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Forecasting the development of renewable energy sources in the Visegrad Group countries against the background of the European Union

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ABSTRACT

Objective: The aim of the article was to forecast the necessary pace of changes in the share of RES in the V4 countries resulting from the EU's renewable energy sources directive compared to other European Union countries.

Research Design & Methods: The research area included all EU Member States, and in particular the Visegrad Group countries. Forecasts of future RES share values were based on two models: Holt-Winters and the auto-regressive (AR) model based on EUROSTAT statistical data.

Findings: The potential failure to meet the recommendations of the RES share in gross final energy consumption for 2022 concerns 19 of the 27 Member States, of which 2 countries belong to the Visegrad Group.

Implications & Recommendations: The research has implications mainly to raise awareness of the direction of RES development in the European Union countries.

Contribution & Value Added: The study contributes to the estimation of the future value of the share of renewable energy sources in the V4 countries compared to other countries European Union on the basis of the current activities of these Member States. The forecast makes it possible to initially determine the possibility of meeting the specific target regarding the share of renewable energy sources in the final energy consumption set out in the European Union directive.

Article type:	research article
Keywords:	prediction of green energy development; RES in the European Union; Holt-Winters model; economic analysis; autoregressive model
JEL codes:	O13, P48

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INTRODUCTION

The global energy transition requires a gradual transformation from a fossil energy system to a low carbon energy system and ultimately to a sustainable energy path based on renewable energy (Dizdaroglu, 2017). Effective implementation of the idea of sustainable energy and the need to counteract the negative consequences of global warming requires a gradual reconstruction of the global energy infrastructure based on oil, coal, natural gases, hydropower and nuclear energy (Singh, 2008). On the one hand, concern for the well-being of the environment requires increasing energy efficiency and reducing greenhouse gas emissions, and on the other hand there is the need to meet the growing energy demands.(Kaygusuz 2012; Keles & Bilgen, 2012; Li *et al.*, 2022). Renewable energy sources including wind, solar, hydroelectric, geothermal, biomass and biofuels are seen as alternatives to fossil fuels and contribute to reducing greenhouse gas emissions, diversifying energy supply and reducing dependence on uncertain and volatile fossil fuel markets, especially oil and gas (European Parliament, 2021), whose reserves are limited and subject to price fluctuations (Owusu & Asumadu-Sarkodie, 2016) resulting, for example, from international politics, or the situation in global financial markets (Hsiao *et al*., 2019). The substitutive character of renewable energy and crude oil has a significant impact on shaping the demand for these goods. Oil price fluctuations determine the costs of its use, which in turn shapes consumers' interest in clean energy (Hu & Ding, 2016). Increasing energy security through the use of renewable energy sources has been noticed in many European countries (Angheluta *et al*., 2019), which are taking a number of measures to move towards a sustainable and more efficient energy system (European Parliament, 2021). The progress in the area of renewable energy sources is related to the principle of sustainable energy use, which significantly shapes environmental, social and economic development, which is reflected in better availability of clean, affordable and efficient energy, as well as provides a foundation for meeting many environmental, economic and developmental needs (Hess, 2014). The progress in the use of renewable energy sources supports economic development (Bhattacharya *et al*., 2016), economic growth and employment (Lehr & Ulrich, 2017), shapes economic competitiveness and more efficient use of resources (Falkner, 2014).

The aim of the article was to forecast the necessary pace of changes in the share of RES in the V4 countries resulting from the EU's renewable energy sources directive compared to other European Union countries. The long-term vision strategy adopted by the EU was of interest to the authors of the article, who adopted the following research hypothesise:

H1: In the following years, the growth of the RES share in the energy mix will be maintained, averaging 1% per year for the EU.

The study considers a maximum forecasting period of 4 years from the last known statistical value. In the scope of the study, two models were used: the Holt-Winters' model and the autoregressive model (AR). The specific study design is justified by the number of model inputs, whose statistical values for each EU Member State are 17 years (period: 2004-2020 based on EUROSTAT).

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Energy Policy of the European Union in the Area of Renewable Energy Sources

Along with the global development of renewable energy sources, there is a need for an energy policy aimed at their support (Edenhofer *et al*., 2013), as exemplified by actions taken within the European Union. The energy policy of the European Union is characterized by a comprehensive approach to the aspects of energy security, satisfaction of social needs, competitiveness of the economy, as well as environmental and climate protection. The Europeanization of energy policy supports the creation of an environment shaping the development of the energy industry and energy companies in the European Union. It determines the convergence of macroeconomic systems among the member states and the convergence of industries and sector policies, with particular emphasis on energy policy. Due to the sectoral nature of the energy policy, energy policy belongs to the common competences of the European Union and its member states (Wach *et al*., 2021).

In 2018 the European Union adopted a revised Renewable Energy Directive (Directive (EU) 2018/2001) (European Parliament, 2018a). It establishes a new target that at least 32% of final energy consumed in the European Union should be obtained from renewable sources by 2030 and includes a clause to increase this target by 2023 (European Parliament, 2021). A significant change occurred in relation to the 2009 Directive, as the target indicated is binding only for the EU as a whole, and not for individual Member States (Monti & Martinez, 2020). The EU Member States were required to propose national energy targets and establish 10 year National Energy and Climate Plans under the programme 'Horizon 2030' (European Commission, 2021a) and will then submit progress reports every two years. It will remain for the European Commission to assess these plans, as well as to possibly take measures at the EU level to ensure that they are consistent with the overall objectives of the European Union (European Parliament, 2021).

Another of the objectives of the European Union's energy policy until 2050 is to achieve climate neutrality within the European Green Deal, which will result in the elimination of fossil fuels as energy sources (Brodny *et al*., 2021). In 2021 the European Commission presented a new legislative package on energy entitled 'Ready for 55: meeting the EU's 2030 climate target on the road to climate neutrality' (COM(2021)0550) (European Commission, 2021b). The new revision of the Renewable Energy Directive (COM(2021)0557) (European Parliament, 2018b) proposed to increase the mandatory target for the share of renewable energy in the European Union's energy mix to 40% by 2030, as well as new targets at national level (European Parliament, 2021).

