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INVESTING IN UKRAINIAN ENERGY: THE IMPORTANCE OF INTEGRATION INTO ENTSO-E

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Abstract. *The article considers the Unified Energy System (UES) of Ukraine, its main capacities. The structure of electricity generation and consumption in Ukraine is studied. Electricity prices for household consumers in Ukraine and Europe have been determined. Energy trade is considered, the largest partners are identified. The synchronization of Ukraine with ENTSO-E, the European network of electricity transmission system operators (unites 43 operators in 39 countries of the European continent) has been studied. The volume of foreign direct investment in Ukraine and their growth rates are analyzed. It is determined that the industry is the most attractive for attracting foreign investment. Thus, the Ukrainian renewable energy sector has significant potential to attract investment. That is why the dynamics of the installed capacity of renewable electricity facilities in Ukraine was analyzed. The study found that after synchronization with ENTSO-E, Ukraine will have much more opportunities and prospects to attract investment in its own energy.*

Key words: *investment, integration, energy, ENTSO-E, renewable energy.*

Introduction.

Independent Ukraine inherited from the Soviet Union a centralized energy complex dominated by large nuclear and coal-fired power plants. Most thermal power plants were built in the 1950s and 1960s, and nuclear power plants in the 1970s and 1980s. Currently, most coal-fired power units have long exceeded the design life and have low technical, economic and environmental performance. The generating capacity of the NPP was put into operation a little later than the TPP, but most of the power units also exceeded their initial design life by 30 years.

Significant threats are the war with the Russian Federation and the occupation of Donetsk and Luhansk oblasts, where the main production of thermal coal is used, which is used by thermal power plants to generate electricity, and monopolization of the electricity market, and high depreciation of power plants, and low introduction of alternative sources .

That is why Ukraine has clearly identified a path that can significantly improve and make changes in the country's energy sector. Thus, the terms of the Association Agreement with the EU and the Energy Community Treaty stipulate that Ukraine must change the model of the electricity market in accordance with the provisions of the Third Energy Package, make the transition to a modern, open, competitive pan-European electricity market, in which priority is given to the development of renewable energy sources.



In June 2017, Ukraine signed an agreement with the ENTSO-E network operators, which was based on key conditions for the future integration of Ukraine's energy systems with the continental European energy system. However, on March 16, 2022 (5 years later) the country officially joined the ENTSO-E [9].

Since then, the electricity industry has begun to actively attract significant investment in network upgrades and the construction of new renewable energy facilities.

Problems of economic activity of electricity companies, analysis of the electricity market of Ukraine and tools for its regulation, investment attractiveness of the energy sector of Ukraine, the importance of "green energy" is raised in a large number of studies by domestic scientists: O. Hubriienko, V. Yevdokimov, M. Zemlianyi, V. Saprykin, B. Slupskyi, V. Tsaplin and others. Among the foreigners are: B. Vidi, R. Brown, G. Masters, T. Gonen, R. Bansal, G. J. Anders. At the same time, in the conditions of transformation processes in the electric power industry of Ukraine, there is a need for a more detailed study of current trends, opportunities and challenges.

The objective of the article is to analyze the electric power industry of Ukraine, determine its investment attractiveness and study the importance and impact of Ukraine's integration into ENTSO-E.

Main text.

The basis of Ukraine's electricity is the Unified energy system (UES) of Ukraine, thanks to the operation of which the electricity needs of domestic consumers of the country's energy system, interaction with the energy systems of neighboring countries, electricity export and import are centrally provided. It includes power generating capacities, distribution networks of the regions of Ukraine, interconnected by system-forming power transmission lines with a voltage of 220-750 kV. Operational and technological management of the UES and management of power system regimes is carried out centrally by the State Enterprise NEC "Ukrenergo" [2].

