sciendo

A Causality Perspective: Investments in Green Energy Business vs. Conventional Business

Diana TIMIȘ
The Bucharest University of Economic Studies, Bucharest, Romania
[*]Corresponding author, diana.timis10@gmail.com

Cătălin-Laurențiu ROTARU
The Bucharest University of Economic Studies, Bucharest, Romania
rotarucatalin@gmail.com

Giani-Ionel GRĂDINARU
The Bucharest University of Economic Studies, Bucharest, Romania
Institute of National Economy-Romanian Academy, Bucharest, Romania
giani.gradinaru@gmail.com

Abstract. *At the level of the European Union numerous sustainability programs are being created. Considering these the main role f the research is to explore the potential of green energy production along with its limitations. Studies have found that by combining multiple sources of green energy and harnessing technological advances, there is the possibility to believe that one can reduce human's dependence on fossil fuels. The aim of this study is to create a stock market analysis in order to identify future investment trends by assessing whether there is greater interest in investing in renewable electricity companies. The current paper explores the impact of investing in renewable electricity companies versus investing in the stock market of fossil fuel-based energy companies. The dataset includes closing stock price data for two major companies, one of which is the British-Dutch company SHELL.L Global (known in the oil industry as well as the energy sector) and the other company is Vestas Wind Systems (a Danish company that manufactures wind turbines for renewable energy parks around the world). This dataset covers the period 3rd of January 2011 to 24th of November 2023 and is used together with time series statistical tests. The purpose is to highlight the main objective of this article: to demonstrate through Granger causality whether investment in the renewable electricity market affects investment in the conventional energy market. This result will shed light on whether long-term investments in fossil fuel-based businesses are worth investors' attention going forward. While the major purpose of the paper is the research mentioned above, there is also a secondary objective, that of carrying out a descriptive analysis of the two listed companies and their evolution in order to identify the key periods that led to significant fluctuations in the series temporal.*

Keywords: Granger Causality; Time Series; Renewable Energy; Conventional Energy.

Introduction

The European Union (EU) recorded approximatively 2,54 billion metric tons of carbon dioxide (CO_2) emissions in 2020. EU had already made firm commitments to reduce its greenhouse gas emissions before the historic Paris Climate Agreement of 2015 (Michael et al, 2021). The EU target consisted in getting a great reduction in emissions of at least 40% below 1990 levels by 2030. These were accompanied by specific targets for renewable energy and energy efficiency. However, understanding the pressing need to block climate change, the EU has embarked on a new path. In 2020, EU member states adopted a binding target. This commitment helped in accomplish a net domestic reduction in greenhouse gas emissions of at least 55% by 2030 compared to 1990 levels.

DOI: 10.2478/picbe-2024-0006

Another major objective was that the EU decided to achieve climate neutrality by 2050. With the adoption of the European Climate Law in 2021 (a. European Commission, 2023), these commitments were officially consecrated in law.

Building on the fundamental principles highlighted in the December 2019 publication of the European Green Deal, the European Commission unveiled the roadmap "Fit for 55: Delivering the EU's 2030 Climate Target on the Way to Climate Neutrality" in July 2021. This strategy serves as a means of accelerating the EU's efforts to combat climate change (Fetting, 2020).

Central components of the Fit for 55 roadmap contains strengthening existing legislative frameworks and introducing innovative initiatives in different policy areas and economic sectors. These sectors include climate, energy, forestry, buildings and transport. The last goal of the research is to reduce greenhouse gas emissions with 55% from 1990 levels by 2030, in line with the EU's expansive climate goals. Distinctive feature of this agenda includes the expansion of emissions trading systems, added reliance on renewable energy sources, improved energy efficiency measures, strategies to mitigate carbon leakage, and a deliberate effort to strike a balance between mechanisms for setting prices, objectives, standards and support measures (b. European Commission, 2023).

The main objective of this research is to analyze future investment trends in renewable electricity companies using a stock market data and analyse them by approaching the subject from two different angles. The research aim is to assess the level of interest in investing in renewable electricity compared to investing in fossil fuel energy companies. In addition, one seek to examine the impact of investments in renewable electricity companies on the stock values of fossil fuel energy companies. To achieve these goals, one will use a comprehensive data set covering a significant period. We will use specific time series statistical tests to investigate the Granger causality of the influence of renewable investment on conventional energy investment in the long run.

