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Climate-aligned Tokens as Instruments of Climate Change Financing and Investment – the Case of Energy Tokens

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Abstract

The growing role of Tokenomics in the world of finance has stirred much interest in different areas of the economy. Digital tokens as financial innovations, also known as cryptoassets, emerged alongside the blockchain technology (or the more broadly applied concept of the 'distributed ledger technology' – DLT). At present, numerous analyses are being carried out on the ever emerging new types of digital tokens and the process of tokenization. In recent years, tokenization has also found application in the field of organising and financing climate change and energy policies.

The aim of the article is to identify climate-aligned tokens, with particular regard to energy tokens. In the second part of the paper, the authors evaluate the investment attractiveness of 12 selected energy tokens from the point of view of the effectiveness measures applied to ordinary financial instruments. In this way, it was possible to compare energy tokens with traditional financial instruments. Furthermore, the authors attempted to investigate the relationship between the formation of rates of return of the researched energy tokens and the rates of return on stock and commodity markets. The aim of this study was to point to the possibility of diversifying an investment portfolio using the tokens in question.

The results of the study indicate the low investment attractiveness of energy tokens compared to investments in stock markets, commodity markets, and investments in major cryptocurrencies such as Bitcoin and Ethereum. The research therefore indicates that buyers of energy tokens today should not be driven by investment or speculative motives, but rather by a desire to obtain a means of clearing energy trading, or other utility.

Keywords: digital tokens, tokenization, climate-aligned tokens, energy tokens, investment efficiency.

JEL Classification: G11, G12, O13, Q54.

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1. Introduction

The ever-advancing climate change requires taking immediate action if we want to halt environmental degradation and ensure the ecological security of our planet. This issue has become so important and pressing that in 2015 the UN passed the Resolution on Sustainable Development Goals, among which – in addition to tackling poverty, hunger, exclusion, inequality, armed conflict – climate and environmental issues were prioritised. In particular, the promotion of water resources management, access to affordable and clean energy, protection of life on land and in water were mentioned (United Nations, 2015). On 7 March 2018, the European Commission launched the Action Plan for Financing Sustainable Growth, with the aim of encouraging and promoting sustainable investment. This act is in line with the European policy for a new sustainable world and continues the work carried out by European authorities following the Paris Agreement and the UN Agenda (European Commission, 2018).

However, the latest report of the Intergovernmental Panel on Climate Change (IPCC, 2021) leaves no illusions that climate change can be stopped now. The authors predict that over the next 20 years, global temperatures will on average reach or exceed a 1.5°C increase. Hence, there are numerous calls for governments and international associations (such as the European Union) to accelerate action to reduce carbon emissions. It is therefore becoming a priority for the EU to implement the Green Deal strategy, including, in particular, the energy sector, which is responsible for 75% of the EU's greenhouse gas emissions (EC, 2019). It should also be noted that the European Union is increasingly promoting further legislative initiatives related to financing and investing in sustainable and green assets (investments), such as the Sustainable Finance Disclosure Regulation (European Parliament and the Council, 2019), among others, which is a set of new regulations that help to better classify the sustainable specification of investment funds and the new EU Taxonomy, which offers a classification for economic activities that are green and sustainable.

The renewable energy market is therefore becoming an increasingly attractive market from the point of view of financing and investment, including financial investment. Furthermore, the use of the decentralised ledger technology (DLT) and the tokenization process is increasingly being considered in the energy sector. According to the Union of the Electricity Industry, which represents 3500 energy sector companies across Europe, a blockchain enables secure data storage and executing smart contracts in peer-to-peer networks. Owing to its unique attributes, this technology has the potential to play a significant role in the energy sector. The possible solutions that could be implemented across the electricity supply chain, with regard to process optimization, include networks and trading platforms as the traditional wholesale trading as well as peer-to-peer (Eurelectric, 2017).

The first aim of the article is to identify climate-aligned tokens, including energy tokens, based on the practice of their use to date. Another objective is to answer the question about the attractiveness of energy tokens as an instrument for investment and diversification of the investment portfolio of market investors.

To the best of our knowledge, this is the first analysis ever to include energy tokens in a portfolio analysis as financial instruments. This is because so far the main focus has been on researching this digital token in its payment and utility function only.