The main generating capacities of the UES of Ukraine are concentrated in [2]:

- five energy generating companies – PJSC DTEK Dniproenergo, PJSC Donbasenergo, PJSC Centerenergo, PJSC DTEK Zahidenergo, PJSC DTEK Vostokenergo. The total number of power units at TPPs and CHPs is 106 units, including capacity: 100 (120) MW, 150 MW, 200 MW, 250 MW, 300 MW, 800 MW;
- NNEGC Energoatom, which has 15 power units operating at four nuclear power plants;
- PJSC Ukrhydroenergo, which includes cascades of hydroelectric power plants on the Dnipro and Dniester rivers with a total number of hydro units – 103 units.

Given the structure of electricity generation of the Unified energy system of Ukraine, it should be noted that the largest share is occupied by nuclear power plants– more than 50%. According to Interfax-Ukraine, electricity production at nuclear power plants last year increased by 13.1% to 86 billion 205.4 million kWh. In particular, the production of Zaporizhzhya NPP amounted to 35 billion 457.5 million kWh (+23.4% by 2020), Rivne – 18 billion 827.3 million kWh (+10.3%), Khmelnytsky – 13 billion 294.6 million kWh (+ 20.5%) (Table 1) [2].



Electricity production of thermal power plants (29.3%) depends on the supply of gas and thermal coal; the available production capacity of TPPs allows to increase generation volumes. In 2021, thermal power plants reduced production by 12.5% to 45.834 billion kWh (Table 1) [13].

Hydroelectric power plants (HPP) and pumped-storage hydroelectricity power plants (PSPP) increased production by 37.7% to 10 billion 445.8 million kWh, while block stations decreased by 14.9% to 1 billion 570.8 million kWh [13].

Table 1 - Electricity generation by type of power plant, 2008-2021, %

Type	NPP	TPP	HPP / PSPP	SPP / WPP / Biomass	Block stations
2008	46,9%	43,0%	5,9%	-	4,2%
2009	48,0%	41,1%	6,8%	-	4,1%
2010	47,4%	41,5%	6,9%	-	4,2%
2011	46,5%	43,7%	5,6%	0,0%	4,2%
2012	45,5%	44,7%	5,5%	0,3%	4,0%
2013	43,0%	44,7%	7,3%	0,7%	4,3%
2014	48,5%	41,3%	5,0%	1,0%	4,3%
2015	55,6%	35,2%	4,3%	1,0%	3,9%
2016	52,3%	39,7%	6,0%	1,0%	1,0%
2017	55,1%	35,9%	6,8%	1,2%	1,0%
2018	53,0%	36,9%	7,5%	1,7%	0,9%
2019	53,9%	36,2%	5,1%	3,6%	1,1%
2020	51,2%	35,2%	5,1%	7,3%	1,2%
2021	55,1%	29,3%	6,7%	8,0%	1,0%

Created by the author based on [14]

A small share in the structure of electricity generation is occupied by RES (renewable or green energy) – 8%. The low level of RES implementation is due to the high cost of installing the appropriate equipment. However, production volumes are growing rapidly. Thus, in 2021 they increased by 15.3% to 12 billion 519.7 million kWh.

In general, the production of electricity in the Unified Energy System (UES) of Ukraine in 2021, according to current data, increased by 5.2% (7 billion 719.5 million kWh) compared to 2020, to 156 billion 575.7 million kWh.

Distribution of electricity consumption in Ukraine is carried out by legal entities and individuals. The largest amount of electricity is consumed by the industry of Ukraine – 45.1% (including metallurgy – 25.2%), in 2021 it increased electricity consumption by 6% – up to 52 billion 273.6 million kWh. Agricultural enterprises consumed 3.692 billion kWh (-2.8%), transport – 6 billion 171.2 million kWh (+8%), construction – 1 billion 64.2 million kWh (+11, 2%) (Figure 1) [13].

The population consumes 28.3% (38 billion 659.3 million kWh) of electricity. During the same period last year, the total volume of electricity consumption by all consumers in Ukraine increased by 5.3%.

Thus, the total share of industry in total electricity consumption in 2021 decreased to 41.7% from 41.8%, and the share of the population – to 30.8% from 31%.