At the same time, to enhance the current analysis, a descriptive analysis of two prominent publicly traded companies, SHELL.L Global and Vestas Wind Systems, will be carried out in order to identify the key periods that led to significant fluctuations in their data from chronological series. In the literature review section, the potential of green energy production and its limitations in the European Union will be explored. European programs to gradually reduce dependence on fossil fuels by combining green energy sources and harnessing technological advances will also be explored.

Literature review

The European Commission set-up the Net-Zero Industry Act (NZIA), which concentrates on promoting the development of net-zero technologies and contribute to the achievement of the Fit for 55 goals. Another focus of this legislation is to improve the energy resilience of the European Union and contribute to the achievement of the Fit for 55 goals. This marks an important path in the transition to the climate neutrality. It can be underlined that this regulation covers a range of products, components and equipment necessary for the production of net-zero technologies. In this framework, an essential difference has to be made between net-zero technologies and strategic net-zero technologies (v. European Commission, 2023). Strategic net-zero technologies represent those with the potential to have a significant impact on reducing carbon emissions by 2030 and are currently available on the market or scheduled for immediate release. Strategic net-zero technologies benefit from additional advantages, including recognition of their resilience in procurement processes, along with the opportunity to be classified as strategic net-zero projects (Benjamin et al, 2023).

The proposal sets a key objective: ensuring that at least 40% of the European Union's annual implementation requirements by 2030 are met by the production capacity of strategic net-zero technologies. This benchmark provides producers and investors with a long-term framework, making it easier to monitor progress towards this goal. In addition, the regulation sets another significant target: to achieve an annual CO2 storage capacity of 50 million tonnes by 2030, with the aim of supporting carbon capture and storage projects and increasing the accessibility of carbon storage locations.

At COP28, an assessment of progress made in relation to the 2015 Paris Agreement was carried out, and future directions and priorities for achieving the set goals were set (UN, 2023). Considering the analysis carried out in recent years, it is clear that people must learn to live more sustainably and industrial sectors must undergo a technological transformation. Oil and gas production must decline rapidly, while global energy capacity must triple by 2030. At the same time, adaptation finance and investment in climate resilience require a major leap forward.

In terms of the Net-Zero Industry Act (NZIA), the European Union is boosting innovation through regulatory sandboxes. All these measures aim to create a favorable environment for investments in net-zero technologies through specific actions such as: simplifying administrative procedures, facilitating access to information and supporting participation in public procurement and auctions. Moreover, these measures have been shown over time to significantly accelerate sustainable development and facilitate the transition to a climate-neutral economy in Europe (Eric et al, 2023).

To highlight the transition to green energy and the actions taken to reduce dependence on fossil fuels, a research study supporting this cause has been identified. In the work developed by Antonio et al (2023) it was concluded that several archipelagos are dependent on diesel fuels to support energy production for local residents. The study covered the Galapagos, Noronha and Príncipe Islands and highlighted a rapid increase in energy demand driven by technological advances and increased tourism. There is a desire to reduce the dependence on fossil fuels that make currently interest to develop large parks with photovoltaic solar panels. In the case of the Galápagos and Noronha islands, it was desired to have capable renewable energy, which is why battery storage facilities were created. In the island of Príncipe, although the projects developed are in the early stages, substantial investments are being made in the local electricity network.

Methodology

The proposed research is based on two primary pillars and aims to develop a comprehensive analysis of the impact of renewable energy companies on the conventional industry. To meet this overall objective, one will detail and expand on each stage of the research, providing in-depth insight into the methodologies used, the data sources used and the rationale behind our selections.

The research will start with the statistical description of two distinct data series representing two publicly traded companies: Shell.l Global (acronym SHELL.L) and Vestas Wind Systems (acronym VWDRY). Our data was obtained from credible deposits on the Yahoo Finance website, covering a long period, from 03-01-2023 to 24-11-2023. This data set provides 3316 days of analysis for each of these companies.

The argument underlying the selection of these two companies is substantiated by several aspects. Vestas Wind Systems was chosen due to its expertise in the wind turbine manufacturing sector. This component is very important in the renewable energy mix that is being built at the level of the European Union and represents a foundation for the global economy that aims to achieve the transition from conventional energy sources until the year 2050. The second company Shell.l Global stood out for its outstanding position in the petrochemical and energy investment landscape. Considering the increasing use of renewable energy in the automotive industry, Shell.l Global has a key role in the transition to climate neutrality. Moreover, it is worth noting that even in the case of Shell.l, famous primarily for its automotive gas stations, the fuel itself is a form of energy. With the advent of electric vehicles powered by renewable energy, this aspect assumes an increasingly central role. The research developed aims to analyze the influence of renewable energy companies on conventional industry, focusing on businesses based on fossil fuel products. The analysis was performed to assess the causal relationships in the data series using the Granger causality method.