Thus, the article is organised into four main sections. The first section presents an analysis of the research to date on providing public access to environmental resources, including clean and affordable energy as public goods, and traditional ways of financing this process. This is followed by a description of the issues of using new blockchain technology and climate-aligned tokens to achieve climate goals. In the next section, the essence and significance of energy tokens as a way of using blockchain technology in the energy sector is discussed in more detail using the classification criteria of digital tokens and the existing issuing practice. In the last section, the authors present the results of empirical studies conducted on the investment efficiency of energy tokens and their portfolio attractiveness.

2. Climate-aligned Traditional Financing

The implementation of sustainable development goals is automatically connected with the tasks of the state. It is so because ensuring citizens' access to environmental resources, including clean water, clean air, energy sources, etc., is perceived in terms of a public good, construed as a good that, once produced for specific consumers, can be consumed by other entities as well, without incurring additional costs (Samuelson, 1954). This feature can be described as “non-rivalry” in consumption (McNutt, 1998), “jointness” in consumption, or “non-excludability” from consumption (Holcombe, 1997). Moreover, the globalisation processes taking place in recent decades have resulted in a change in the perception of public goods. In 1999, the concept of global public goods emerged. Its authors defined global public goods as “outcomes (or intermediate products) that tend toward universality in the sense that they benefit all countries, population groups, and generations. At a minimum, a global public good would meet the following criteria: its benefits extend to more than one group of countries and do not discriminate against any population group or any set of generations, present or future” (Kaul et al., 1999, p. 16). Such goods are the emanation of national public goods beyond the borders of specific states, and the fundamental difference in their provision is that they do not result from coercion but from international agreements (Kleer 2014, p. 45). In considering the nature of goods whose provision should be handled by the state, a true milestone is the definition of the so-called merit goods by Richard A. Musgrave (1957, pp. 33-43; 1959, pp. 13-15), who argues that these goods include public goods and selected private goods that have positive and measurable spillover effects (or "externalities") on other people and society as a whole. Education and healthcare, among others, are also included in this group of goods. Such a broad approach to the definition of goods, the provision of which is the responsibility of the state, strongly implies the need for the government to also engage in environmental protection issues. It is precisely providing people with fair and sustainable access to environmental resources, including diversified energy sources, that is now becoming the key merit good.

Bearing in mind the above considerations concerning the essence of the public good, it should be stated that, in principle, the burden of financing the implementation of measures related to climate change lies with the state (public funds). The actions of public authorities supporting environmental protection under the conditions of climate change have, therefore, consequences both on the side of public expenditures (financing or co-financing of pro-environmental and energy projects) and public revenues (e.g., lower budget revenues caused by the application of reliefs in public levies, rewarding pro-environmental activity of taxpayers). The accumulation of public funds for the described objectives may consist in obtaining new public revenues, including taxes and fees imposed, e.g., on entities whose activities harm the environment and increase carbon emissions. Appropriate construction of the tax system (including green tax) and budget revenues obtained from the auction sale of emission allowances, including EU ETS, is yet another issue (Marchewka-Bartkowiak, Jarno, 2020).

In addition to budgetary resources, climate finance can also be repayable and result from public commitments in the financial market. The last decade has seen a sharp increase in the volume and value of green bonds and climate-aligned bonds, including those issued by governments, both central and local governments (Wiśniewski, Zieliński, 2019, pp. 83-96). According to the Climate Bond Initiative (2021), in 2020, the global green bond market was worth USD 1.1 tn – dominated by bonds issued by sovereigns, government-back entities, local governments and development banks. Additionally, sustainability bonds, which finance the implementation of both green and social goals, appeared in the statistics. In 2020, the value of the market for these bonds amounted to USD 317 bn, and their issuers included mainly development banks, however, not excluding sovereigns, government-back entities, and local governments.

This path is also being followed by private entities, which increasingly use repayable financing (loans, bonds) of green nature. The commitments entered into finance green activities specified by the issuer, which constitutes an incentive for socially and environmentally responsible investors to purchase these instruments. In order for an investor to be confident in the greenness of their investment, certification by institutions such as the Climate Bond Initiative, CICERO, Moody's Green Bond Assessments and Standard & Poor's Green Evaluation is required (Ehlers, Packer 2017, p. 93). It is emphasised that such certification makes it easier for a green debt issuer (both public and private issuer) to place a bond issue and reduces the investor's margin, thus reducing the cost of debt, due to the additional bonus investors receive in the form of the belief that they are doing something valuable for the environment (Wiśniewski, Zieliński, 2019, pp. 83-96).

