Public policies and the business environment, factors that condition Romania's transition to green energy. Case study: cogeneration plants.

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Abstract: *Combating the effects of climate change, energy security and providing the resources we need for life is the greatest trilemma of our times. This conflict could also be resolved through the transition to renewable energy and the implementation of the latest technologies that contribute to the efficiency of resource consumption and the minimization of losses. In this context, the adoption of cogeneration, trigeneration and cogeneration systems, based on renewable sources, intensely promoted in recent years, are solutions that can successfully contribute to achieving the green goals. However, such an approach depends very much on the quality of public policies and the way in which the business environment reacts, being important factors that can condition the pace and succession of the transition to the ecological future. From this point of view, Romania has not made significant progress. Although it has set up a state aid scheme under which it has provided financial support to high-efficiency cogeneration systems, the amount of electricity produced by the beneficiaries of this scheme has fallen by more than 35% in the last 8 years. Moreover, from a technical point of view, these plants remained at the level of the years 1960-1970, oversized and with a high fuel consumption. Based on this reality, the current study aimed at conducting several analyses to justify the causes for which the targeted objectives were not achieved. The results indicate that there is no causal link between the financial support provided and the amount of electricity produced by cogeneration systems, that could be explained by the lack of a common denominator between public and private initiatives.*

Keywords: energy security, renewable resources, climate change, public policy, sustainable development.

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Introduction

With regard to energy production, since the last century, the transition to cogeneration systems (CHP) has been achieved. This solution has led to a reduction in fuel consumption by at least 10% because it has generated both electricity and heat usable in the domestic and industrial sectors, at the same time and with the same resources. Along the way, concerns for reducing consumption of natural resources have continued and turned into more advanced technologies in which trigeneration (CCHP) and quadgeneneration have taken place through the addition of cooling and carbon dioxide treatment systems from the gasses that are emitted from the engine. However, at least in the last half century, the topic of replacing fossil fuels with renewable energy has been the subject of many international summits, according to Hansen and colleagues (2019), "research on the design of 100% renewable energy systems in articles […] have gained increasing attention in recent years […], with 180 articles published […] with a predominant focus on the electricity sector being identified and analyzed since 2004". Some of these concerns have been aimed at finding the most efficient methods of storing the energy produced by energy systems, such as the integration of "TES (thermal energy storage) in cogeneration plants that store the heat produced by the cogeneration unit when there is no load or when production exceeds the load" (Sala, 2020). As they have influenced the state of natural ecosystems, most research aims to improve the energy systems, in the long run, contributing to global warming and changing weather patterns. Much research has been done to create indicators for resource efficiency and for measuring the amplitude of losses and wastes resulting from energy production processes, because there is a cross-cutting between factors that affect the sustainability of energy systems and technologies (environmental, economic and social) which in turn have effects on the environment.

From this point of view, the notion of exergy was introduced, as a method and measuring instrument for evaluating the performance of systems. The fields of application of exergy concepts and methods are varied, and cogeneration systems are perfectly suited to the problems and industrial operations addressed in this regard. Thus, cogeneration plants can use these energy methods "both to improve efficiency and to solve the problem of economic costs and prices". (Dincer and Rosen, 2020) Exergy helps to assess sustainability, as it can serve as an indicator to characterize the depletion of resources, be they energy or raw materials, as well as to characterize emissions. (Lizarraga and Perez, 2020) The evaluation of the exigo sustainability of energy systems takes into account the entire life of the system and investigates energy flows. (Dincer I., 2018)

In terms of consumption, energy demand is a basic need. The quantity needed cannot be greatly influenced by price, as it can be affirmed for other consumer products and services. According to Alfred Marshall's[1] theory, energy demand is perfectly inelastic, given that "a maximum change in price does not change the amount consumed." For these reasons, the steps that research has taken in developing new technologies and concepts must inspire decision-makers. So, the public policies should come with appropriate measures to stimulate the business environment to invest in those technologies that ensure the transition to the green economy and address the energy prices, currently on an unprecedented upward trajectory, experienced by many countries globally. As energy prices rise, there will most likely be an avalanche of price increases of the minimum basket necessary for a decent living. This issue could be amplified by rising geopolitical tensions, exacerbated by declining gas flows in Russia.

[1] Principles of Economics (1890) - Fondator al economiei moderne (neoclasice).