Energy Sources in the Visegrad Group Countries in the Light of the EU Energy Policy

The Czech Republic, Hungary, Poland and Slovakia, which are members of the Visegrad Group, are former socialist countries undergoing economic transformation since the early 1990s. (Godawska & Wyrobek, 2021). The similarity of the economies of the Visegrad Group countries resulted from the departure from central planning, although certain differences were visible in the national, ethnic and cultural areas (Pach-Gurgul & Ulbrych, 2019). Political instability in the Central and Eastern European region gave rise to the Visegrad countries in 1991, followed by the break-up of Czechoslovakia in 1993, which led to the formation of the Visegrad Group (V4) (Kumar *et al*., 2021). Initially, the main goal of this informal association was the full integration of cooperation in the political and economic dimensions (Latawski, 1993). The Visegrad Group countries are an example of countries with mutual interests that should transcend borders to develop emerging energy sectors (Kumar *et al*., 2021). The possibility of close economic cooperation of the Visegrad Group countries resulting from geographic proximity enables the reduction of costs resulting from the transmission of energy between countries (Sulich & Sołoducho-Pelc, 2021).

The energy production in Central and Eastern Europe is traditionally based on non-renewable energy sources (Sulich & Sołoducho-Pelc, 2021). The energy production in the Visegrad countries is based to a large extent (the Czech Republic, Hungary, Slovakia) or very much (Poland) on the exploitation of fossil fuels (Godawska & Wyrobek, 2021). It is worth noting that the group of countries mentioned above includes one of the largest coal producers – Poland, which has the ninth largest deposits of this raw material in the world (Sulich & Sołoducho-Pelc, 2021).

Undoubtedly, a particularly important factor determining the shape of the energy sector in this part of Europe is the historical background, among which the dependence on the supply of fossil fuels from Russia (Center for European Policy Analysis, 2016), combined with an active mining lobby, promotes a cautious approach to the policy of transformation of the community. On the one hand, the decreasing profitability of coal based energy and on the other, the growing attractiveness of renewable energy sources favors the former. In the economic reality, this situation is exacerbating the differences between the energy policies of these countries and causing significant internal shocks. An example is the timing of the departure from coal as an energy source in individual countries. Slovakia has announced the cessation of coal use for electricity production by the end of 2023, and Hungary has announced its withdrawal by 2030 (Heilmann *et al*., 2020; Księżopolski *et al*., 2020). In the Czech Republic, on the other hand, it will be 2033 (300gospodarka, 2022), and in Poland it will be 2049 at the latest (300gospodarka, 2021).

The energy transformation of the countries in question makes it necessary to invest in gas or nuclear solutions, as well as in renewable energy sources. In the case of the development of the latter, the key role in the nearest financial perspective will be played by the European funds, which constitute as much as 40-60% of national public investments in the Visegrad countries (Heilmann *et al*., 2020). In addition to the above mentioned financial support, the geographical location and environmental conditions are important assets of the Visegrad countries, which favor the development of renewable energy sources (Kotulewicz-Wisińska, 2018).

The natural conditions for investing in renewable energy sources in the Visegrad countries are generally moderately positive, although some regional differences can be observed (e.g. Slovakia has favorable conditions for the development of hydropower, while Hungary for the development of geothermal energy) (Godawska & Wyrobek, 2021). The contrasts can also be seen in the diversity of technologies used to achieve the targets in the area of renewable energy sources (Kozar, 2019). The propensity of individual Visegrad countries to develop renewable energy sources is also different due to the possibility of obtaining nuclear energy. In the case of Slovakia (Kratochvíl & Mišík, 2020), the Czech Republic and Hungary, obtaining energy from the atom may limit the interest in obtaining energy from renewable sources (Księżopolski *et al*., 2020). Whereas Poland assumes construction and commissioning of 2 nuclear power plants with 3 reactors each. Construction of the first reactor is to start in 2026 and its commissioning in 2033 (Ministry of Climate, 2020). The energy transformation of these countries makes it necessary to invest both in gas or nuclear solutions and in renewable energy sources. In the case of the development of the latter, the key role in the upcoming financial perspective will be played by the European funds, which constitute as much as 40-60% of national public investments in the Visegrad countries (Heilmann *et al*., 2020). In addition to the financial support mentioned above, the geographical location and environmental conditions are important assets of the Visegrad countries that favor the development of renewable energy sources (Kotulewicz-Wisińska, 2018).

Differences can also be observed in the area of inhabitants' environmental awareness and willingness to undertake pro-environmental investments. An upward trend in these aspects is observed in Hungary and the Czech Republic. In the case of Poland and Slovakia, on the other hand, this trend is less noticeable despite huge campaigns and outlays on education (Magda *et al*., 2019).

All Visegrad countries (as well as other European Union Member States) have submitted National Energy and Climate Plans for 2021-2030, which include climate and energy targets for 2030 (Ministry of Industry and Trade, 2019; Ministry of Innovation and Technology, 2019; Ministry of National Assets, 2019; Slovak Ministry of Economy, 2019). The share of RES in gross final energy consumption (in %) in 2020 and the targets for 2025 and 2030 vary from country to country (Figure 1.).