However, modern technologies are increasingly becoming an alternative to the so-called traditional methods of financing climate policy. In this article, the authors will focus on the latest trend in financing and investing in the field of climate and energy policy based on the distributed ledger technology (DLT, or more narrowly: blockchain), namely tokenization.

3. Climate-aligned Digital Tokens

The increasing interest in the new DLT technology has resulted in the growing popularity of digital tokens and the process of their creation (issuance) called tokenization. Accordingly, tokenization may revolutionise and fundamentally diversify sources of funding and investment in the so-called climate and energy market in the future. As mentioned in the introduction, blockchain and digital tokens are already seen by potential issuers and investors as a future-oriented asset for practical application in the field of energy and climate change financing. Therefore, it should be assumed that climate-aligned tokens will increasingly be taken into account in financial decisions by both the private and public sector (Table 1).

Table 1. Financial instruments in financing tasks and activities regarding climate change

Economy sector	Financial instruments	
	Traditional	Modern (digital)
Public	**Budgetary sources** (incl. budgetary spending on green investments, green tax credits, public taxes and charges on entities acting to the detriment of the environment, public revenues from green debt, especially green bonds)	**Climate-aligned tokens** (e.g., green bond tokens)
Private	**ESG-linked loans and securities** (incl. green bonds and loans)	**Climate-aligned tokens** (e.g., energy, climate, green tokens)

Source: Authors' own elaboration.

Generally, digital tokens or cryptoassets are defined as a digital representation of value or rights which may be transferred and stored electronically, using the distributed ledger technology or a similar technology (definition adopted by the European Commission in COM(2020)593). Digital tokens are currently used in many business models (Diedrich, 2016; Adhami et al., 2018). Their diversity in terms of functionality has also given rise to the recognition of a new area of analysis called the Token Economy, or Tokenomics for short (Mougayar, 2017). The most important division of digital tokens is mainly based on three aspects: the purpose of their creation, the function they are supposed to perform, and their technical aspects.

Based on these three criteria, the authors separated climate-aligned tokens as a type of digital asset used in the field of climate-energy policy. The characteristics of climate-aligned tokens within the framework of digital tokens classification accepted in the literature (BIS, 2018; FSB, 2018; ESMA, 2018; ECB, 2019; OECD, 2019; FCA, 2018; Oliveira et al., 2018) are presented in Table 2.

Table 2. Climate-aligned token features

Criteria	Climate-aligned tokens features
Aim of the creation (issuance)	**Energy tokens** Green (climate) tokens
The value or rights represented	Exchange type (payment tokens) Utility type (utility tokens) Investment type (asset or security tokens)
Type of the issuance	Public or private sector Institutional or individual entities
Method of technological link	Native or non-native tokens
Price/value stability standard	Stable or non-stable tokens
Digital contract	Fungible or non-fungible tokens

Source: Authors' own elaboration.

Climate-aligned tokens can be used in a wide variety of ways for direct financing of climate and energy policy (on digital platforms); they can also be used as an investment instrument (e.g., for trading on digital stock exchanges); they can also be used for clearing purposes (e.g., in energy trading) or for utility purposes, entitling their holder to certain services. It is also worth noting that although digital tokens are most often issued by institutional entities, personal tokens are becoming increasingly popular (Marchewka-Bartkowiak, Nowak, 2020). In the future, it should therefore be possible to use tokens by households or individuals in the climate-energy area not only as beneficiaries, but also as issuers of tokens (e.g., of energy surpluses). From a technical point of view, the construction of climate-aligned tokens can be based on existing functionalities of digital tokens, such as technological link with platforms, price stability standard, or smart contract. However, these issues will largely depend on the further development of DLT technology in the near future.

Today, one of the most popular climate-aligned tokens is energy tokens, to which a more in-depth analysis is devoted.