Ahead of the EU summit in Slovenia (October 2021), Ursula Von Der Leyen stated that "... gas prices are skyrocketing. However, with regard to renewable sources, prices have fallen in recent years and are stable." [2] Contrary to these statements, the price of electricity has continued to rise, which calls into question the ability of renewable energy-based systems to meet the energy demand. It is known that wind turbines and solar panels cause stress on the electricity grid, because they depend on the weather and cannot provide constant energy flows. From this perspective, nuclear energy and the return to fossil fuels are alternatives that have already been considered by several developed countries in the EU and globally. Moreover, in early February 2022, a document was drafted at EU level[3] that will be officially adopted once translations are available in all EU languages. Through this document, nuclear energy (which meets the requirements of nuclear safety and the environment) and the one based on natural gas (only to ensure the transition from coal to renewable sources) will continue to be allowed to ensure the acceleration of the transition to a climate-neutral future.

In such a context, it emphasizes the importance of high-efficiency cogeneration energy systems and all new technologies adopted in this regard, especially cogeneration systems based on renewable resources. So, the acquisition of biomass-based systems resulting from the exploitation of raw wood can play a key role in reducing the consumption of depletable resources and combating the effects of climate change (tops, roots, branches, forest sanitation etc.). The European Union has set out to adopt policies to encourage cogeneration systems based on wood-based pellets, that are known to account for more than 75% of global pellet consumption.

Given the current circumstances regarding the evolution of prices, how does Romania understand to resolve the conflict between energy security and the transition to green energy?

The study area

Beyond speculation, various interpretations and conjunctural solutions proposed by the decision maker, the energy crisis installed in the world and strongly felt by Romanians shows the legislative gaps and lack of firm public policies in the field of energy, based on clarity and predictability, especially in recent months. The price of energy in Romania has risen, even though over 60% of electricity production has been produced by systems based on renewable and nuclear resources, whose price has fallen and is relatively stable. This increase is due to the fact that energy produced from renewable sources was sold close to the price charged by systems producing energy from conventional sources, with the highest production costs.

At the end of 2020, according to the INS, Romania's electricity production was about 56 TWh, 6,18% less than in the previous year. The systems based on conventional fuel (coal, liquid and gaseous hydrocarbons) continue to have the supremacy in the production of electricity, with a share of 36% (Figure 1). On the 2nd place, the hydro resource holds a percentage of 28%, followed by the energy produced from nuclear sources, with a share of 21%, in the 3rd place. The last place is wind energy (12%) and solar sources (3%). The main producers of electricity in Romania continue to be Hidroelectrica, Nuclearelectrica and Complexul Energetic Oltenia,

[2] https://finance.yahoo.com/news/eus-von-der-leyen-must-072855527.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuY3J5c3RhbGZ1bmRzLmNvbS8&guce_referrer_sig=AQAAAIWYBeWRPb-eGxeW1Z6gLZdtOFQoIbl5Bo-oCiy-9mNXIvGtYFY3tZl4dNKL3hlGcUqBRqFh0zM5ICs6iV3gzPH7VGPE4-6-DcPUX67zej9wIysb9frLv9bt1SvWInp5oBo7ztWuU6CWq3nsXtPABydCce2V6A4mkY-1Dd7OerQu accesat la 05.02.2022 (htt3).

[3] (https://ec.europa.eu/commission/presscorner/detail/en/ip_22_711 accesat la 07.02.2022, 2022).

operators in which the Romanian state is the the main owner. In 2020, the three state-owned operators delivered 64.22% of the total amount of 50,794GWh that was delivered to the electricity networks by producers with dispatchable units (Autoritatea Națională de Reglementare în domeniul Energiei, 2021).

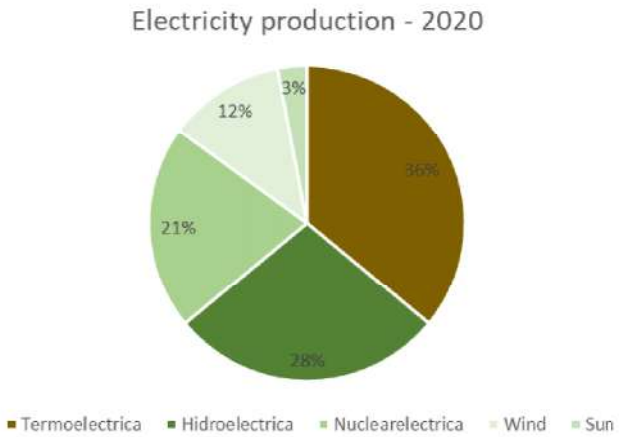


Figure 1. Electricity production by power plant categories (%)
Source: Processing of authors based on INSSE data (TEMPO_IND118A_7_2_2022).