Regarding data analysis I worked with Python programming languages and the Google Colab environment. The research includes a descriptive analysis with the help of which it is desired to identify some preliminary results on the basis of which the analysis will continue. Both line graphs will be built to analyze trends and the evolution of time series as well as statistical measures such as Skewness and Kurtosis. The main objective of the paper is to understand the dynamics of conventional energy and renewable energy markets. We want to highlight the mutual impact and the evolution of the energy price of the two markets in the period January 3, 2011 - November 24, 2023.

As the last step of the research, an evaluation of the distribution of the data series will be carried out to analyze their stationarity. If non-stationarity is identified, differentiation techniques will be used. These additional tests that are performed on the data series aim to perform a Granger causality analysis with maximum significance. Only in this way can we analyze whether the emergence of green energy creates a substantial impact in the stock market. Using the aforementioned preliminary tests and analyses, it will be possible to identify statistically significant results for the developed research.

Results and discussions

The data set was taken from the Yahoo Finance website and covers 3316 trading days, recording the closing prices of both companies. Before starting the analysis of this data set, a data cleaning operation will be performed to determine the presence or absence of missing values. In the case of the SHELL.L company, 62 missing days were identified, while the VWDRY company presents 72 missing days. To rectify these missing values, they will be replaced with values from the nearest non-null previous day.

The revised data set, with the corrected values for the SHELL.L company, is shown in Figure1.

Figure 1. Stock Price Evolution of SHELL.L Company from 3rd of January, 2011, to November 24, 2023

Source: Authors' representation in Python based on the dataset obtained from Yahoo Finance.

SHELL.L's stock price uses data spanning the time period of 2011 and 2015, fluctuating in a range of approximately 2400 dollars at highs and 1850 dollars at lows. However, the oil market saw a significant decline in 2016. The company's stock subsequently recovered after 2016, reaching record highs of 2700 dollars by the end of 2019. With the onset of the COVID-19 crisis, the company faced a severe decline. Share prices continued to fall to 900 dollars, diminishing with the pandemic. SHELL.L share price trajectory shows an inverse relationship with the COVID-19 crisis. As the cases of COVID-19 have decreased, the share price has recovered with a steady upward trend. The declines were first seen for the first time when the waves of coronavirus were announced. However, similar to the SARS crisis of 2003, the company bounced back, eventually reaching a price of 2595 dollars on 24-11-2023.

The average value of the data set is around 2070 dollars, which is a significantly inflated number by the rapid recoveries that followed the company's intermittent periods of instability. Consequently, the company's shares can be considered a highly volatile investment that should be approached with caution by investors which want to diversify their portfolios.

Figure 2. Stock Price Evolution of VWDRY Company from 3rd of January, 2011, to 24th of November, 2023

Source: Authors' representation in Python based on the dataset acquired from Yahoo Finance.

Vestas Systems experienced a decline immediately after its public debut, hitting a low of 0,026 dollars per share. However, by the year 2023, the company's returns have increased by about 300%. There have also been periods of significant increases, such as in 2021 when the company reached a high of 17,29 dollars. From 2014 to 2020, the company has shown an ascendend trend with minor price fluctuations, making it a relatively less volatile. However, after the historic peak in 2021, the company started to show a lot of volatility, primarily due to the impact of the COVID-19 crisis and the presence of security-related uncertainties, including geopolitical tensions. Without taking in consideration this volatility, the company has managed to achieve periodic increases of up to 2 percent, largely attributed to its investments in green energy, particularly wind turbines. During the reviewed period, the company maintained an average closing price of 5,23 dollars.

Taking in consideration the analyse from Figure 1 and Figure 2, these leads to the conclusion that both series of financial data have a stochastic trend, with unpredictable fluctuations. SHELL.L is a company that has higher volatility in its closing prices compared to VWDRY, which initially experiences an upward trend but eventually follows a similar volatility pattern to SHELL.L after 2021. Also, the two figures reveal an interesting dynamic: in 2020, the two companies' share prices seem to mirror each other. When the SHELL.L stock price falls, the VWDRY stock price rises, indicating an inverse relationship between them. To improve our understanding, it is imperative to assess whether the data follows a Gaussian distribution. As a result, a test for the Gaussian distribution will be constructed and descriptive statistics such as Skewness and Kurtosis will be used to characterize the distribution.