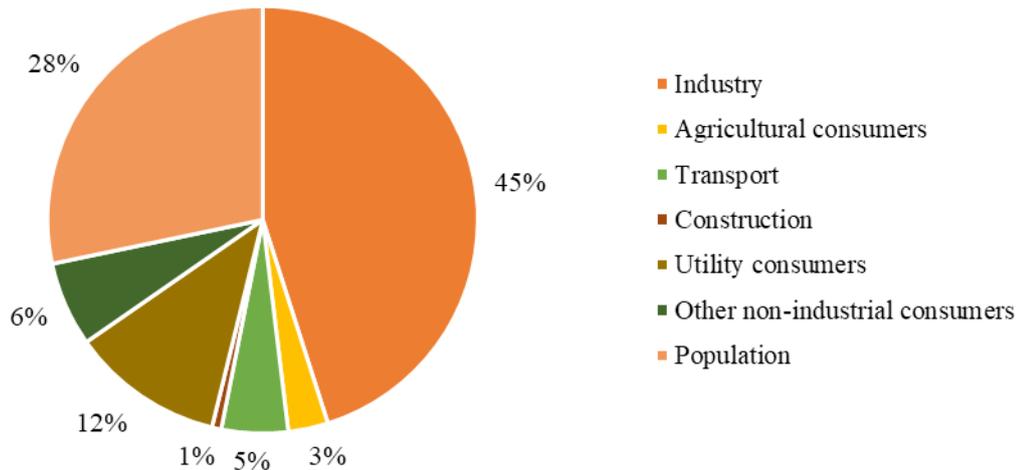


Figure 1 - Structure of electricity consumption in Ukraine by consumer groups, in 2021, %

Created by the author based on [1]

It is worth noting that in the first quarter of 2021 electricity prices for household consumers in Kyiv were the lowest in Europe. Thus, in the capital the cost of electricity for the population was at the level of 5 eurocents / kWh (1.68 hryvnias). The lowest prices were also recorded in Belgrade (Serbia), Podgorica (Montenegro) and Budapest (Hungary). The cost of electricity in these places is 8-12 eurocents / kWh.

For example, the highest prices are in Berlin (Germany), Copenhagen (Denmark) and Dublin (Ireland). In the first two cities, the cost of this energy resource exceeds 30 eurocents / kWh (over 10 hryvnias) [7; 12].

Considering trade in energy resources, it should be noted that in 2021 the total volume of electricity exports from Ukraine amounted to 3,495.4 million kWh, which is 26.5% less than in 2020 (4,754 million kWh) (Figure 2). The largest volumes in 2021 were exported to Hungary – 1,570 million kWh (44.9% of the total), Poland – 819.6 million kWh (23.5%) and Romania – 642.6 million kWh (18.4%).

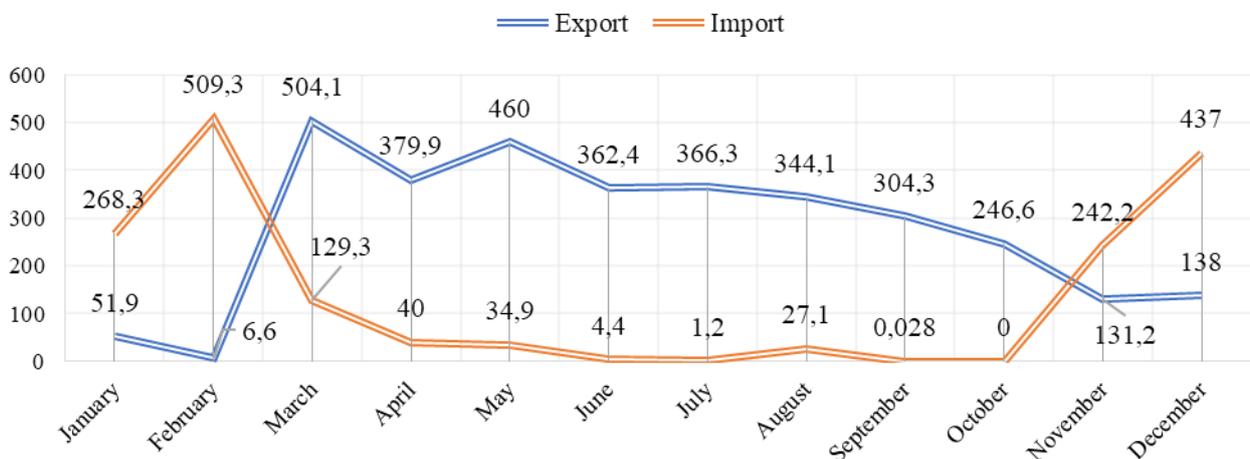


Figure 2 - Total exports and imports of electricity in 2021, million kWh
Created by the author based on [4]