As can be seen in Figure 2, it can be stated that the installed power (gross) of the power plants based on renewable resources has increased from 45% (at the end of 2014) to 60% (at the end of 2021).



Figure 2. Installed power in Romania (MW) - 2014 and 2021
Source: Transelectrica - Total production capacity installed and available in SEN, differentiated by primary energy sources. Available at:https://www.transelectrica.ro/ro/web/tel/productie - pct. 23, data accessed on 5.02.2022 (Transelectrica, 2021).

In fact, this increase is the combined result of a 45% reduction in energy production from conventional resources and an increase in capacity from renewable resources by only 1.8% (Figure 3). Overall, the total capacity installed and available in the National Power System (SEN) has decreased by almost 25%, in the last seven years. Here, it is also necessary to emphasize an aspect regarding the fact that, within the total electricity generation capacity, the groups that have been refurbished or have been preserved for more than 1 year have been taken into account, that may mean that the installed power in Romania could be much lower.

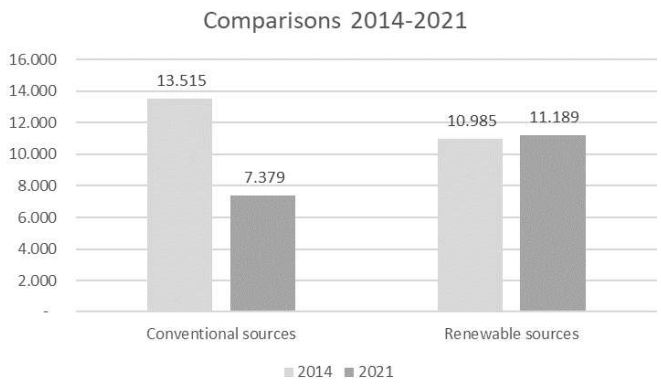


Figure 3. Installed power in Romania (MW) – comparisons on 2014 and 2021 sources
Source: Transelectrica - Total production capacity installed and available in SEN differentiated on primary energy sources. Available at:https://www.transelectrica.ro/ro/web/tel/productie - pct. 23, data accessed on 05.02.2022.

Moreover, in 2020, Romania imported electricity of over 7.6 TWh and exported only 4.8 TWh. Overall, it can be said that our country has become a net importer of electricity. The decrease in installed capacity could turn into a permanent shortage of production capacity. In such a context, the price of energy in Romania could continue to remain high for a longer period of time, if appropriate public policies are not adopted to stimulate the business environment to increase investment in green energy, cheap and neutral in terms of pollutant emissions.

Methodology

The cogeneration plants were analyzed in this case study, in order to draw realistic conclusions about the nature of the impact of public policies on energy developments. From this perspective, the analysis focused on the legislative framework adopted and applied in Romania - in the last decade - to support the transition to green energy, as well as on a series of statistical data collected from several public sources. Thus, the bonus granted to the beneficiaries accredited for cogeneration systems, the amount of energy produced in these units using the Romanian financing scheme and the total amount of electricity produced and delivered in the National Power System were taken into the study. The time period for which complete statistics were found was between 2012-2020. In this regard, data were analyzed from a statistical point of view, in order to demonstrate the economic links between the financing scheme created by the legislator to support cogeneration plants and the amount of energy delivered by them in the national grid.