Table 1. Statistical measures

Company name/ Statistical measure	Skewness	Kurtosis	Gaussian Statistics	Gaussian p value
SHELL.L	-0.94	0.32	373.72	0.00
VWDRY	0.76	0.04	259.95	0.00

Source: Authors' own research.

According to Table 1, it is obvious that both the closing price data series for Shell.l and VWDRY do not conform to a Gaussian distribution. This conclusion is supported by the p-value, which is less than the 0,05 threshold, thus leading to the rejection of the null hypothesis that postulates a Gaussian distribution for these data series. Kurtosis, a measure of the tail or peak of a distribution compared to a normal distribution, is used for additional information. The Kurtosis value for the company SHELL.L is approximately 0,32, indicating that its distribution closely resembles a leptokurtic distribution while remaining close to a normal (mesokurtic) distribution. The SHELL.L data series has present some risks because of occasional sudden price fluctuations. However, over an extended time interval, the distribution approximates a normal distribution, suggesting periods of stability. For SHELL.L, the Skewness is negative, meaning the mean is less than the median and the distribution is skewed to the left.

In contrast, for the company VWDRY, the Kurtosis value is 0,04, indicating a platykurtic distribution. This value suggests a higher level of risk associated with potential losses in this relatively smaller company. Additionally, the Skewness for VWDRY is 0,76, implying a left-skewed distribution. A positive skew like this suggests the potential for substantial returns for investors. To provide a visual representation, the distributions of both time series will be illustrated in Figure 3 for both SHELL.L and VWDRY.

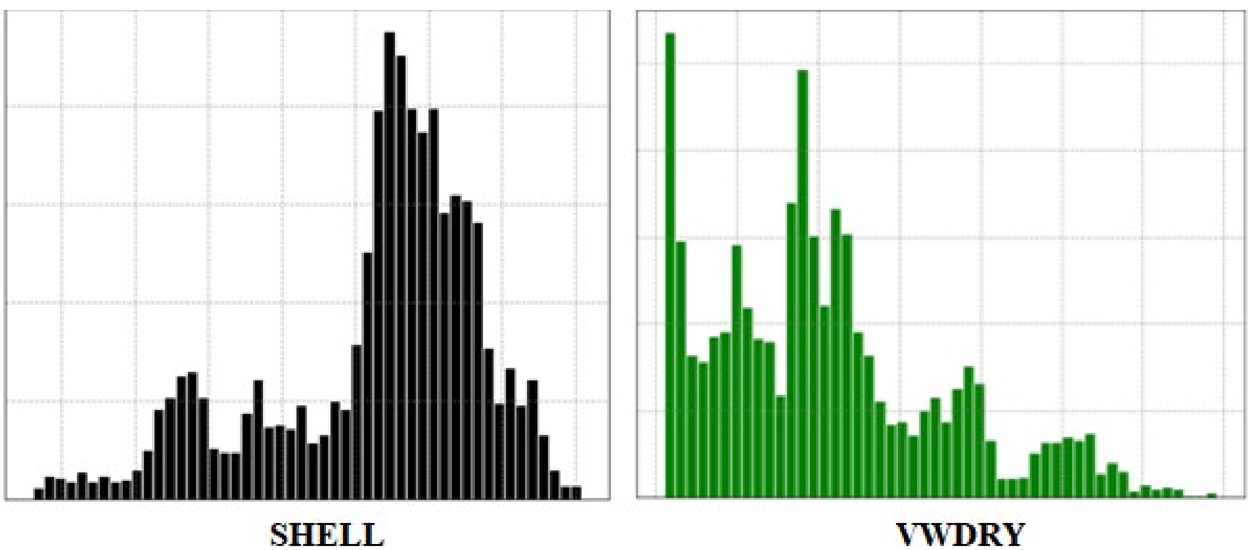

Figure 3. Distribution of SHELL.L and VWDRY Companies from 3rd of January 3, 2011, to 24th of November, 2023

Source: Authors' Python representation based on the dataset obtained from Yahoo Finance.

In Figure 1, it can be seen that the distribution of the company SHELL.L closely resembles a normal distribution. This alignment with a normal distribution is corroborated by the Kurtosis coefficient, which indicates a distribution with a sharp tail on the left side, as expressed by the Skewness coefficient. SHELL.L shares is a long-term investment opportunity, albeit with intermittent periods of higher risk.

