threats to the quality and reliability of the energy supply. Traditional energy sources pollute the environment and consume non-renewable resources. That is why the development of alternative energy is relevant for Ukraine.

In our opinion, the use of biomass and biogas based on the agricultural sector should be the largest share in renewable energy. This is due to a number of reasons:

- ◆ the development of agriculture and the availability of access to biomass as an energy resource that is relatively free and will not require transportation to the place of processing (unlike fuel such as coal or gas);
- ◆ improving the environmental situation through the production of pure fertilizers;
- ◆ use of food waste and crop waste for biogas generation;
- ◆ predictability and stability of energy generation;
- ◆ the possibility of ensuring uninterrupted energy supply in rural areas;
- ◆ reduction of pressure on the environment;
- ◆ reduction of own costs of agricultural enterprises to pay for heat or energy supply.

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Energia alternatywna na Ukrainie: stan obecny i możliwe rozwiązania istniejących problemów

Streszczenie

Najważniejsze problemy ukraińskiej energetyki, w szczególności przestarzała baza wywórcza, niedostatek infrastruktury energetycznej i znacznie gorsza w porównaniu z krajami europejskimi jakość dostaw energii, zostały przedstawione w oparciu o porównania wskaźnika SAIDI (System Average Interruption Duration Index). Stwierdzono znaczące przerwy w dostawach energii zarówno w osadach wiejskich, jak i miejskich. Opisano aktualny stan rozwoju energetyki alternatywnej, przeanalizowano strukturę wytwarzania energii oraz tempo rozwoju wykorzystania odnawialnych źródeł energii. Wskazano na wyzwania związane z nierównomiernością produkcji w odnawialnych źródłach energii i przeanalizowano ich konsekwencje, m.in. zmienność poziomu produkcji zarówno w SPP, jak i WPP, które wymagają dostosowania się przedsiębiorstw wykorzystujących źródła tradycyjne.

Udowodniono negatywny wpływ „zielonej” taryfy, która miała stymulować budowę obiektów OZE. Ogólnie i szczegółowo przeanalizowano negatywny wpływ zmian finansowania na państwo, przejawiający się w narastaniu długów wobec wywórców energii. Przeanalizowano ograniczone próby rozwiązywania problemów rozwoju energetyki alternatywnej, polegające w szczególności na ogłaszaniu przez państwo „zielonych” aukcji, określeniu optymalnego przewidywanego poziomu wytwarzania energii przez SPP i WPP w celu zapobieżenia głębokiemu brakowi równowagi pomiędzy zapotrzebowaniem a podażą energii elektrycznej. Wskazano, że biogazownie mogą stanowić racjonalną alternatywę w stosunku do wytwarzania z wykorzystaniem energii słonecznej i wiatrowej.

SŁOWA KLUCZOWE: energetyka, energia alternatywna, „zielona” taryfa, „zielona” sprzedaż, biogazownia

