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Digital transformation of energy efficiency at Ukrainian NPPs

ABSTRACT: In this article, the author will try to conditionally transform the energy capacities of NNEGC Energoatom by converting a liability into an asset using the example of bitcoin. With a surplus of nuclear power generation, one of the modern tools for using excess electricity is directing it to cryptocurrency mining. The author of the article will try to calculate the possibilities of Ukrainian NPPs in the cryptoindustry market by analyzing the competitiveness, market trends and the approximate profitability of this kind of activity. The essence of the article lies in the intervention of the state energy giant in completely new activities, partial monopolization of the market and interference in the activities of decentralized cryptocurrencies, as well as the very novelty of combining two different fields of activity and the global nature of the consequences. Mining can be used to convert the underdeveloped electricity or all of Energoatom's capacities totally, but at the same time it can also affect the cryptoasset market in the field of decentralization, as the primary cost factor to affect the price of assets and allow for obtaining super-profits at a state enterprise. The author of the article tries to understand the profitability of such actions and, in general, to understand the globality of the idea. The results of the entry of the national energy giant into the cryptoasset market will change the global processes in the ecosystem of the cryptoindustry and change the situation both

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on the electricity market in the region and, in general, will affect the processes of globalization and unification of the financial sectors of the economy.

KEYWORDS: digitalization, energy efficiency, digital transformation, mining on NPPS

Introduction

In 2019, with the coming to power of a new government represented by President Volodymyr Zelensky, a new word for the Ukrainian political movement, “Digitalization”, appeared in everyday life. In connection with the stagnation of economic processes in Ukraine, the Ministry of Energy and some politicians have proposed mining cryptocurrencies at nuclear power plants. The department said that such an approach can “Really transform a liability into an asset”. With a surplus of nuclear power generation, one of the modern tools for using excess electricity is directing it to cryptocurrency mining. Mining cryptocurrencies at nuclear power plants began to be seen as a method of guaranteed sales. Presumably, mining will keep the guaranteed load on nuclear power plants and attract additional funds. Due to the lack of political support, as well as the inability of energy markets to attract long-term investments, we have to look for new ways of development, resorting to new approaches and methods. Nevertheless, the article will partially consider not only the novelty of the approach and possibilities, but also the impact of this approach on the world market, trends in general, ecosystem of the cryptoindustry and even more so on the role and place of Ukraine in the processes of globalization and unification of the financial sectors of the economy.

1. Possibilities of NPP's

The author conventionally divided the article into several parts, each of which will consistently paint the overall picture. The word “Why”, in the opinion of the author of the article, is the only word that characterizes the reason for the activity, regardless of its type. So the first question is why NNEGC Energoatom needs digital transformation of energy efficiency. Having a surplus of nuclear power generation, one of the modern tools for using excess electricity is directing it to cryptocurrency mining. Mining cryptocurrencies at nuclear power plants began to be seen as a method of guaranteed sales. Presumably, mining will keep the guaranteed load on nuclear power plants and attract additional funds. The author notes that within the framework of state policy this is a very advantageous position, since NNEGC “Energoatom” is a state-owned enterprise and the operator of all operating nuclear power plants in Ukraine. The President of

NNEGC Energoatom Yuri Nedashkovsky noted that within the framework of the Energy Strategy approved by the Government until 2035, not only is the extension the operating life of the existing NPP power units planned, but also the designing and building of new ones. In addition, Nikolay Kukharchuk, Director for International Cooperation of NNEGC Energoatom, noted that the main risks holding back the development of nuclear energy are the overdue and costs of NPP construction in the world, the lack of political support, and the inability of energy markets to attract long-term investments. At the time this paper was written, 15 power units are in operation at Ukrainian NPPs, with a total installed capacity of 13,835 MW, which is 26.3% of the total installed capacity of all Ukrainian power plants. According to the data from the beginning of the year, the share of energy of NAEK Energoatom in the total volume of electricity production in Ukraine was 56.2%. At the same time, in the period from 6/18/2020 to 6/19/2020, the nuclear power plants of Ukraine did not generate 80.84 million kW of electricity, and since the beginning of 2020, they have not generated 4,193.65 million kW. The author will try to calculate the capabilities of Ukrainian NPPs for mining Bitcoin cryptocurrency based on the above-presented underdevelopment data, as well as compare the obtained data with the capacities of the largest Bitcoin mining pools. At its core, mining is the process of decrypting data and energy power is only a consumable for computing processors. In addition, in the field of mining, a certain type of technical equipment is required, which tends to become obsolete. The purpose of writing this material is to determine the competitiveness of NNEGC “Energoatom” in the cryptocurrency industry, not only in terms of capacity, but also in terms of the profitability of this kind of activity. The cryptocurrency industry is a huge variety of different cryptocurrencies working on different kinds of mechanisms. It is very important to correctly assess and enter the market in a timely manner in order to generate sufficient profits and take your place among the rest of the monopoly giants.