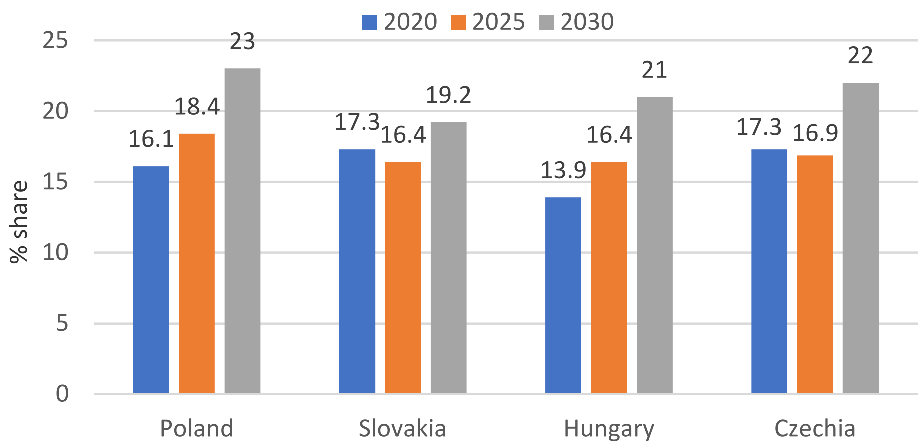

Figure 1. Share of energy from renewable sources in final gross consumption of energy in V4 Countries National Energy and Climate Plans and future expectations by 2025 and 2030
Source: own studies based on: (Ministry of Industry and Trade, 2019; Ministry of Innovation and Technology, 2019; Ministry of National Assets, 2019; Slovak Ministry of Economy, 2019)

Forecasting the development of renewable energy sources makes it possible to assess the chances of achieving the targets set out in the European Union documents and provides a basis for their possible modification. In the literature, there are studies on forecasting the development of renewable energy sources, which were carried out for selected areas using different econometric methods. Among studies covering the selected EU member states (and others), one can point to forecasts of: the level of renewable energy consumption in Belgium, the Czech Republic, France, the Netherlands, Poland and the UK by 2030 (Manowska, 2021); energy production from renewable sources in Poland by 2025 (Brodny *et al*., 2020); renewable energy consumption in France, Germany, Italy, Spain, Turkey and the UK by 2030 (Utkucan, 2021). The multifaceted projections of the development of renewable energy sources in member and associated countries of the International Energy Agency (including the selected countries belonging to the European Union) until 2026 are included in the latest report of this institution (International Energy Agency, 2021).

RESEARCH METHODOLOGY

Model Characteristics

In the scope of the study consisting in forecasting the development of RES, in particular its share in gross final energy consumption, two models were used: the Holt-Winters' model and the autoregressive model (AR). The first one allows for forecasting variables with seasonal fluctuations in the scope of complete time series, while the second model concerns higher order autoregression. The aim of the study is to predict the development of renewable energy sources in the European Union Member States. The study was based on EUROSTAT resources concerning the share of energy from renewable sources in gross final energy consumption falling on the years 2004-2020. When carrying out the study with the Holt-Winters' model, calculations can be based on two variants: additive and multiplicative. The additive variant is described by the following equations (Szumksta-Zawadzka & Zawadzki, 2014):

$$m_t = \alpha(Y_t - C_{t-m}) + (1-\alpha)m_{t-1} \quad (1)$$

$$S_t = \beta(m_t - m_{t-1}) + (1-\beta)S_{t-1} \quad (2)$$

$$C_t = \gamma(Y_t - m_t) + (1-\gamma)C_{t-p} \quad (3)$$

The multiplicative variant is described by the equations:

$$m_t = \frac{\alpha Y_t}{C_{t-m}} + (1-\alpha)(m_{t-1} + S_{t-1}) \quad (4)$$

$$S_t = \beta(m_t - m_{t-1}) + (1-\beta)S_{t-1} \quad (5)$$

$$C_t = \frac{\gamma Y_t}{m_t} + (1-\gamma)C_{t-m} \quad (6)$$

where:

m_t - assessment of average value;
S_t - the directional parameter of the trend (trend growth);
C_t - assessment of seasonality;
p - the length of the period of periodic fluctuation;
α, β, γ - the volatility and trend smoothing constants, take values in the range [0,1].

The predictor based on the additive model is expressed by the formula:

$$Y_t = m_{t_0} + S_{t_0}h + C_{t_{0-m+h}} \quad (7)$$

For the multiplicative model, we describe the predictor as follows:

$$Y_t = (m_{t_0} + S_{t_0}h)C_{t_{0-m+h}} \quad (8)$$

We take the following equations as the initial values of the forecast variable:

$$m_1 = \frac{1}{r}\sum_{i=1}^{r} y_i \quad (9)$$

$$S_1 = \frac{1}{r}\sum_{i=r}^{2r} y_i - \frac{1}{r}\sum_{i=1}^{r} y_i \quad (10)$$

For the additive model:

$$C_m = y_m - \bar{y} \quad (11)$$

For the multiplicative model:

$$C_m = \frac{y_m}{\bar{y}} \quad (12)$$

For the AR predictive model, the equation is defined by the following form (Autoregressive models, 2021):

$$X_n = \alpha_0 + \alpha_1 X_{n-1} + \alpha_2 X_{n-2} + \cdots + \alpha_k X_{n-k} + \varepsilon \quad (13)$$

where:

X_n - the value of the time series;
$\alpha_0, \alpha_1, \ldots, \alpha_k$, - coefficients;
ε - white noise;
k - row of autoregression.

RESULTS AND DISCUSSION

Intended Targets and RES Achievements in the European Union

Due to the large differences in RES share in the EU Member States, resulting from spatial and financial aspects, the Directive stipulated national targets, which could differ from the EU target, and the way to achieve them was to be presented in a detailed RES policy action plan. At the time of this study, all Member States had presented their national RES share in gross final energy consumption, allowing for an assessment of the targets.