In contrast, Figure 1 depicts a distribution for the VWDRY company with a cluster of values on the left. This distribution closely reflects the evolution of the company, depicting the characteristics of a developing enterprise that has embarked on a safe trajectory to sustained growth. In order to achieve the main objective of knowing if investments in renewable energy companies impact fossil fuel energy companies, we calculated the Pearson coefficient, which in this case is -0,42. This coefficient signifies a medium to strong negative relationship between the share prices of SHELL.L and VWDRY companies, this suggests that when the closing prices of VWDRY shares rise, those of SHELL.L fall. This observation implies that the business market is shifting towards investing in renewable energy, especially when the conventional energy market faces a decline in confidence or instability, as seen in times of oil price crisis.

To ensure the highest level of accuracy in the current analysis, we will evaluate the accuracy of the model using the auto-correlation plot (ACF) with a lag period of 40 days (40 lags). This assessment is shown in Figure 4.

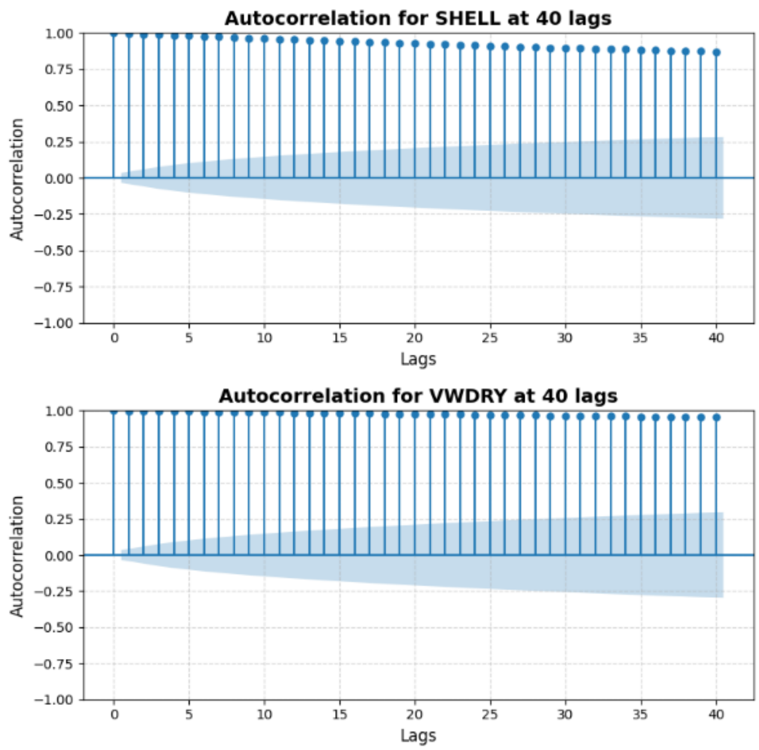

Figure 4. Auto-correlation graph

Source: Authors' Python representation based on the dataset obtained from Yahoo Finance.

For both companies, as shown in Figure 4, there is a gradual decrease in autocorrelation towards 0, suggesting potential stationarity. The chart doesn't indicate the seasonality of the data. To further remove even the slightest doubt about the stationarity of the time series, we will perform the Augmented Dickey-Fuller (ADF) test. The results of this test, along with the differences between them, will be presented in Table 2.

Table 2. Results of Augmented Dickey-Fuller

Company name	5% critical value	Statistical ADF	ADF type of differencing	ADF p value
SHELL.L	-2.86	-2.17	ADF p value without differencing	0.21
		-20.92	ADF p value fist differencing	0.00

Company name	5% critical value	Statistical ADF	ADF type of differencing	ADF p value
VWDRY		-1.28	ADF p value without differencing	0.63
		-10.60	ADF p value fist differencing	6.18

Source: Authors' own research.

In table no. 2, when examining the undifferentiated data series for the SHELL.L company, it is observed that the p-value of the ADF statistic exceeds the critical value at a 5% confidence interval with a value of 0,217 > -2,86. However, the p-value exceeds the 0,05 threshold, implying that the null hypothesis of non-stationarity cannot be rejected. Despite the proximity of the ADF statistic to the critical values, the high p-value suggests that the data are not stationary at a significant level, casting doubt on the non-stationarity of the series.

For the "VWDRY" column, the ADF statistic comes in at about -1,28, with a corresponding p-value of about 0,638. Both the ADF statistic and the p-value indicate insufficient evidence to reject the null hypothesis of non-stationarity, stating that the data series is indeed non-stationary. When applying the first difference, stationarity is obtained for both data series. Further, the Granger causality test will be performed using differenced data, incorporating a unique period difference and spanning 40 lags. The results of the Granger causality test are shown in Table 3.