For comparison, the author gives a graph of the distribution of hash iterations among the largest Bitcoin mining pools by month. On Figure 1, you can see that as of the day from 4/7/2020 to 5/7/2020, the f2pool mining pool prevailed. Figure 2 shows the distribution of the hash search per day as of 8/12/2020. On Figure 3, 48 hours in advance. On Figure 4 for 4 days. Over time, as the network grows, so does the hash rate of most pools. The displayed values are the relative pool sizes depending on the network: Small: less than 2%, Medium: 2–10% Large: more than 10% of the network. The author has provided these graphs to understand the mining market conditions, and the fact that hash rates are very dynamic in most pools. This can be attributed to the fact that large pools have a large number of different miners with different mining equipment, showed on Table 1 as an example.

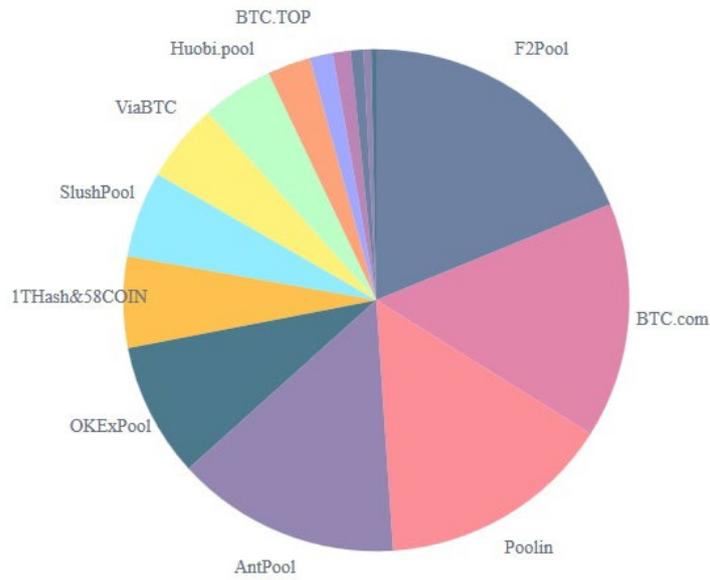


Fig. 1. An estimation of hashrate distribution amongst the largest mining pools from 04/07/2020 to 05/07/2020
 Rys. 1. Szacunkowa dystrybucja hashrate wśród największych puli wydobywczych od 04.07.2020 do 05.07.2020

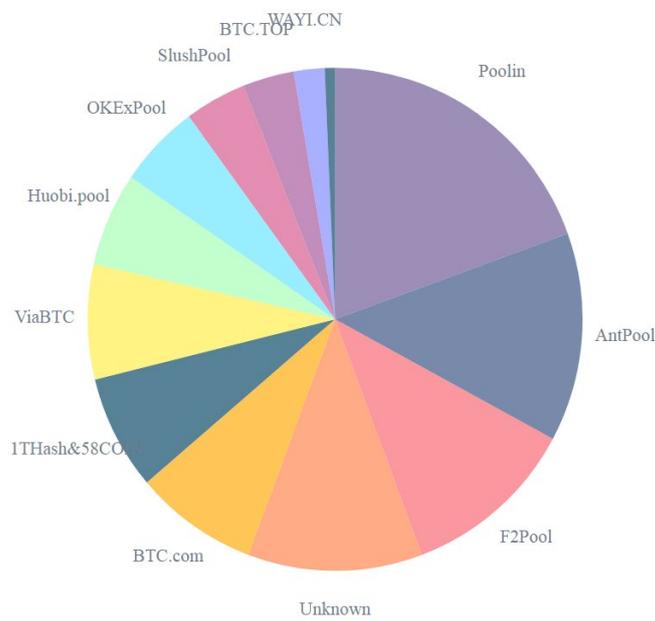


Fig. 2. An estimation of hashrate distribution amongst the largest mining pools for 24 hours
 Rys. 2. Szacunkowa dystrybucja hashrate wśród największych puli wydobywczych w ciągu 24 godzin