4. Energy Tokens as the Climate-aligned Tokens

Nowadays, many different applications of the DLT technology can be found as far as energy is concerned. First of all, the blockchain is used in energy trading – buying and selling individually generated energy – by individual users. With the help of this technology, electricity trading platforms are created, services enabling payment for charging electric vehicles at stations, or giving users the opportunity to quickly change energy service providers (Basden, Cottrell, 2017). The literature highlights that the use of new technological solutions can increase the security of energy trading, as the technology perfectly allows for confirmation of ownership, it is a reliable and inexpensive way to conduct and control transactions without a central generation unit of power, and promote the development of the renewable energy microgrid. In addition, it introduces intelligent solutions and energy management systems to ensure universal and safe access to energy. Blockchain, through liquidation of intermediaries and introduction of P2P transactions, also allows reducing energy prices, under the conditions of high competition

(Varnavskiy et al., 2018, pp. 46-49). Researchers dealing with the possible applications of the technology described also point to its use for: crowdfunding of assets and distribution of revenue, facilitating green energy investments and assets co-ownership, bringing together sustainable energy projects and prospective investors, rewarding low-carbon and green energy production (Andoni et al., 2019, pp. 158-159).

Generally speaking, energy tokens issuers are entities involved in providing clean energy, mediating its settlement, as well as implementing new solutions in the renewable energy market.

Energy tokens can thus be considered as a means of payment in a clearing or utility function (Varnavskiy et al., 2018; Andoni et al., 2019), but also as a commodity (Guseva, 2021, pp. 175-176) or decentralised means of investments (Lin, Tjio, 2020, p. 1). Thus, these tokens can also represent an alternative form of investment compared to classical financial instruments, such as stocks, bonds, or mutual fund units. Even if they are not "equity" tokens, which are a digitalised form of financial instruments, they can be regarded as an alternative investment, such as investments in commodities (oil, metals, and grain).

The study conducted below is based on a group of 12 energy tokens. Table 3 presents their characteristics, specifying the type of issuer, services offered, availability, etc., as well as their market capitalisation value, and describing their essence. Data for the analysis was obtained from the CoinMarketCap and CoinGecko portals, while detailed information on the tokens was collected from the websites of their issuers. Detailed descriptions of the energy tokens and the technical solutions used are also described in detail in: Andoni et al., 2019; Varnavskiy et al., 2018; SolarPlaza, 2018; PWC, 2018.

Table 3. The energy tokens under study

Acronym	Name	Market capitalisation (USD)*	Date of "issuance"	Characteristics
EWT	Energy Web Tokens	206 787 847	31/03/2020	native token behind the Energy Web Chain, a blockchain-based virtual machine designed to support and further application development for the energy sector; used to create DApps
WPP	WPP Token	138 884 888	14/04/2019	native token which allows market participants to trade Energy and biofuel production (Switzerland)
POWR	Power Ledger	120 547 246	08/11/2017	native token which uses public ETH blockchain, designed to enable local areas to sell and distribute solar power without the help of middlemen, used to facilitate energy and environmental commodity trading

Acronym	Name	Market capitalisation (USD)*	Date of "issuance"	Characteristics
WOZX	EFFORCE	76 678 254	07/12/2020	native cryptocurrency token of energy efficiency platform Efforce, used as the medium through which energy savings created on the Efforce platform are tokenized for use by any participant
MWAT	Restart Energy	17 608 389	02/03/2018	cryptocurrency operating on the ETH platform, which enables energy producers to tokenize their energy
GRID+	GRIDplus	8 392 318	02/03/2018	cryptocurrency operating on the ETH platform, that gives consumers direct access to wholesale energy markets (USA)
CHG	Charg Coin	4 149 307	14/06/2018	native coin which binds energy to money using the power of electric vehicle charging as a basis of value; time of charging vehicle (in Charge Coin network) is transformed into the price of the coin
SNC	SunContract	4 021 650	19/11//2017	native cryptocurrency which empower individuals to freely buy, sell or trade electricity by providing an open energy marketplace (Slovenia)
WPR	WePower	3 909 418	11/02/2018	a platform which allows green energy producers to raise capital by issuing these tokens
ELEC	Electrify.Asia	527 240	21/03/2018	cryptocurrency operating on the ETH platform, that allows for the trading of energy among individual producers of energy (Singapore)
PYLNT	Pylon Network	358 687	21/03/2018	Native cryptocurrency, which enable digital energy trading, and foster market transparency by tracking and certifying source of energy (Spain)
TSL	Energo / Tesla	203 381	28/12/2017	native cryptocurrency, which supports peer to peer power trading system by applying a blockchain to the microgrid for decentralized energy autonomy

* data as of 1 August 2021

Source: Own elaboration based on energy tokens issuers' websites.