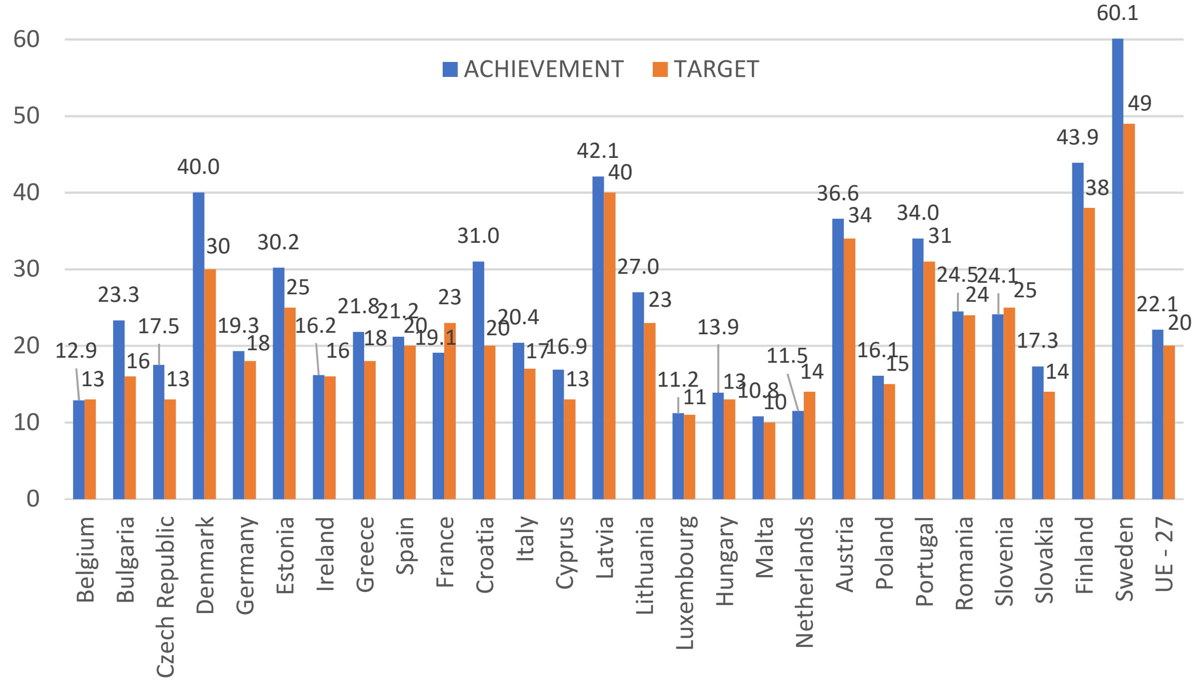

Figure 2. Summary of the adopted target and the actual share of RES (2020) in gross final energy consumption in the EU Member States

Source: own study based on EUROSTAT data.

The EU target of a 20% RES share by 2020 has been overachieved by 2%. Unfortunately, not all the EU member states have fully achieved their national targets, we are referring to: Belgium, France, the Netherlands and Slovenia. The effectiveness of the national targets within the EU as a whole was 85%. The results are worse if we assume that each EU Member State should achieve the expected 20% RES share in 2020. It turns out, therefore, that less than 15 countries can boast of exceeding such a value, which translates into the effectiveness of 56%. At the next stage, the European Commission proposed that the share of RES in the EU energy mix should reach 40% by 2030 (Ciucci, 2021). In the implementation of the European Green Deal, such a move would be a kind of a 'milestone' towards achieving climate neutrality by 2050 (European Parliament, 2009). In order to achieve this target, a minimum increase of 1% per year within the EU should be adopted (as a reminder, in 2020 the value was 22.10%).

Table 1 presents a summary of the results for the use of the two forecasting models, the values of which often differ from each other. The most divergent forecast models are visible for countries such as: the Netherlands, Cyprus or Estonia, where the values of the difference oscillate even within 10%. This may be due to the fact that in these countries a linear increase in RES share has been observed in recent years. The aforementioned linearity of the growth trend, combined with the dynamic difference in the share over 2019 and 2020, may have influenced the final values of the model coefficients and thus the direction of the forecast. Therefore, assuming that the forecast can be considered most plausible when both models have similar values and the difference between them does not differ by more than 1 pp, then: Greece, France and Finland, which will meet the above requirements in terms of 4-

year prognosis. Greece will have the highest dynamics of change (for the above mentioned countries) with the value of ≈ 1.4%, while Finland will approach the share of RES in final energy consumption to ~49% already in 2024. The closest forecasts of the models used are for 2021 and 2022, where 14 out of 28 surveyed entities (50%) achieved a difference of less than 1 pp, while the following years are characterized by progressive divergence.

Table 1. Forecast values of RES energy share in gross final energy consumption for 2021-2024, according to Holt-Winters' (H-W) and autoregressive (AR) model [data in %]

COUNTRY	YEAR								$\overline{x}$	
	2021		2022		2023		2024			
	H-W	AR	H-W	AR	H-W	AR	H-W	AR	H-W	AR
Belgium	13.53	13.58	14.55	14.25	15.84	14.08	18.77	15.03	1.75	0.48
Bulgaria	24.71	23.89	26.40	24.40	27.60	25.11	29.19	25.69	1.49	0.60
the Czech Republic	18.52	18.25	20.20	18.47	22.12	18.47	23.12	18.65	1.53	0.13
Denmark	41.01	40.04	42.52	42.95	45.53	44.47	47.59	44.83	2.19	1.60
Germany	18.85	20.81	19.79	22.60	21.63	24.92	22.90	27.43	1.35	2.20
Estonia	28.32	30.75	24.98	30.35	24.15	31.49	22.45	31.46	-1.96	0.24
Ireland	18.32	18.27	20.51	20.35	23.49	27.05	27.61	32.55	3.10	4.76
Greece	22.90	23.51	24.45	24.97	26.50	26.28	27.19	27.74	1.43	1.41
Spain	21.95	21.46	23.37	19.40	25.67	19.49	28.63	22.24	2.22	0.26
France	19.50	18.98	19.98	19.54	20.98	20.42	22.46	21.60	0.99	0.87
Croatia	32.53	31.41	32.56	31.75	33.08	31.63	35.10	31.74	0.86	0.11
Italy	19.83	20.54	20.11	19.71	22.15	19.95	23.22	20.98	1.13	0.15
Cyprus	18.02	12.71	19.99	21.48	21.93	13.06	23.56	32.47	1.85	6.59
Latvia	43.87	42.57	43.77	43.31	43.84	44.03	45.64	44.65	0.59	0.69
Lithuania	28.43	27.52	29.18	27.59	31.24	27.81	32.74	28.25	1.44	0.24
Luxembourg	11.28	10.17	13.48	13.85	12.60	14.08	15.98	17.72	1.57	2.52
Hungary	12.60	14.20	11.38	14.44	12.35	14.36	13.38	14.28	0.26	0.03
Malta	11.32	12.45	12.20	14.32	12.98	16.12	14.75	18.26	1.14	1.94
the Netherlands	12.83	15.61	14.69	22.80	17.22	34.80	19.55	54.88	2.24	13.09
Austria	35.29	33.93	35.88	36.09	37.47	33.93	39.56	36.22	1.42	0.76
Poland	17.03	15.44	17.96	16.34	18.87	17.11	19.79	18.10	0.92	0.88
Portugal	34.28	36.23	36.65	36.90	39.81	35.97	42.59	35.90	2.77	-0.11
Romania	24.10	24.81	23.55	24.71	24.07	24.71	24.23	24.74	0.04	-0.02
Slovenia	25.27	23.79	24.95	23.35	26.24	22.35	27.05	22.56	0.59	-0.41
Slovakia	18.44	15.30	20.19	16.89	22.93	19.26	23.47	19.12	1.68	1.37
Finland	44.69	45.50	47.08	46.37	47.87	47.81	48.66	48.89	1.32	1.13
Sweden	59.98	59.37	61.00	60.56	64.33	62.31	66.82	63.01	2.28	1.21
UE-27	22.27	23.06	23.38	23.51	25.29	23.99	26.75	24.81	1.49	0.58