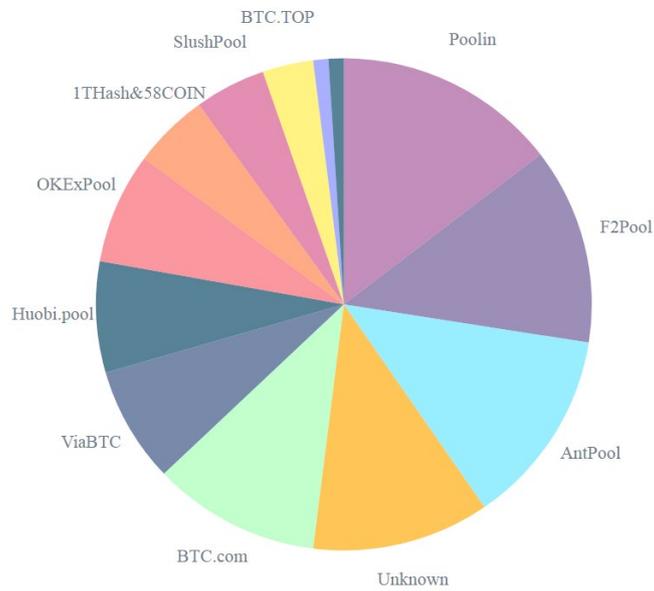


Fig. 3. An estimation of hashrate distribution amongst the largest mining pools for 48 hours

Rys. 3. Szacunkowa dystrybucja hashrate wśród największych puli wydobywczych przez 48 godzin

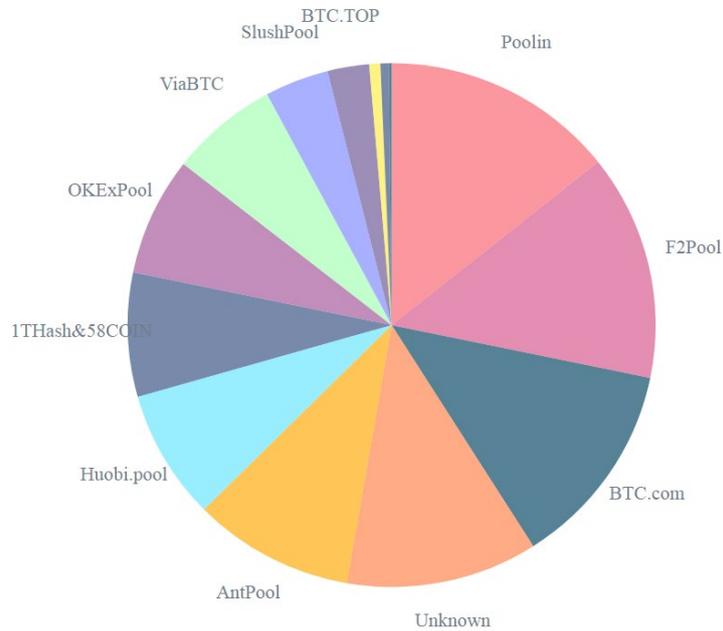


Fig. 4. An estimation of hashrate distribution amongst the largest mining pools for 4 days

Rys. 4. Szacunkowa dystrybucja hashrate wśród największych puli wydobywczych przez 4 dni

TABLE 1. Examples of recent bitcoin ASIC Miner machine types

TABELA 1. Przykłady ostatnich typów maszyn Bitcoin ASIC Miner

Machine	Hashrate [TH/s]	Power Use [W]	Power Efficiency [J/GH]
Antminer S9	14	1,372	0.098
Antminer T9	12.5	1,576	0.126
Antminer T9+	10.5	1,323	0.127
Antminer V9	4	1,027	0.257
Antminer S7	4.73	1,293	0.273
AvalonMiner 821	11	1,200	0.109
AvalonMiner 761	8.8	1,320	0.150
AvalonMiner 741	7.3	1,150	0.160
Bitfury B8 Black	55	5,600	0.11
Bitfury B8	47	6,400	0.13

Source: Bitmain, Bitfury and Canaan.