The list of energy tokens presented in Table 3 allows several observations to be made:

- in most cases, energy tokens have the nature of payment tokens - with their help individual energy producers and energy buyers can make settlements without an intermediary, which can reduce the cost of electricity; others allow, for example, the self-creation of tokens by entities interested in using the created blockchain or decentralised applications (DApps), or even the creation of coins thanks to charging electric vehicles from a specific network;
- the first tokens of this type appeared in 2017 and the dominant part of them was implemented a year later; two of them were launched only in 2020;
- the majority (8 out of 12) of the surveyed energy tokens are native tokens, meaning that their issuers have created their own blockchain - the others were based on Ethereum (non-native tokens);
- market capitalisation of the researched tokens is very diverse and very variable, too - from a few hundred thousand USD to over 200 million. In August 2021, the average value of the market capitalisation of all energy tokens, as reported on the aforementioned portals, amounted to approximately USD 700 million, with the daily turnover exceeding USD 20 million.

It is therefore clear that most of the instruments described are of payment or use character, which definitely defines the nature of their users (buyers). In such an approach, the valuation of these instruments is highly difficult, as it is subjective in nature to value access to some service, or the possibility of relatively cheaper acquisition or disposal of energy, or to value the "utility" of owning a token that has created capital for the creation of renewable energy sources, or to value the possibility of creating one's own DApp.

5. Energy Tokens as the Investment Instrument

In the era of progressive changes related primarily to the greater digitalisation of modern life, the change in investor behaviour, including a greater interest in acquiring digital and at the same time alternative instruments, with their greater availability and lower transaction costs compared to classical financial instruments, the acquisition of energy tokens may represent an alternative for the investor. Of course, valuing his satisfaction resulting from the fact that he allocates his resources to finance environmentally friendly actions is highly difficult due to its subjective nature. However, evaluation, from the point of view of financial investment, is also most possible and objective, too

The fundamental research on energy tokens undertaken by the authors concerns in particular the following:

- analysis of profitability, risk, and investment efficiency of tokens in the light of classical measures used by investors;
- correlation between the rates of return of the tokens under study (intra-group), as well as between the rates of return of these tokens and selected stock indices.

The authors have attempted to apply classical investment measures, including in particular profitability, risk, and efficiency, to the verification of the tokens under analysis. Such an analysis of energy tokens leads to an assessment of their investment attractiveness from the perspective of portfolio analysis. By investment attractiveness of a particular instrument, the authors understand its high expected rate of return and low risk (low volatility of return rates) - according to the portfolio theory of Markowitz (1952). Investment efficiency, on the other hand, will be considered in terms of reward-to-variability, as the relationship between the above categories, according to the commonly used concept, formulated by Sharpe (1952, 1994).

Although in the literature it is possible to find a study of the risk of investing in tokens (initial coin offerings – ICOs) using the Value-at-Risk methodology (Kuryłek, 2020, pp. 512-530), in this study, the authors focused on classical risk measures such as standard deviation of returns, which to the best of the authors' knowledge no one has done before.

The study conducted concerns the energy tokens characterised above for the period from 12 November 2017 to the end of June 2021 (i.e., from when they were listed on the indicated information platforms).

To measure their investment attractiveness in a comparative manner, the study was also conducted for:

- the major cryptocurrencies (Bitcoin (BTC) and Ethereum (ETH));
- indices of the largest world stock exchanges (American: SPX, DJI, Brazilian: BVP, British: FTM, German: DAX, French: CAC and Japanese: NKX);
- and for alternative commodity investments (gold price (XAU) and WTI-NYMEX crude oil price (CL.F)).

Weekly logarithmic returns were determined for the investment evaluation of the tokens. The choice of such an interval was dictated, among others, by the need to standardise the frequency of data – in the case of stock market indices, a week is, in principle, five days long, while in the case of tokens, data are available on each day of the week.