In 2021, Ukraine imported 1,693.6 million kWh of electricity, which is 26.5% less than in the previous year. The majority of imports – 69.5%, came from Belarus. The second place was taken by Slovakia with 308 million kWh, the third – Russia (101 million kWh). In general, the import of electricity to Ukraine in 2021 amounted to 1.1% of total electricity consumption in the country [4].

However, in 2022, the temporary isolation from the power systems of Russia and Belarus, which began on February 24 and was to last three days, has not ended. On the same day, a full-scale war with Russia began, and since then the Ukrainian energy system has been operating in isolation but stably.

It is under these circumstances that Ukraine joined the integrated continental European energy system ENTSO-E a year earlier than planned.

After signing the Agreement on the terms of Ukraine's future unification with ENTSO-E, NPC Ukrenergo, as the operator of the electricity transmission system in Ukraine and the only operator of high-voltage transmission lines in the country, began preparations for synchronization. Since 2017, a number of important measures have been taken: testing of power units of NPPs, TPPs and HPPs of Ukraine, creating a mathematical model of Ukrainian and Moldovan power systems, on the basis of which the ENTSO-E Consortium conducted a study of static and dynamic stability of Ukrainian and Moldovan power systems. After a significant stage of preparation, a decision was made on possible synchronization and the necessary technical capacity for its implementation [3, 10].

With a total investment of over € 700 million in energy infrastructure construction, IT infrastructure strengthening and cybersecurity over five years, Ukraine has all the key technical conditions for ENTSO-E integration [3; 10]

Synchronization of the Ukrainian energy system with the European one in general will reduce Russia's influence in the energy sector of Central and Western Europe and increase energy security in the region.

After Ukraine's victory in the war, new opportunities will open up for it and Europe to consolidate the electricity market and support the "green transition". In particular, the entry of European producers and suppliers of electricity into the Ukrainian market will promote competition, which in turn will ensure greater development and improvement of their own production; will stimulate investment in Ukrainian energy resources. Ukrainian electricity generators will be another opportunity that will contribute to the export of electricity to Europe and the full transition of European countries to renewable energy sources [3, 10].

Considering the most attractive industries for attracting investment, it should be noted that in 2020 the largest inflow of FDI was observed in industry (39.8%), followed by wholesale and retail trade (16.3%), financial and insurance activities (9.4%), real estate transactions (9.3%), information and telecommunications (5.9%). Although FDI declined in 2020 due to a pandemic and volatile political situation, investment in the third quarter of 2021 was \$ 2.3 billion. In the first half of the year, FDI grew by \$ 2.7 billion (compared to the corresponding period of 2020). Last year, the net outflow of foreign direct investment amounted to \$ 868.2 million (compared to their net inflow to Ukraine of \$ 5.86 billion in 2019) [11] (Figure 3).

So, we see that the industry is the most attractive for attracting foreign



investment.

The Ukrainian renewable energy sector has great potential for attracting investment. In general, the Ukrainian legal framework provides favorable conditions for the functioning of the energy market and in fact guarantees a return on investment.

Today, the installed capacity of solar and wind power plants in Ukraine is about 8.9 GW, of which 1 GW belongs to DTEK companies. The installed capacity of the renewable energy sector may increase to 20 GW. Increasing investment in the renewable energy sector will allow Ukraine to produce more electricity that can be exported to Europe instead of Russia's energy resources.