$\overline{x}$ – average annual growth forecast

Source: own study based on EUROSTAT data.

Referring to Table 1 and to hypothesis 1 (H1), where an average annual RES growth dynamics of 1% within the community of the EU Member States was determined, it can be stated that on the basis of the study, the AR model did not confirm such growth within the next 4 years. The perspective of introducing by the European Commission a 40% share of RES by 2030 with unchanged achievements in its development, together with a sustained growth trend of 1.49% (Holt-Winters' model) and 0.58% (AR model) may not be achieved. Assuming that the target set in the current directive (32%) remains unchanged, it is very likely to be met. Based on the Holt-Winters' model this is almost certain, while based on the AR model it is not necessarily so. However, using the average growth dynamics received on the basis of these two models we obtain a value of ≈ 1.04%, which also confirms the aforementioned assumption of meeting the target. On this basis, the authors of the study are inclined to confirm the truth of hypothesis 1 (H1).

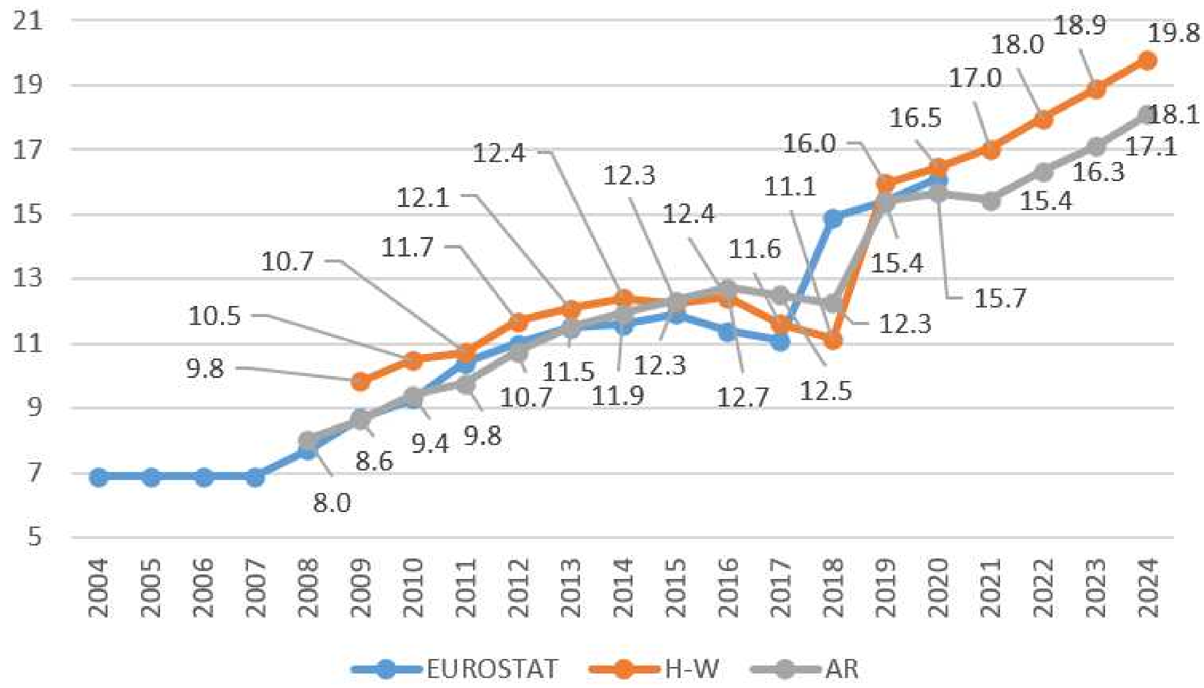

Figure 3. Actual (EUROSTAT) and projected (H-W, AR) share of RES in gross energy consumption [%] – projection for Poland
Source: own study based on EUROSTAT data.

Referring to the obtained forecasts for Poland (figure 3), further development of RES can be expected in the coming years without major disturbances. However, there are some difficulties in the area of RES implementation related to the geographical conditions which is reflected in the degree of insolation in the case of photovoltaic panels (Buriak, 2014). Another problem is the size of investment outlays that have to be borne by the investor in order to launch such a system. Despite the complicated situation, a systematic increase in the share of RES is visible, in particular due to the subsidies granted for its development and the possibility to finalize such an investment with foreign capital (preferential investment loans) (Instytut Energii Odnawialnej, 2019; Ministerstwo Klimatu i Środowiska, 2022). Implementation of support mechanisms for prosumers and renewable energy sources must be carried out with simultaneous efforts to maintain the profitability of the mining sector (Księżopolski *et al*., 2020).