In addition to examining the investment attractiveness of energy tokens, the authors also looked at the relationship between their rates of return and those of stocks and commodities, because for investors who want to diversify their portfolio and make it resilient to changes in the economic situation, it is also important whether the prices of the assets held are correlated with each other – how strongly and in what direction. Therefore, the next study undertaken is an analysis of the correlation of the returns of tokens, stock indices, and commodities.

For each token, stock index, and commodity price, the following measures of investment attractiveness were determined (Table 4):

- profitability, determined as the arithmetic mean rate of return;
- risk, described by the standard deviation of the return rates;
- effectiveness, calculated with the Sharpe ratio (quotient of mean rate of return and standard deviation – the value of risk-free rate was omitted in the Sharpe ratio calculation due to the effectively zero interest rates occurring in the analysed period).

Table 4. Investment measures of energy tokens against selected cryptocurrencies, stock market indices, and commodity prices

Energy tokens	**EWT**	**WPP**	**POWR**	**WOZX**	**MWAT**	**GRID**	**CHG**	**SNC**	**WPR**	**ELEC**	**PYLNT**	**TSL**
Number of weeks under study	65	116	190	29	174	190	159	189	177	171	182	183
Profitability	0.0330	0.0049	0.0020	-0.0415	-0.0017	-0.0077	0.0086	-0.0036	-0.0137	-0.0241	-0.0219	-0.0307
Risk	0.2261	0.3801	0.2042	0.1948	0.2310	0.2997	0.6287	0.1929	0.1936	0.2398	0.2769	0.2643
Effectiveness	0.1462	0.0129	0.0096	-0.2132	-0.0072	-0.0257	0.0138	-0.0185	-0.0706	-0.1006	-0.0791	-0.1161
Crypthocurrencies / stock indices / commodities	**BTC**	**ETH**	*SPX*	*DJI*	*BVP*	*FTM*	*DAX*	*CAC*	*NKX*	XAU	CL.F	
Number of weeks under study	190	190	190	190	190	190	190	190	190	190	190	
Profitability	0.0094	0.0103	0.0027	0.0021	0.0030	0.0007	0.0009	0.0010	0.0013	0.0018	0.0015	
Risk	0.1194	0.1531	0.0288	0.0314	0.0360	0.0305	0.0326	0.0313	0.0306	0.0195	0.0671	
Effectiveness	0.0784	0.0673	0.0955	0.0664	0.0833	0.0221	0.0284	0.0331	0.0410	0.0909	0.0221	

Source: Authors' own calculations.

For easier reading, tokens are marked in bold and shaded, cryptocurrencies in bold, stock indices in italics, and commodity prices without distinction (this also applies to the next table). The measures presented in the table indicate significant variation in profitability, risk, and efficiency of the instruments studied. In addition, unlike indices, commodities and BTC and ETH, some tokens are new instruments and therefore have not been traded in the entire period since November 2017. To highlight this fact, the table notes the number of weeks from June 2021 backwards for which data was available.

Table 4, despite providing detailed information on the measures described, does not facilitate the drawing of synthetic conclusions. Therefore, on the basis of this data, an investment ranking was made in the indicated three criteria, and its results are presented in Table 5. The places in the ranking mean respectively the highest profitability, the lowest risk and the highest efficiency of a given token, stock index or commodity.

The results of the study clearly show that – in light of the investment measures used – most energy tokens perform worse than investments in stocks or commodities. The only exception to the list is the Energy Web Token, which is characterised by above-average profitability and efficiency, but its case should be analysed with great caution due to its shortest period on the market. Charg Coin and WPP Token were also characterised by high profitability; however, they both occupy the last places in the risk ranking. The study showed that even during such a turbulent time – the COVID-19 pandemic period – the stock and commodity markets were characterised by lower risk than investments in cryptocurrencies and the energy tokens under study.

In addition to examining the investment attractiveness of energy tokens, another study examined the relationship between their return rates and the return rates of stocks and commodities. This issue is crucial for investors who want to diversify their portfolio and make it resilient to economic fluctuations. It is therefore important whether the prices of the assets held are correlated with each other – how strongly and in what direction.