Regarding the legislative framework adopted by Law no. 57/2017, Romania ratified the Paris Agreement, along with 192 other signatories, including the EU, with the transition to green energy becoming a priority for saving the environment. In fact, according to the commitments undertaken, in the context of the accession negotiations to the European Union[4], with regard to cogeneration energy systems, Romania already had a support scheme since 2011, in force until 2023, for the producers of electricity and heat in cogeneration provided, under the condition that

[4] Directive 2004/8/EC published in the Official Journal of the European Union L52/21.2.2004 - on the promotion of cogeneration based on the demand for useful thermal energy in the internal energy market and amending Directive 92/42/EC (of 21 May 1992 - on energy efficiency requirements for new hot water boilers burning liquid or gaseous fuels, published in the Official Journal of the European Union No L 167/22.6.1992).

part of the electricity produced to be delivered to the electricity networks[5] (approved by Decision COM C (2009) 7085 and harmonized with the environmental and energy requirements - Decision COM C (2016) 7522). This financial assistance can be updated according to the evolution of electricity market prices and production costs and aims at replacing/modernizing existing cogeneration systems and implementing new, clean, competitive and efficient technologies. These public policies have aimed to increase the share of cogeneration production in the mix of energy sources used to produce electricity, in order to increase energy security and ensure sustainable development by reducing the consumption of depletable conventional resources.

At the time of the establishment of these support schemes, Romania had a cogeneration production system that provided heat to about 7 million people, but which was morally worn out, the technical level being at the level of 1960-1970. The budget of the scheme provided by the legislator is over 4.75 billion euros and has been allocated for the entire period 2011-2023.

In short, as a bonus, the aid is granted monthly for each unit of electricity delivered (MWh) through accredited high-efficiency cogeneration systems. The granting of the bonus is conditioned by the fulfillment of some criteria established in Annex III to Directive 2004/8/EC and in accordance with the provisions of art. 12 para. 2 of Directive 2008/8/ EC. The bonus is paid to the beneficiaries from a fund managed by CN Transelectrica SA/SC OPCOM SA which is provided monthly by all consumers and suppliers of electricity that export electricity. Suppliers importing electricity from cogeneration systems in EU countries can also claim a refund for the cogeneration contribution.

This scheme is available to cogeneration producers of electricity and heat *from sources that use gaseous and solid fuels*.

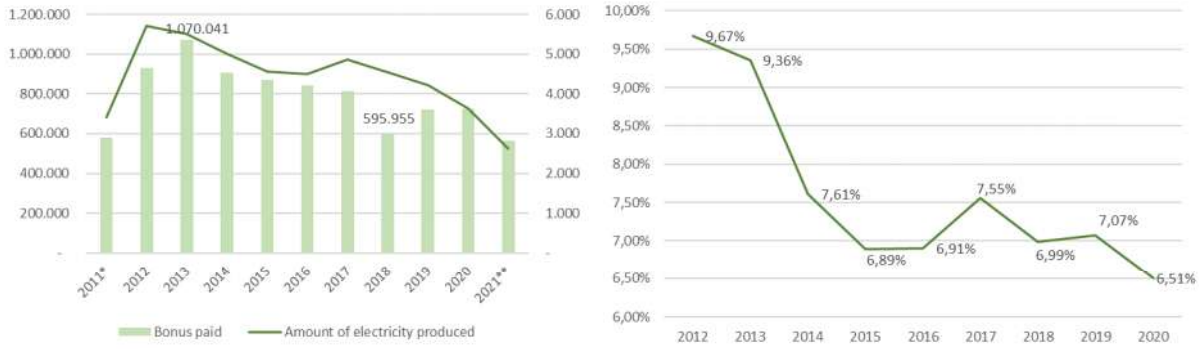


Figure 4.

Left: Bonus paid and the amount of electricity was produced in high-efficiency cogeneration tha from the support scheme - GWh;

Right: Evolution of the share of electricity that t produced in cogeneration from the total benefited electricity produced in the period 2011-2020(%)

Source: Own data processing (ANRE, 2021)

* w/o Q 1

**w/o Q 4

[5] The legal basis for granting the state aid is: Government Decision no. 1215/2009 published in the Official Gazette no. 748 of 03.11.2009, aims at establishing the criteria and conditions necessary for the implementation of the support scheme; Law no. 13/2007 on electricity, published in the Official Gazette no. 51 of January 23, 2007; Government Decision no. 219/2007, published in the Official Gazette no. 200 of March 23, 2007, aims to promote cogeneration based on the demand for useful thermal energy; Government Decision no. 1069/2007, published in the Official Gazette no. 781 of November 19, 2007, aims at approving the Energy Strategy of Romania for the period 2007-2020.