A. Manowska (2021), while forecasting the share of RES in the selected EU countries, presented that the forecasting model for Poland showed a share of about 15% for 2025 and about 17% for 2030. As in the case of this article, the forecasting was carried out using the AR model, but the results differ from those obtained in Table 1. Such differences are related to a smaller amount of input data (data until 2018), which translated, among others, into the forecast of Poland's inability to meet the 2020 target, which was eventually met. Similar results were obtained by another team of researchers, who predicted Poland's inability to meet its 2020 target for the share of RES in gross final energy consumption (Brodny, 2020). In this case, the model was also based on statistical data falling to 2018. It should be noted that in the case of the cited research work and the present study, the EUROSTAT statistical database was used, where there is some irregularity in the data for 2018. In the cited research, the value for Poland for 2018 was determined at the level of approximately 11.5%, while at the moment (February 2022) the statistical base defines the share at the level of 14.9%. Probably there was an update of EUROSTAT statistical data, which significantly affected the level of forecasts and for this reason the mentioned discrepancies in research results could occur.

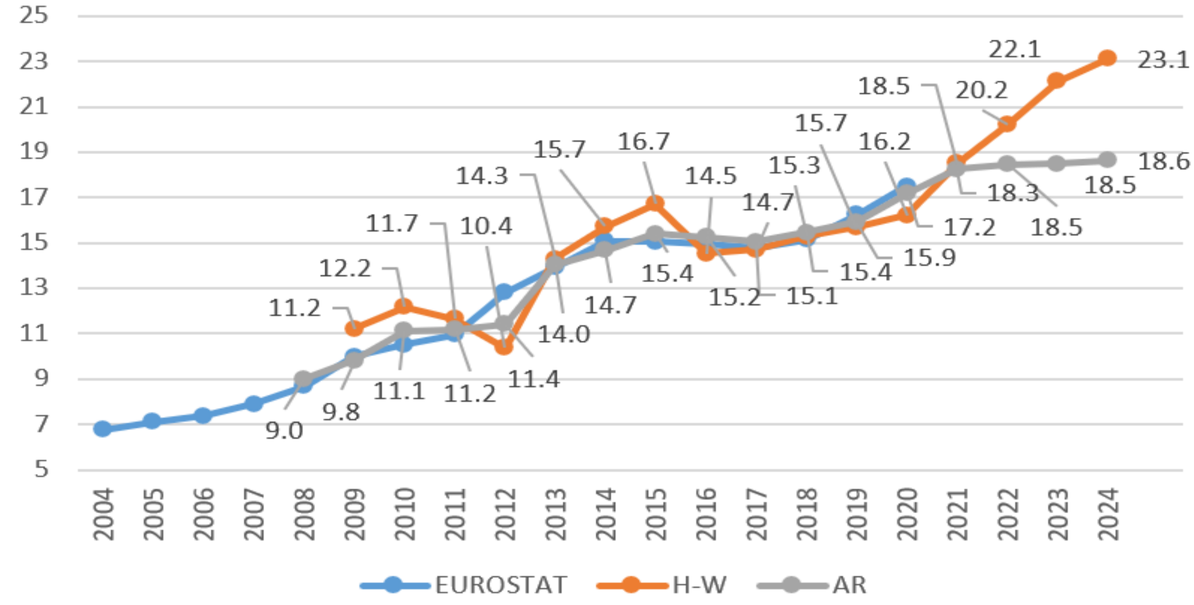

Figure 4. Actual (EUROSTAT) and projected (H-W, AR) share of RES in gross energy consumption [%] – projection for Poland

Source: own study based on EUROSTAT data.

In the case of the Czech Republic, further development of RES is also expected based on the results of both forecasting models (figure 4). In the case of the Holt-Winters' model, forecasts similar to those obtained by A. Manowska (2021) were achieved. The Czech Republic predicts that in 2025 it will reach 16.87% and in 2030 22% share of RES in gross energy consumption. The models indicate that the planned value level is realistic to achieve especially for 2025. Assuming that the average annual value of the growth dynamics for the country is 1.53% (Holt – Winters' model) and 0.13% (AR model), it can be determined that there is a probability of meeting also the forecast for 2030. The level of fear of the inhabitants about the negative effects of wind power plants on the environment and their quality of life, which was one of the barriers to the development of renewable energy in the Czech Republic, has decreased (Cetkovský *et al.*, 2009).

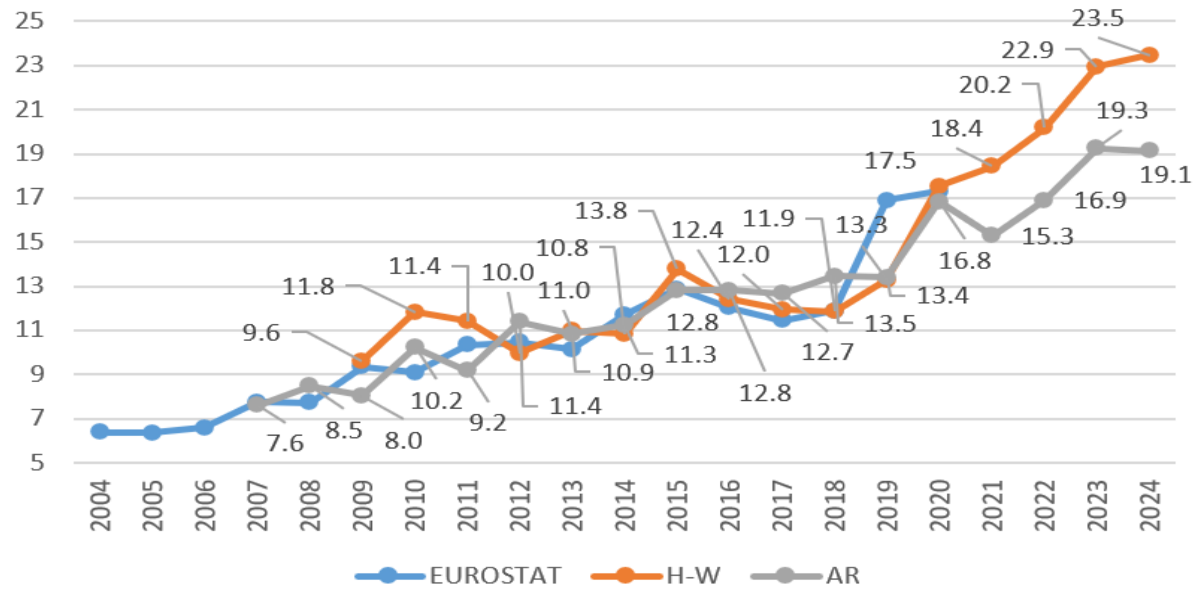

Figure 5. Actual (EUROSTAT) and projected (H-W, AR) share of RES in gross energy consumption [%] – projection for Slovakia

Source: own study based on EUROSTAT data.