Table 5. Investment ranking of energy tokens and selected cryptocurrencies, stock indices, and commodity prices

Rank	Profitability	Risk	Effectiveness
1	**EWT**	XAU	**EWT**
2	**ETH**	*SPX*	*SPX*
3	**BTC**	*FTM*	XAU
4	**CHG**	*NKX*	BVP
5	**WPP**	*CAC*	**BTC**
6	*BVP*	*DJI*	**ETH**
7	*SPX*	*DAX*	*DJI*
8	*DJI*	*BVP*	*NKX*
9	**POWR**	CL.F	*CAC*
10	XAU	**BTC**	*DAX*
11	CL.F	**ETH**	CL.F
12	*NKX*	**SNC**	*FTM*
13	*CAC*	**WPR**	**CHG**
14	*DAX*	**WOZX**	**WPP**
15	*FTM*	**POWR**	**POWR**
16	**MWAT**	**EWT**	**MWAT**
17	**SNC**	**MWAT**	**SNC**
18	**GRID**	**ELEC**	**GRID**
19	**WPR**	**TSL**	**WPR**
20	**PYLNT**	**PYLNT**	**PYLNT**
21	**ELEC**	**GRID**	**ELEC**
22	**TSL**	**WPP**	**TSL**
23	**WOZX**	**CHG**	**WOZX**

Source: Authors' own elaboration.

The values of the Pearson correlation coefficient between the return rates of tokens, stock indices, and commodities were determined for the available data (respectively, the number of weeks of trading of a given token indicated in Table 4). The matrix of the correlation coefficient value is presented in Table 6, with bold highlighting those values where there is statistical significance of the relationship for a significance level of 0.05; while grey highlighting those values where the p-value is below one per mille, indicating a strong correlation.

Table 6. Values of the correlation coefficient between the rates of return of energy tokens, cryptocurrencies, stock indices, and commodity prices

	EWT	*WPP*	*POWR*	*WOZX*	*MWAT*	*GRID*	*CHG*	*SNC*	*WPR*	*ELEC*	*PYLNT*	*TSL*	*BTC*	*ETH*	*SPX*	*DJI*	*BVP*	*FTM*	*DAX*	*CAC*	*NKX*	*XAU*	*CL.F*
EWT	1																						
WPP	0.0260	1																					
POWR	0.4574	0.0997	1																				
WOZX	0.4949	-0.0102	0.4859	1																			
MWAT	0.1300	0.0843	0.3371	0.4600	1																		
GRID	0.2392	0.1143	0.4246	0.2193	0.1964	1																	
CHG	0.0570	-0.0097	-0.0046	0.1802	0.0076	-0.0418	1																
SNC	0.4263	0.1693	0.5999	0.1805	0.3352	0.2934	0.0824	1															
WPR	0.4195	0.1689	0.6839	0.3854	0.3689	0.3437	-0.0458	0.5607	1														
ELEC	0.2931	0.1005	0.4538	0.0105	0.2425	0.2853	-0.0390	0.4391	0.5129	1													
PYLNT	0.3284	0.0102	0.2661	0.1723	0.0388	0.2261	0.0107	0.1399	0.2890	0.1367	1												
TSL	0.2706	0.0529	0.4145	0.0991	0.2242	0.2268	-0.0238	0.3359	0.4446	0.3396	0.2591	1											
BTC	0.4457	0.0591	0.6050	0.1499	0.3844	0.3721	-0.0197	0.6249	0.6317	0.4388	0.2735	0.4041	1										
ETH	0.4723	0.0565	0.6655	0.2517	0.3424	0.4663	-0.0605	0.6132	0.6558	0.4572	0.2505	0.4092	0.7585	1									
SPX	0.1719	0.0544	0.1490	0.0873	0.1205	0.2337	-0.0368	0.1339	0.1779	0.0849	0.0583	0.1263	0.1581	0.2588	1								
DJI	0.1751	0.0619	0.1568	0.1810	0.1517	0.2415	-0.0253	0.1245	0.1825	0.0739	0.0822	0.1193	0.1569	0.2528	0.9765	1							
BVP	0.3673	0.1615	0.2141	0.0722	0.1683	0.2549	-0.0683	0.1389	0.1820	0.1020	0.0831	0.1447	0.2050	0.2702	0.7022	0.7133	1						
FTM	0.2868	0.1154	0.2073	-0.0867	0.2274	0.2718	-0.0645	0.1743	0.2030	0.0710	0.0542	0.1587	0.2211	0.3009	0.8147	0.8315	0.7128	1					
DAX	0.2463	0.1851	0.2394	-0.0708	0.2507	0.3279	-0.1942	0.1652	0.2920	0.1005	0.1280	0.1538	0.2725	0.3467	0.7620	0.7746	0.6504	0.8607	1				
CAC	0.2171	0.2085	0.2141	0.0939	0.3158	0.3043	-0.1576	0.1788	0.2933	0.0644	0.0863	0.1438	0.2738	0.3441	0.7379	0.7561	0.6457	0.8588	0.9555	1			
NKX	0.2279	0.1507	0.1697	0.0001	0.1912	0.2206	-0.0727	0.1766	0.2736	0.0944	0.0794	0.1317	0.1912	0.2459	0.7399	0.7576	0.5906	0.7794	0.7929	0.8084	1		
XAU	0.1535	-0.1334	0.0879	-0.2384	-0.0034	0.1471	-0.0577	0.1782	0.0777	0.0815	0.0626	0.1244	0.1893	0.2516	0.2819	0.2884	0.2776	0.2888	0.2260	0.1900	0.2053	1	
CL.F	0.1587	0.1193	0.1723	0.1761	0.2029	0.1615	-0.1606	0.1098	0.1859	0.0901	0.0202	0.0696	0.1928	0.2253	0.3980	0.3981	0.4228	0.3999	0.3875	0.3761	0.2697	0.0767	1