Regarding the statistical data used in this study, as it is shown in Figure 4, the amount of electricity produced in cogeneration has decreased throughout this period, especially since 2013 and until now, although in the 11 years of financing cogeneration systems for the replacement, modernization and acquisition of new technologies, consumers contributed over 8.6 billion lei. Moreover, the share of electricity produced in these cogeneration plants in the total electricity produced at national level has been downward, which leads us to hypothesize that the policies adopted regarding the financing scheme have not contributed to the increase of energy produced within these units. Regarding the performance of the electricity market in the period 2010-2014, according to the Audit Report of the Court of Auditors, the investments in upgrading cogeneration systems accounted for only 4.13% of the bonus granted, and those in new cogeneration technologies were only 2.26%[6].

In addition, without being the subject of the current study, in order to only complete the overall picture of the Romanian transition to green energy, compared to the scheme described above, there was another support mechanism, by applying the system of green certificates, to which contributed to the entire electricity-consuming population. In this way, accredited producers of electricity produced from renewable sources, in biomass, hydroelectric, photovoltaic and wind power plants also benefited from financing. In the period 2005-2020, the amount of state aid received by E-RES producers, based on the promotion system established at national level (through the sale of green certificates), as a result of the delivery of electricity from accredited plants, was 17,62 billion lei.

Table 1. List of accredited producers - from renewable resources – 31.12.2021

Tip SRE	Accredited producers	Installed power (MW)
Biomass power plants	28	124,16
Hydroelectric power plants	101	304,36
Photovoltaic power plants	558	1.357,02
Wind power plants	59	2.959,98
Total	**746**	**4.745,52**

Source: Processing of authors based on data collected from the website ANRE https://www.anre.ro › download, accessed at 05.02.2022

In last seven years, the total installed capacity, newly added to the system, was around 205 MW, (36 MW - biomass; 171 MW - solar; 62 MW - wind; -64 MW - hydro), although over 90% of biomass-based plants, photovoltaic and wind panels have benefited from this scheme and only 5% of producers of energy produced in hydroelectric power plants.

As a result, the application of the two support schemes - *to promote high-efficiency cogeneration and to promote renewable energy production* - did not lead to an increase in installed capacity. On the contrary, this led to a 25% decrease in total production capacity, in the last seven years. Moreover, electricity production is declining, which may affect the sustainability of the Romanian energy system. In such a context, what could be the causes that prevented the achievement of the green goals?

[6] https://www.curteadeconturi.ro/uploads/fde5b18f/4d913ef9/813b8158/d58016a2/39899d80/899d99ff/7f6a75c2/7c4f51d0/SINTEZA_piata_energie.pdf, page 47, accessed at 05.02.2022 (Curtea de Conturi, 2015).

Results

Based on the premises described above, data collected for the period 2012-2020 were analyzed from a statistical point of view, in order to demonstrate the economic links between the bonus granted to accredited beneficiaries for cogeneration systems, the amount of energy produced in these units who used the financing scheme and the total amount of electricity produced and delivered in the National Power System. Data series that have been used are annual. Figure 4 shows that the evolution over time has a decreasing trend, with slight growth impulses. It is necessary to test data stationarity to see if the shocks to data series are temporary or permanent. If one of the series is not stationary, a stationary series will be obtained by differentiation. Thus, the order of integration of the series will be equal to the number of successive differentiations necessary to reach a stationary series (or the number of unit roots of the series). The most commonly used stationarity tests are the ADF (Augmented Dickey-Fuller) and PP (Phillips-Perron) tests.

Based on these premises, subject to the small number of records, the results are as follows:

Table 2. Unit root tests for the bonus granted to cogeneration plants, the production of energy produced in these units and the total amount of energy produced and delivered in the national system (2012-2020)

Variables	In the level		In the first difference		In the second difference		Conclusions
	ADF	p(H0)	ADF	p(H0)	ADF	p(H0)	
Cogeneration bonus	-1,7959	0,0715	-3,7837	0,0026			I(1)
Total_energy_production	-0,3532	0,5249	-1,7373	0,0787	-4,4721	0,0013	I(2)
CHP	-2,5124	0,0196					I(0)

Source: Own processing in Eviews12, based on data (ANRE, 2021)