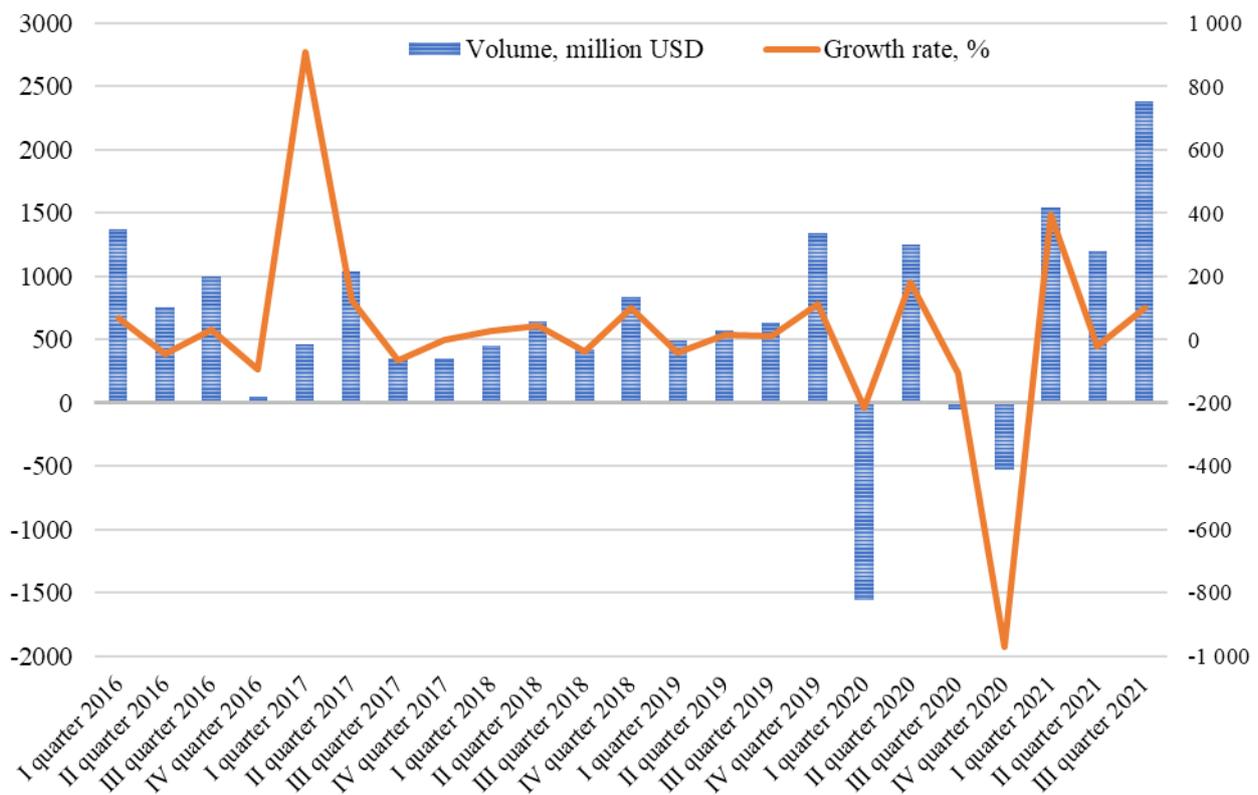


Figure 3 - Volume of foreign direct investment for 2016-2021 (left scale, million USD; right scale - growth rate,%)

Created by the author based on [8]

It is important to invest in solar energy, primarily due to the so-called "green tariff" (solar energy is the most expensive) and Ukraine's favorable location for solar panels, as the level of solar activity throughout the country does not fall below three conventional units, unlike other European countries (Figure 4).

According to the State Agency on Energy Efficiency, more than 3 billion euros have been invested in Ukraine's renewable energy sources in recent years, with the European Investment Bank for Reconstruction and Development, China's CNBM and DTEK being the largest investment players. An important incentive for large-scale investment in alternative energy in Ukraine is the country's membership in the International Renewable Energy Agency (IRENA), which creates a solid reputation among investors [6].