Source: Authors' own calculations.

Generally, the results indicate a weak correlation between the return rates of energy tokens and stock market indices, gold and oil prices. This means that the markets for these instruments are not strongly correlated, which is an advantage for an investor wishing to diversify his or her portfolio and make it resilient to economic changes. Additionally, the energy tokens analysed do not show strong intra-group linkages - the exceptions being EWT and POWR tokens, where linkages with some other tokens are noticeable. Importantly, some of the tokens also do not show links to the key cryptocurrencies, Bitcoin and Ethereum, which may be due to the fact that many of them are based on separate blockchains.

6. Conclusions

The herein presented considerations on tokenization in the field of climate and energy policy have allowed the authors to formulate a number of conclusions of theoretical and practical nature.

Taking into account the ongoing climate changes, the authors point to the key role of the state and international organisations in this process. The considerations made at the beginning clearly indicate that common resources, including water, air, solar energy, and land, should be the subject of state interest, and providing society with access to these resources in the modern economy has become a public good. Therefore, the provision of such a good should be financed similarly to other public goods.

This does not mean that private entities do not have the opportunity to care for the environment. On the contrary, in addition to taking action to reduce the burden of our daily lives on the environment, it is also possible to use modern technologies, including blockchain technology, to solve environmental problems.

One possible action is to use tokenization to solve energy problems. Energy tokens on the market allow for energy settlements, in particular between private buyers and providers (prosumers), financing the creation of own renewable energy sources, or creating own DApps (Decentralised Applications).

The valuation of the environmental benefits of acquiring energy tokens remains a subjective issue. These benefits may have a financial dimension, in the form of lower costs of electricity generation, or a more attractive form of their sale by individual small producers, bypassing the intermediary. It may be possible to calculate these benefits for an individual user, but the benefits depend on many individual characteristics - how much energy the user buys/sells, in what cycles, and finally on whether he or she can derive any tax benefits from it. It is even more difficult to assess the value of non-financial benefits, such as the satisfaction of doing something good for the environment.

Despite this, the authors have attempted to evaluate energy tokens from the point of view of their investment attractiveness. Obviously, apart from their clearing and utility values, the buyer of such a token may treat it as an alternative investment instrument. However, the results of the conducted research indicate a low investment attractiveness of the tokens in question. Compared to investments in stock or commodity markets, or even to investments in major cryptocurrencies such as bitcoin and Ethereum, investments in energy tokens are characterised by relatively lower profitability and higher risk, which from the point of view of investment efficiency, measured using the Sharpe ratio, places them lowest in the herein prepared ranking. This research may therefore indicate that purchasers of energy tokens should not be driven by investment and speculative motives, but rather by the desire to obtain a means of clearing energy trading, or other utility.

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