The results suggest that the production of electricity in cogeneration is stationary, without any differentiation. It is therefore found that the cogeneration bonus series became stationary at the first differentiation (the difference between the value recorded at time t and that at time t-1). For the last series regarding the total energy production, the differentiation was continued, until the stationary was obtained. According to the ADF test, for the production of electricity produced in cogeneration, the risk that the initial series, in level, is not stationary is 1.96% in the model without exogenous variables. The value is below the standard threshold of 5%, which leads to the rejection of the unit root hypothesis. In this case, the null hypothesis is rejected, so the series is stationary. For the cogeneration bonus, according to the ADF test, the probability was higher than the 5% threshold, so the null hypothesis cannot be rejected and the series is not stationary in level. Therefore, the series was calculated by simple differentiation, for the model without exogenous variables, the series becoming stationary in the first difference, i.e. integrated of the first order, symbolic I (1). For the total electricity production, according to the ADF test, the probability was higher than the 5% threshold, both in level and in the first differentiation. Thus, a second differentiation was necessary, the series becoming stationary of the second order, symbolic I (II). Similar results were obtained by applying the Phillips-Perron test. The null

hypothesis in the case of the ADF test refers to the presence of unit roots. Given the results in the previous table, the linear correlation coefficients between the variables were further calculated, and the correlation result can be found in Table 3.

Table 3. Correlations between indicators

Covariance Analysis: Ordinary
Date: 02/09/22 Time: 11:35
Sample: 2014 2020
Included observations: 7
Balanced sample (listwise missing value deletion)

Correlation t-Statistic Probability	COGENER...	D(BONUS ...	D(PRODU...
COGENERARE	1.000000 ----- -----		
D(BONUS_COG...	-0.254802 -0.589203 0.5813	1.000000 ----- -----	
D(PRODUCTIA_...	0.749914 2.534797 0.0522	-0.712716 -2.271970 0.0723	1.000000 ----- -----

Source: Own processing in Eviews12.

The analysis of the results in Table 3, at a significance threshold of 10%, shows the existence of an inverse link, of medium intensity, between the bonus granted to accredited beneficiaries for cogeneration systems and the total amount of electricity produced and delivered in the National Power System, respectively, the existence of a direct, medium intensity link between the amount of energy produced by the accredited cogeneration systems that benefited from the financing scheme and the total amount of electricity produced and delivered in the National Power System. These results could be altered by the small number of records, or even real ones. As more statistics are added, the results can be confirmed or denied. These results lead to the conclusion that the decrease in the amount of energy delivered in the National Power System can be attributed to the decrease in production capacity of cogeneration systems, which confirms the economic reality that the number of households with individual heating has increased as a result of adopting alternative solutions. heat supply (individual apartment plants), especially in densely populated areas. This situation has led to an implicit decrease in the amount of electricity, through the underused use of cogeneration systems. Moreover, the results lead to the conclusion of the inefficiency of the aid scheme, which confirms the results highlighted by the Court of Auditors, regarding the extremely low percentage of the bonus received which was invested in modernizing and refurbishing cogeneration energy production systems. However, the implications of these results for sustainable energy development are many.

Discussions

The results of this analysis suggest that the policies adopted may be potential causes for which Romania has emerged from the top of the 40 most attractive countries in terms of renewable energy. If in 2015 Romania ranked 34th, according to the latest EY ranking, Renewable Energy Country Attractiveness Index (RECAI), in 2020 our country was surpassed by many other European countries such as France (4), Germany (6), Spain (10), Italy (13), Ireland (14), Denmark (15), Sweden (22), Poland (22), Greece (24), Belgium (26), Finland (31) and Hungary

(37) [7]. The lack of appropriate public policies can be seen as the key element in contributing to the declining attractiveness of renewable energy investments, which could also affect the transition to green energy. Moreover, public policies must take into account the fact that these investments target strategic areas, both from the perspective of energy security and sustainable development, with a major impact on other areas of activity in the economy.