2. Approximate calculation

For an approximate calculation and comparison, the author will take one of the largest pools, the F2Pool. At the time this paper was written, according to the stated data, the mining speed of Bitcoin is 20.40 EH/s using mining machines such as AntMiner S9k, with a declared hash rate of 13.5 Th/s and power consumption 1148 W/h under optimal conditions. 20.40 EH/s = 20,400,000 Th/s. At the same time, according to F2Pool, the capacity of the entire network is about 105.14 EH/S. Simple calculations can show us the power of the network. For example, Miner AntMinerS9 has a hash rate of 13.5–14.0 TH/s. The simplest calculation will show us the required number of AntMinerS9 mining machines to obtain the same capacities as F2Pool, $20,400,000/14 = 1,457,142$ AntMinerS9 machines. Let's count the number of such miners to service a network with such a hash rate. The author of the article used this calculator (<https://coinguides.org/hashpower-converter-calculator/>).

- ◆ 1 EH/s = 1,000,000 TH/s;
- ◆ 105.14 EH/s = 105,140,000 TH/s;
- ◆ $105,140,000/14 = 7,510,000$ AntMinerS9;

Let's calculate the percentage of the share of the mining market occupied by the F2pool pool, dividing the required number of mining machines to cover the entire bitcoin network by the number of mining machines we calculated based on public data on the hashing power of the pool: $1,457,142/(7,510,000/100) = 19.402\%$. Thus, we can roughly count the number of such devices in each of the pools, just to estimate the approximate number of possible miners. We present this data in a % ratio with the above Figures 1–4, we can see the approximate number of miners in

each pool, if, of course, it is not presented in the public information of the pool. And the actual power consumption for maintaining the network with such a power with the above technical support can be approximately $7,510,000 * 1,148 \text{ W/h} = 0.00862148 \text{ Twh}$. Let's try to check our calculations by dividing the consumed energy of the entire bitcoin network by the number of hours per year. $64.49 \text{ Twh}/8766 \text{ hours} = 0.00735683 \text{ Twh}$, which is pretty close to our original estimate, considering that we took only 1 type of mining equipment as a constant. If the capacity of Ukrainian NPPs is 13,835 MW, which equals 0.013835 Twh per hour, then the possible output per day can be $24 * 0.013835 = 0.33204 \text{ Twh}$, i.e. $365 * 0.33204 = 121.1946 \text{ Twh}$. Please note that the consumption of the Bitcoin network at the time of publication is 64.49 Twh. The author notes that the cost of mining equipment strongly affects the ability to enter the market, but the amount of excess energy will allow for older samples of technical equipment to be used. The output of NNEGC Energoatom exceeds the consumption of the bitcoin network by almost 2 times. The AntMinerS9 equipment was taken simply to compare the capacities of bitcoin pools with the capacities of nuclear power plants. If we take newer models, such as the Bitmain Antminer S19 Pro, we get completely different results in terms of both energy efficiency and mining payback (see Fig. 6).

This calculation takes into account the price of USD 0.06 (UAH 1.68) per kWh of electricity, which is equal to the price of electricity for the consumer. By dividing the NPP power in TWC by the power consumption of the latest Bitmain Antminer S19 Pro miner, we can see the income of this type of equipment with such capacities.

$$(\text{Twh/h}) \text{ to } (\text{w/h}) : 0.33204 \text{ Twh} = 13,835,000,000 \text{ Wh} \quad (1)$$

$13,835,000,000 \text{ w}/3250 \text{ wh} = 4,256,923$ (number of Bitmain Antminer S19 Pro) = 4,682,615,30 TH/s (hash rate). The author of the article notes that in the case of the PoF algorithm, which is used in cryptocurrencies such as: Bitcoin, Ethereum, Bitcoin Cash, Litecoin, Monero, Dash, etc., most of which use the SHA-256 hashing algorithm. The author gives an example of calculating profitability for the Proof-of-work consensus algorithm based on SHA-256:

$$N = (t \cdot R \cdot H)/(D \cdot 2^{32}) \quad (2)$$

where:

- N – income in coins
- t – mining period in seconds (for example, day = 86,400)
- R – block reward in coins
- H – hash rate per second (for example, 1GHsh = 1,000,000,000)
- D – difficulty.