Table 2. Results of Granger causality test

	SHELL.L_y	**VWDRY_x**
SHELL.L_y	1.00	0.0009
VWDRY_x	0.11	1.00

Source: Authors' own research.

The closing price of SHELL.L exhibits significant Granger causality compared to the closing price of VWDRY shares. It is worth noting that the closer the Granger value is to 0, the stronger the causality (required source). This conclusion implies that investments in SHELL.L shares, positively or negatively influenced, have an impact on investments in VWDRY.

Additionally, based on the value distribution, it become evident that during times of crisis in fossil energy companies, investors tend to shift their focus to renewable energy companies like VWDRY.

In contrast, there is no causality when investments in VWDRY affect investments in SHELL.L as the Granger value exceeds the 0,05 threshold.

Conclusion

Through the developed research, it was desired to develop an investigation regarding the stock market in the current context in which the European Union offers very large funding for projects that develop green energy and provide for the total elimination of fossil fuels. In practice, it was desired to analyze the investments in the current context in which all large European programs aim for climate neutrality. By implementing renewable energy, the harmful effects on ecosystems that are currently affecting the entire planet by using fossil fuels are permanently eliminated. The processes through which renewable energy is obtained are in continuous development, being financially supported by various sustainability programs whose main objective is to identify the maximum potential of green energy. There are three main renewable energy types that after

DOI: 10.2478/picbe-2024-0006, pp. 57-66, ISSN 2558-9652 |
Proceedings of the 18th International Conference on Business Excellence 2024

multiple analyzes it's concluded that using them depends also on the relief, for example geothermal energy is effective only in areas with easy access to this resource, solar energy only in countries that have sun on a longer period of the year, and wind energy only in windy geographical areas. In order to reach the main objective, that of having climate neutrality in Europe by 2050, a mix will have to be created that utilizes several sources of green energy. The main objective of the research was to compare investments in green electricity companies and investments in fossil fuel energy companies. Data from two large companies in the electricity market SHELL.L Global and Vestas Wind Systems were used. The first company develops its activity in the oil sector and in the field of electricity, while the second creates wind turbines. The analysis period used in the statistical tests is from January 3, 2011 to November 24, 2023. Through the preliminary analyzes carried out, we wanted to analyze a causality relationship (using the Granger test) between the two-time series to answer the question of whether investments in companies that develop technologies based on green energy production have an influence on the investments of other companies that develop technologies based on conventional energy. Following the developed research, we can conclude whether investors should currently invest on the stock market in companies based on fossil fuels.

References

Antonio Santos Sánchez, Euripedes Pontes Junior, Bernardo Machado Gontijo, Pieter de Jong, Idelfonso Bessa dos Reis Nogueira (2023). *Replacing fossil fuels with renewable energy in islands of high ecological value: The cases of Galápagos, Fernando de Noronha, and Príncipe.* Renewable and Sustainable Energy Reviews, 183, ISSN 1364-0321.

a.European Commission (2023). Commission welcomes completion of key 'Fit for 55' legislation, putting EU on track to exceed 2030 targets. Brussels, 9 October.

b.European Commission (2023). 'Fit for 55': Council and Parliament reach deal on proposal to revise energy performance of buildings directive. 7 December 2023.

c.European Commission (2023). The Net-Zero Industry Act: Accelerating the transition to climate neutrality.

Benjamin K. Sovacool, Morgan D. Bazilian, Jinsoo Kim, Steven Griffiths (2023). Six bold steps towards net-zero industry. *Energy Research & Social Science*, 99, ISSN 2214-6296.

Eric Ohene, Albert P.C. Chan, Amos Darko, Gabriel Nani (2023). Navigating toward net zero by 2050: Drivers, barriers, and strategies for net zero carbon buildings in an emerging market. *Building and Environment,* 242, ISSN 0360-1323.

Fetting, C. (2020). The European Green Deal, *ESDN Report*, December 2020, ESDN Office, Vienna.

Michael Köhl, Stefanie Linser, Kit Prins, Andrzej Talarczyk (2021). The EU climate package "Fit for 55" - a double-edged sword for Europeans and their forests and timber industry. *Forest Policy and Economics,* 132.

United Nations (2023). The 28th Conference of the Parties to the UN Framework Convention on Climate Change. Dubai, United Arab Emirates, 30 November -12 December.