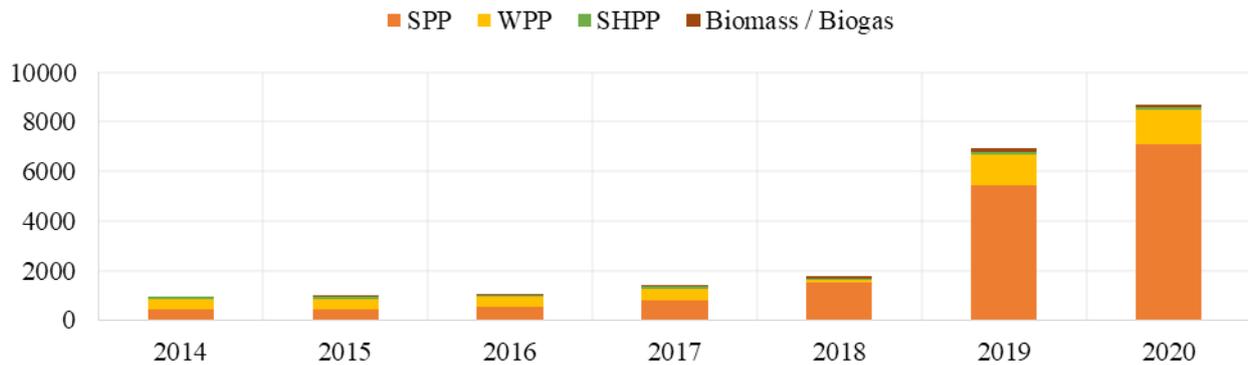


Figure 4 - Installed capacity of renewable electricity facilities operating on the "green tariff" in 2014-2020, MW

Created by the author based on [5]

It should also be noted that the State Agency on Energy Efficiency and Energy Saving of Ukraine is working on a list of investment projects and proposals in the field of renewable energy, which can be presented to potential investors, including official international events to support important and priority investment projects in the field of renewable energy. In order to obtain certain financial resources, the State Agency on Energy Efficiency cooperates with the following international financial organizations: the International Finance Corporation, the International Bank for Reconstruction and Development, the European Bank for Reconstruction and Development, the Eastern European Partnership for Energy Efficiency and Environment, etc. [6].

Thus, power lines are already available in Ukraine, there is a possibility of exporting electricity. Ukrainian generation and supply companies have low costs, and a high level of professional training significantly increases the chances for foreign investment.

Summary and conclusions.

Attracting investment in the energy sector is an important priority for the Ukrainian government, as the sector continues to play a key role in ensuring security and promoting sustainable growth. After receiving synchronization with ENTSO-E, Ukraine has become part of the European energy system, which allows access to market integration. This, in turn, will enable Ukraine to trade freely with Europe, especially Ukrainian power producers will be able to export electricity to Europe, and will facilitate the full transition of European countries to renewable energy. The entry of European producers into the Ukrainian market will help to increase competition and develop market mechanisms. It has been found that synchronization generally increases the investment attractiveness of the Ukrainian energy sector.

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Анотація. У статті розглянуто Об'єднану енергетичну систему (ОЕС) України, її основні потужності. Досліджено структуру генерації та споживання електроенергії в Україні. З'ясовано ціни на електроенергію для побутових споживачів в Україні та в Європі. Розглянуто торгівлю енергоресурсами, визначено найбільших партнерів. Досліджено синхронізацію України з ENTSO-E, європейською мережею операторів системи передачі електроенергії (об'єднує 43 оператори у 39 країнах європейського континенту). Проаналізовано обсяг прямих іноземних інвестицій в Україну та їх темпи приросту. Визначено, що промисловість є найбільш привабливою для залучення іноземних інвестицій. Так, значний потенціал залучення інвестицій має український сектор відновлюваної енергетики. Саме тому було проаналізовано динаміку встановлених потужностей об'єктів відновлюваної електроенергетики в Україні. З проведеного дослідження з'ясовано, що після синхронізації з ENTSO-E в Україні буде значно більше можливостей та перспектив залучення інвестицій у власну енергетику.

Ключові слова: інвестиції, інтеграція, енергетика, ENTSO-E, відновлювана енергетика.

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