This threshold, called difficulty, determines the competitive nature of mining: the more computing power is added to the network, the higher this parameter is, also increasing the average number of computations required for a new block. This method also increases the cost of

creating a block by nudging miners to improve their mining efficiency in order to maintain a positive economic balance. From this formula, it is clear that huge capacities are required to maintain the equipment, and the success in finding the unit depends on these capacities. The author explains the possible success of NNEGC Energoatom precisely with the presence of huge capacities, which will give an advantage over other competing pools. This applies not only to the capacities of the enterprise, but also to the price of electricity. Electricity in Ukraine is one of the cheapest in the world, which gives a huge advantage when entering the market. The author of the article notes that Altcoin mining may become more attractive in terms of the threshold for entering the market due to the small capitalization of certain currencies, the absence of giants' competitors, which will allow it to take a monopoly position and more effectively influence pricing in the long term. You can also consider mining on CPU/GPU for some altcoins. Equipment released several years ago is still relevant, which is basically impossible for ASIC's.

3. Impact on the hasrate and profit

The transformation of such a volume of electricity will lead to a colossal increase in the complexity of block mining and an increase in the network hash rate, which will entail an increase in the transaction costs of users, as well as the price of cryptocurrency, which will give additional profits at the initial stage, until the corresponding adjustment of the network complexity. The author notes that the availability of a resource does not yet speak of future success, since the cost of mining equipment itself is very high, due to the constant growth in the complexity of mining, it quickly becomes obsolete and ceases to give the expected profit. At this stage, the next question arises about changes in market conditions after entering the market. Across the years, the correlation between the Bitcoin price and the hash rate has been very high, suggesting a relationship between the two variables. In 2016, these two variables were correlated at 86.2%, while in 2017 the relationship was even greater at 91.5% – the highest across from 2016–2020 (showed in fig. 5).

However, in 2018, a high opposite relationship was observed between hash rate and Bitcoin price at negative 66.2%, being the only year with a negative correlation between these variables. Naturally, the positive relationship was again shown in 2019 with a correlation of 59.5%. Data shows a significant negative relationship between hash rate and returns. When employing regression models to determine the influence of the hash rate on Bitcoin's price, one can observe conflicting non-significant results, meaning we cannot reach a conclusion about the behavior in individual years with a slight exception in 2019. During 2019, there was a very small significant negative relationship between the hash rate and Bitcoin's price, meaning when the hash rate increased by 1%, Bitcoin's price would drop by 0.01%. The reason for the variation lies in the fact that the hash rate is all but impossible to measure in real terms. Resources can only analyze recent network activity and from that create an estimate of presumed hash rate. In September,