In the case of Slovakia (figure 5), the Holt-Winters' model showed the highest growth dynamics in the aspect of the whole Visegrad Group and the RES share was determined at the level of 1.68% per year. The growth dynamics is close to the average value obtained for the Czech Republic, and the graphical visualization of the share in the presented period is very similar to each other. This may be related to similar GDP growth for these countries with some advantage for Slovakia (Brożyna *et al.*, 2020). The RES share target for this country is 16.4% for 2025 and 19.2% for 2030 (figure 1). The predicted forecast values of the different models clearly indicate that Slovakia will definitely increase the share of green energy in the coming years. The forecast may be true due to the planned allocation of 220 million EUR for the implementation of RES projects in the coming years (Hudec, 2021).

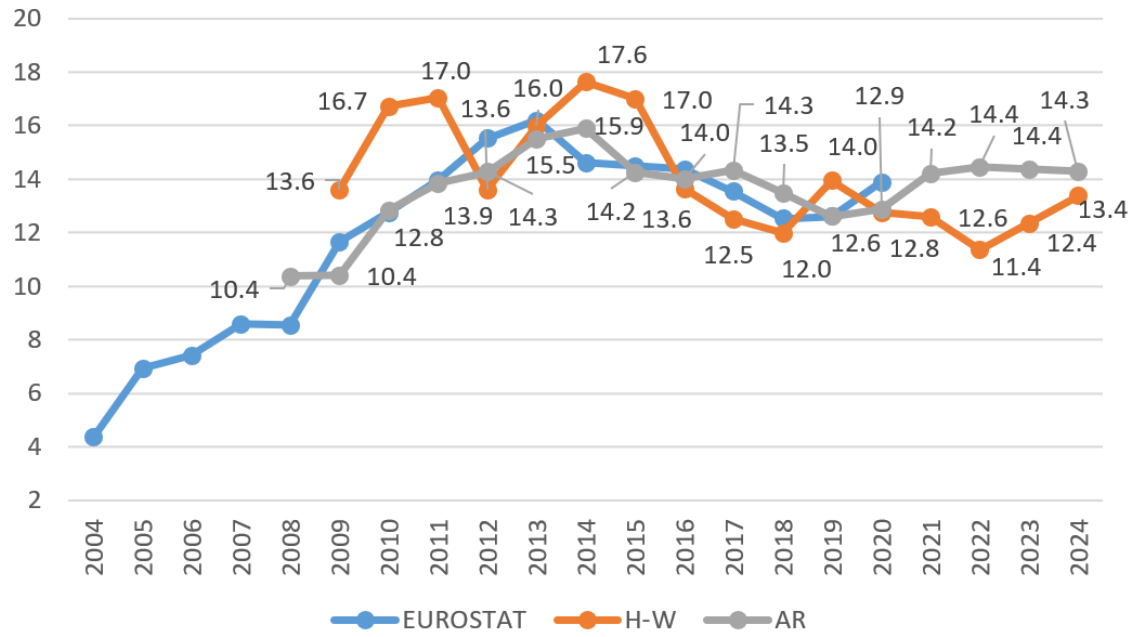

Figure 6. Actual (EUROSTAT) and projected (H-W, AR) RES share in gross energy consumption [%] – projection for Hungary

Source: own study based on EUROSTAT data.

As for Hungary, the forecast showed an average annual growth rate of around 0.26%. The value shown is obviously less optimistic than for the other Visegrad countries. This is mainly due to the fact that a decrease in the share of RES in gross final energy consumption was noticeable in the period 2013-2019 (fig.6). Despite a slight decrease in the RES share since 2013, Hungary reflects the highest potential in terms of solar radiation among the four V4 countries (Kumar *et al.*, 2021), which translated into a significant increase in solar energy production from 2019 onwards by more than 59% (Renewables Now, 2019b). The increase in the number of photovoltaic power plants in recent years is due to the possibility of subsidies from 2019 for this type of investment (Simon & Deák, 2022). Hungarians have set as a target of RES share in gross energy consumption values of 16.4% in 2025 and 21% in 2030. In the actual actions in this regard, the forecasting models did not make it possible to state that such values will be achieved, however, further growth in the importance of solar energy in this country may change them.

Reading the Regulation of the European Parliament and of the EU Council of 11 December 2018 (Chapter 2, Article 4) we will encounter the following provision (European Parliament, 2018c):

> *„(…) By 2022, the indicative trajectory shall reach a reference point of at least 18 % of the total increase in the share of energy from renewable sources between that Member State's binding 2020 national target, and its contribution to the 2030 target. (…)"*