For energy security and independence and achieving the goals of carbon neutrality by 2050, many countries around the world have taken a number of measures that have been doubled by a number of restrictions in this regard. France wants to build nuclear reactors[8], recently approved by the EU as solutions for the transition to green energy. France is also considering a floating offshore wind project to develop 750 MW with the potential to increase capacity to 2 GW. Belgium is on track to supply more than 10% of its electricity demand, with only 4.4 GW of offshore wind power and the possibility of expanding to 6 GW, including doubling installed capacity. The Netherlands has increased its renewable energy consumption by more than 20%, but the volume deficit has been acquired from Danish renewable energy projects, which cost around € 200 million. However, Germany may force a potential re-adoption of fossil fuels[9], given the lack of predictability induced by the vagaries of the weather for wind and solar installations. Spain has adopted a series of temporary measures (applicable between 15 September 2021 and 31 March 2022) to reduce the impact on final consumer bills. Denmark has launched an offshore project of up to 1.2 GW in the offshore perimeter between the region of Jutland and Sweden for the exploitation of wind energy. Finland has been adopting modern cogeneration systems for two decades now to reduce the consumption of renewable resources. Globally, Australia has tightened rules on foreign direct investment in recent years, particularly in electricity infrastructure and agricultural land, and the United States has imposed more than 27 restrictions, particularly in the energy sector (Global Risk Report, 2020). The same report mentions the emergence of more restrictive rules and regulations for non-governmental organizations, especially those receiving external funding, which must align their work with government policies, under threat of sanction for non-compliance. At EU level, since December 2017, a number of control measures have been proposed on foreign investment from outside the Union. At that time, only 12 EU countries had screening mechanisms. According to a study conducted in this regard, in the long run, foreign investment and the poverty rate may affect resource productivity (Ciornei and Munteanu, 2020).

Romania needs coherent and continuous public policies to ensure energy independence and security. The introduction of effective control mechanisms must be inspired by the global measures and restrictions.

Conclusions

The results of this case study suggest that the development of future public policies needs to consider a different approach, in line with the current global and regional context. Moreover, in developing these policies, the decision-maker must also take into account the particularities of the energy business environment, the state and location of energy systems and the environmental objectives assumed. The financial leverage that the authorities want to use to stimulate and

[7] (https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/power-and-utilities/ey-recai-58th-edition-top-40-ranking-october-2021.pdf accesat la 05.02.2022, fără an).

[8] (https://www.usnews.com/news/business/articles/2021-11-09/france-to-build-new-nuclear-reactors-to-meet-climate-goals, fără an).

[9] (https://www.dw.com/en/germany-coal-tops-wind-as-primary-electricity-source/a-59168105 accesat la 05.02.2022, fără an).

accelerate the transition to green energy must allow for particularization, as it is known that the treatment of causes cannot be done through a universal panacea. Specific problems require specific solutions, and current cogeneration systems need dedicated solutions on a case-by-case basis. Currently, the application of the financing scheme is conditioned by the type of fuel used and other elements of an economic and financial nature. Thus, for the same type of fuel used, the value of the bonus is the same for all energy producers (thermal and electric), for each unit of electricity (expressed in MWh) produced and delivered in the national grid, the calculation being based on the analysis of production and revenues from the sale of electricity produced in cogeneration. Or, depending on the final objectives to be achieved, the establishment of funding schemes must take into account the differentiated granting of bonuses, according to a number of well-defined particulars. The need for thermal and electrical energy in the coverage area of the cogeneration units, the capacity included in the technical documentation of the factory, the degree of moral wear of the installations, alternative technical solutions for modernization/replacement, elements regarding exergy concepts and methods, storage capacities and many other relevant elements can be criteria for building the aid schemes.

At the same time, by adhering to the 2030 Agenda, the results suggest that public policies must take into account the integration of the environmental objectives assumed, into the entire energy system - from producer, distributor to final consumer. Failure to integrate environmental targets across the population has led to individual heating solutions gaining momentum over the past two decades. The solutions were used even in situations where low-capacity cogeneration plants could have been chosen. These causes have led to a decrease in the demand for thermal energy in a centralized system and have led to an implicit decrease in production capacity and an increase in imports of electricity. Moreover, individual solutions are a significant source of pollution in that the elimination of gasses from the combustion process takes place at low altitudes. From this point of view, it can be stated that public policies have contributed negatively, mainly due to the unpredictability of the legislative framework, both to the increase in the share of green energy and to the improvement of environmental conditions.

It should also be noted that the current study is part of a much broader analysis in which the authors consider energy solutions focused on small, cogeneration systems based on renewable sources that serve entire communities. From this point of view, the study complements other previous studies on biomass-based solutions and will be followed by a number of other studies focused on reducing the consumption of primary resources.

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