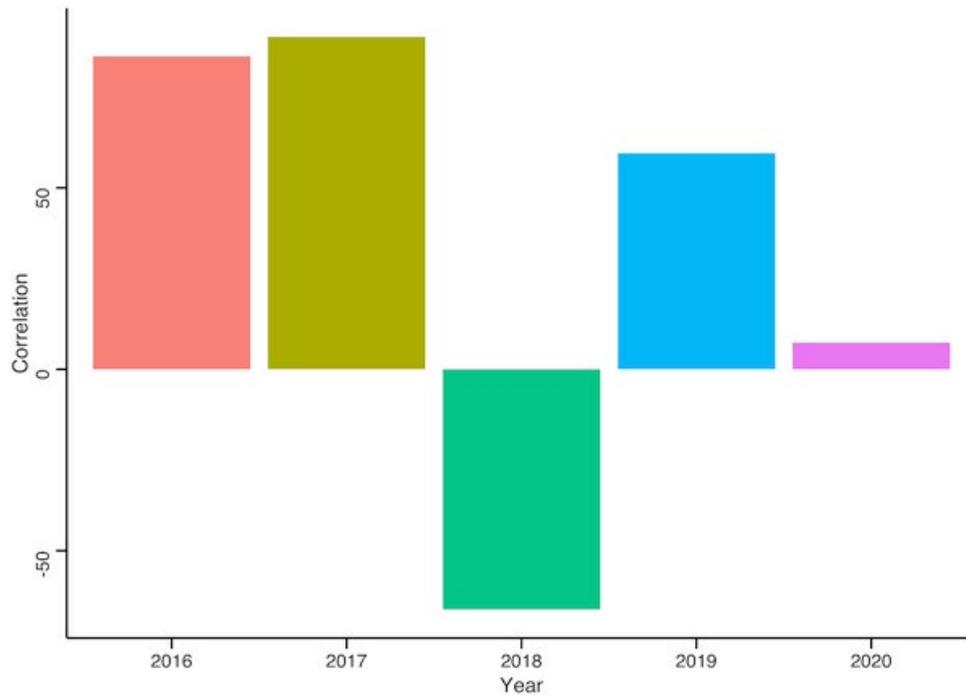


Fig. 5. Correlation between Bitcoin price and its hashrate

Source: <https://cointelegraph.com/news/hash-rate-and-bitcoin-price-during-mining-events-are-they-related>

Rys. 5. Korelacja między ceną Bitcoina a jego hashrate

what appeared to be an overnight 40% drop in hash rate was subsequently attributed to the way it is calculated. The recent records have further come independent of Bitcoin price action. BTC/USD fluctuated between USD 3100 and USD 13,800 last year, but the hash rate trend endured. It is crypto assets on a deflationary platform that would allow not only using excess energy selling it at a fixed price, but also increasing the size of their own capital by influencing the pricing, popularity, and liquidity of the asset, depending on the position of NNEG C Energoatom in the structure of the service link.

Conclusion

This issue still needs to be studied, but the author of the article is convinced that mining as a primary cost factor together with the deflationary bitcoin platform will in any case provoke an increase in the price of this cryptocurrency, and a positive correlation will always be present,