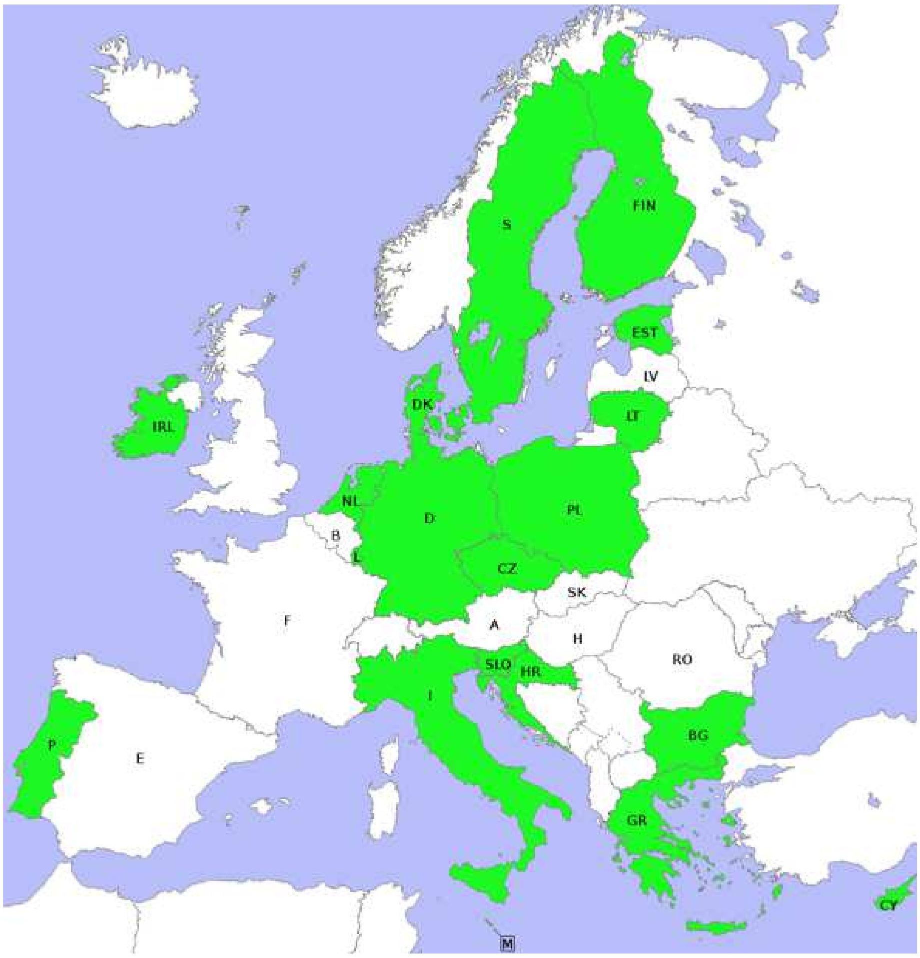

Figure 7. The map of the member countries showing potential compliance with RES share requirements in gross final energy consumption for 2022. The countries are marked in green

Legend: *B – Belgium; BG – Bulgaria; CZ – Czech Republic; DK – Denmark; D – Germany; EST – Estonia; IRL – Ireland; GR – Greece; E – Spain; F – France; HR – Croatia; I – Italy; CY – Cyprus; LV – Latvia; LT – Lithuania; L – Luxembourg; H – Hungary; M – Malta; NL – Netherlands; A – Austria; PL – Poland; P – Portugal; RO – Romania; SLO – Slovenia; SK – Slovakia; FIN – Finland; S – Sweden.*

Source: own study based on EUROSTAT data.

The quoted fragment sets out guidelines for the EU Member States regarding the minimum incremental share of RES in final energy use for 2022. Figure 7 shows those countries, which as a result of the conducted forecast will exceed the aforementioned increase (green colour) using at least one model. Referring to the results of the study, 19 out of 27 EU countries will meet the targets set in the regulation, which translates into an effectiveness of 70%. For the EU as a whole, the increase is 18%, which, despite the limit value, allows us to conclude that the RES increase targets for 2022 can be met.

The authors of the study emphasize that the models used did not take into account the financial outlays for the development of RES, which was characteristic and noticeable in recent years of green energy development and could have affected the forecast results. In the case of Poland, high RES growth dynamics was achieved, among others, due to the introduction of the so called green certificates (Pająk & Mazurkiewicz, 2014). The dynamic growth of RES share in the case of the Netherlands has a basis in technological aspects. In recent years, the installed capacity of offshore wind turbines has been increased and new ones have been put into operation, which has allowed to increase the capacity from 4500 MW (2019) to 6600 MW (at the end of 2020) (International Trade Administration, 2020). According to the Estonian Energy Development Plan, the RES share by 2030 is assumed at the level of 50% (Renewables Now, 2019a), the combination of this target with the results of forecasts determining the continuation of dynamic development, allows us to state that the assumed values are realistic to achieve. A study by

Utkucan (2021) presented a dynamic growth of RES share in Spain, among others, where the forecast for 2024 was similar to the values obtained using the AR model and amounted to about 22.5%.

There may be many reasons for RES development, the most important of which is counteracting climatic changes manifested by temperature increase, melting of glaciers, etc. (Kundewicz & Juda-Rezler, 2010). Maintaining the dynamic development of RES also has an economic justification, related to the constantly increasing prices of CO2 emission allowances.

CONCLUSIONS

The development of renewable energy sources is an important challenge in the process of energy transformation in the Visegrad Group countries, which is implemented, among others, on the basis of the energy policy of the European Union. The perspectives for the use of renewable energy sources are differentiated due to the specific conditions of individual economies. The European Union, as well as the Czech Republic, Hungary, Poland and Slovakia, are aware of the potential of investments in the renewable energy sector, which in the long term perspective will translate measurably into a reduction in greenhouse gas emissions, increased energy efficiency and improved energy security.

The research contained in this paper contributes to the body of literature on the subject in several dimensions. Firstly, a review of the latest theoretical and empirical research provides a basis for a discussion on the prospects for the development of renewable energy sources in the Visegrad Group countries against the background of the European Union. Secondly, based on the empirical research, the following conclusions can be drawn:

1. The target for the share of renewable energy sources in gross final energy consumption in the European Union member states in 2020 has only been met at the community wide level, as several countries have not met the targets at the national level.
2. The projected average growth rate of the share of renewable energy sources in gross final energy consumption for the period 2021-2024 in the European Union is just over 1%. The prospects for achieving the target in this area by 2030 in the European Union are therefore good.
3. The European Union's objective of increasing the share of renewable energy sources in final consumption to a minimum of 18% in 2022 is achievable only at community level.
4. Forecasts of the growth of the share of renewable energy sources in the Visegrad Group countries for 2022 vary, but unfortunately are often insufficient to meet the requirements set by the European Union in this regard. Among the Visegrad Group countries, only the Czech Republic and Poland are up to the challenge.
5. Divergent results in the area of forecasting the share of renewable energy sources in consumption in the Visegrad Group countries may result from a number of reasons. For example, the different technologies used to meet the renewable targets or the stage of development of the country.

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