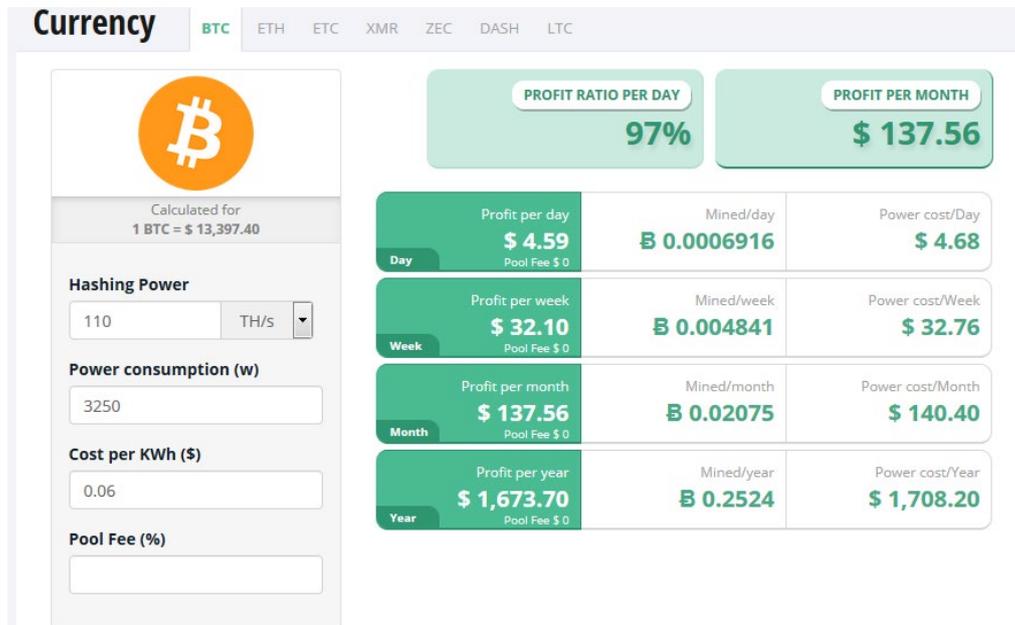


Fig. 6. Bitcoin profitability calculator

Source: <https://www.cryptocompare.com/mining/calculator/>

Rys. 6. Kalkulator rentowności Bitcoina

except for some unpredictable exceptional situations. Therefore, the entry into the market of NNEG Energoatom will provoke not only the taking of a leading position in the mining market, but can also provoke an increase in prices, which will have a positive effect on the profitability of all market participants. The next question is the change in the electricity market in Ukraine itself, whether the transformation of underdeveloped capacities will affect the subsequent volumes of electricity allocated by the NPP for these needs. It is impossible to say exactly how profitable mining at the facilities of NNEG Energoatom will become, but it can be assumed that this alternative method of use will become more profitable than just selling electricity to the population. Will the price of electricity rise later, or will this sector fall into the hands of alternative, green energy sources. How will this be legally regulated and what will happen to the capacity and resources spent on equipment in case of an unsuccessful entry into the mining market. The author of the article notes that it is possible that Bitcoin mining may not be as profitable as mining another cryptocurrency, altcoins. In this article, the author has made only small calculations that make it possible to present the scale and possibilities of using such an energy giant as NNEG Energoatom to us. New technologies, and even more so cryptocurrency, provide a number of new opportunities for transforming energy efficiency in other industries related to IT, including the security of various systems. According to the author, NNEG Energoatom has the opportunity to change the entire financial sector of the cryptoindustry, as well as change the place of Ukraine in

the development of cryptocurrencies and, moreover, become a monopolist in this industry. The author notes that open data of this kind make it possible to fairly accurately calculate the possibilities of entering the cryptocurrency market, and, moreover, to stabilize and strengthen the financial position of the state-owned enterprise NNEGC Energoatom. The digital transformation of the energy efficiency of Ukrainian NPPs would speed up the formation of market conditions for the development of Ukraine's energy networks and revenues to the country's budget.

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Vladyslav Gennadyevich STANISLAVSKYI

Cyfrowa transformacja w zakresie efektywności energetycznej w ukraińskich elektrowniach jądrowych

Streszczenie

W artykule autor bada teoretyczne możliwości przekształcenia zobowiązań zdolności produkcyjnych NNEG Energoatom w aktywa, na przykładzie bitcoina. Przy nadwyżce produkcji energii jądrowej jednym z nowoczesnych narzędzi wykorzystania nadwyżki energii elektrycznej jest użycie jej do wydobycia kryptowalut. Autor szacuje możliwości ukraińskich elektrowni jądrowych na rynku kryptowalut poprzez analizę konkurencyjności, trendów rynkowych oraz przybliżoną analizę opłacalności tego rodzaju działalności. Istota przedstawionej analizy polega na ingerencji państwowego giganta energetycznego w zupełnie nowe działania, częściowej monopolizacji rynku i wejście na rynek zdecentralizowanych kryptowalut. Nowością jest tu łączenie dwóch odmiennych dziedzin działalności, a także globalny charakter konsekwencji takich działań. Wydobycie kryptowalut może być wykorzystane do konwersji zbyt wysokich mocy produkcyjnych Energoatomu, ale jednocześnie może również wpłynąć na rynek kryptowalut poprzez jego decentralizację, ponieważ podstawowy czynnik kosztowy wpływa na cenę aktywów i pozwala na uzyskanie nadwyżki zysków w przedsiębiorstwie państwowym. Autor stara się zrozumieć opłacalność takich działań i jak ogólna jest taka idea. Skutki wejścia krajowego giganta energetycznego na rynek kryptowalut zmienią globalne procesy w ekosystemie branży kryptowalut i sytuację zarówno na rynku energii elektrycznej w regionie, jak i całościowo wpłyną na procesy globalizacji i unifikacji sektorów finansowych gospodarki.

SŁOWA KLUCZOWE: cyfryzacja, efektywność energetyczna, transformacja cyfrowa, wydobycie kryptowalut przez przedsiębiorstwa energetyczne