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ANALYSIS OF THE SHARE OF ENERGY FROM RENEWABLE SOURCES IN THE ELECTRICITY SECTOR IN POLAND AND THE EUROPEAN UNION

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Purpose: The article aims to analyze the share and forecast the share in the following year's share of renewable energy sources in Poland and the European Union; it will present the situation of Poland and the European Union to determine new directions of action towards increasing the share of renewable energy sources.
Design/methodology/approach: The work analyzes changes in subsequent periods, compares shares in Poland with shares in the European Union, and uses an analytical model to present forecasts for the coming years.
Findings: The work identifies a growing trend in the overall share of renewable energy sources in Poland and the European Union, draws attention to Poland's low share compared to other EU countries and examines changes in the shares of individual factors in the Electricity sector.
Research limitations/implications: Based on the analysis of the energy shares from renewable sources in the Electricity sector, it seems reasonable to conduct a similar analysis for the other two sectors and link the results with changes in environmental pollution.
Practical implications: The results of the analysis may influence actions taken in Poland to increase the share of energy from renewable sources and be the basis for analysis in terms of Poland's implementation of Directive (EU) 2018/2001.
Originality/value: The article presents analyses of the share of energy from renewable sources along with forecasts for the following years, which analyses can be used by the entity responsible for implementing activities under Directive (EU) 2018/2001.
Keywords: renewable energy, forecasting, Directive (EU) 2018/2001.
Category of the paper: Research paper, general review.

1. Introduction

Energy from renewable sources, commonly referred to as renewable energy, is defined by the International Energy Agency (IEA, 2024) as "renewable energy is derived from natural processes that are replenished at a faster rate than they are consumed" (SHARES, 2023). That is energy, including non-fossil sources, using the Earth's natural resources, characterized

by renewable energy as "inexhaustible" energy sources (Szafrański, 2004). The concept of renewable energy sources is fundamental due to its appearance in EU legal acts, as well as in the legal regulations of the European Union Member States. The first definitions of renewable sources are included in 2003/54/EC, 2009/72/EC, 2001/77/EC (Pobrzeżyńska, 2020). The definition currently in force in Directive 2009/28/EC is mainly similar to that in Directive 2009/28/EC, but updated with a more precise definition and taking into account new technologies and sustainability criteria: "renewable, non-fossil energy sources including wind energy, solar radiation, aerothermal energy, geothermal energy, hydrothermal energy, hydro energy, energy of waves, sea currents and tides, ambient energy, energy obtained from biomass, biogas, agricultural biogas, biomethane, bioliquids and renewable hydrogen" (Dziennik Ustaw, 2024). Directive (EU) 2018/2001 (RED II) replaced Directive 2009/28/EC, which was in force until December 31, 2020. This directive was created due to the lack of apparent progress towards achieving the objectives in Directive 2001/77/EC and the need to combat climate change. This directive sets new goals for Member States: 20% share of renewable energy in gross energy consumption in the EU by 2020 and at least 10% of renewable energy in transport by 2020. The targets were set at the national level, and Member States could choose the means to achieve them. Directive (EU) 2018/2001 (RED II) introduced new objectives and rules for 2021-2030. RED II raised the average EU target to 32% renewable energy by 2030 and updated the methods of calculating this indicator, considering more sustainable energy sources (Dziennik Ustaw, 2024).

Due to the requirements of EU regulations, such as the Renewable Energy Directive and the need to monitor progress in achieving climate and energy goals in various sectors of the economy, the shares of energy from renewable sources have been divided into sectors such as electricity, transport, and heating and cooling (Dziennik Ustaw, 2024). The Electricity sector refers to using renewable energy sources (RES) to produce electricity. This sector's leading renewable energy sources are wind, solar, geothermal hydropower, ocean, biomass, and biogas. This sector's data is broken down into Hydro, Wind, Solar, Solid biofuels, and all other renewables. The next sector – Transport – is a key area in the energy transformation because itis responsible for a significant part of global greenhouse gas emissions. The introduction of renewable energy sources in this sector is aimed at reducing CO2 emissions, reducing pollution, and limiting mining resources. The renewable energy sources within this sector are biofuels (biodiesel, bioethanol), biogas, renewable hydrogen (green choice), and energy produced from organic and industrial waste. The third sector is Heating and Cooling, which includes heating or cooling energy production and supply. Renewable energy comes here from, among others, biomass, biogas, geothermal energy, heat pumps, solar collectors, wind turbines, and hydroelectric power plants. The Renewable Energy Directive (RED I, RED II) requirements regulate the development of renewable energy sources (RES) in the European Union. Their main goal is to promote the use of energy from renewable sources to achieve sustainable development, reduce greenhouse gas emissions, and increase energy security.

The electricity sector plays a key role in the energy transition and achieving renewable energy goals. For this reason, the study analyzed the share of renewable energy sources in Poland and the European Union. It determined the dynamics of changes in the share of renewable energy sources, taking into account the division into factors of the energy mix of the Electricity sector: wind, hydro, solar, and solar biofuels. Additionally, short-term forecasts were estimated, which may indicate actions to achieve the objectives of Directive (EU) 2018/2001. Considering these analyses will allow us to present the situation of Poland and the entire European Union in the context of the current possibilities of obtaining energy from renewable sources. It may also determine new action directions towards energy security, sustainable development, or reducing the negative environmental impact.

2. Analysis of the share of energy from renewable sources in the Electricity sector in Poland

Below is data obtained from Eurostat - the official statistical database of the European Union, which collects and provides statistical data on, among others, EU Member States. These data concern the electricity produced from renewable sources within the Electricity sector (Total (RES-E numerator)). The first part of the analysis includes data for Poland regarding the division of renewable sources within the electricity sector, the second part concerns the shares of the entire European Union, and the next part determines the location of Poland's shares in the European Union.

Table 1 presents data from 2004-2023 of the Electricity sector, divided into Hydro, Wind, Solar, Solid biofuels, and all other renewables (the data unit is ktoe, where one ktoe = 11.63 GWh).

Table 1.
The share of energy from renewable sources in the Electricity sector in Poland

	Hydro	Wind	Solar	Solid biofuels	All other renewables	Sum
2004	157.9462	10.00582	0	77.09966	7.401118	252.4528
2005	163.9889	17.47881	0	120.3654	9.5681	311.4012
2006	169.0568	27.95813	0	157.5813	13.76784	368.364
2007	172.5635	45.11882	0	202.9544	16.78538	437.4222
2008	177.9279	73.60088	0	289.1965	21.91548	562.6407
2009	182.1233	100.1006	0	421.6778	27.70482	731.6066
2010	188.7115	146.1987	0	507.7567	34.3319	876.9988
2011	191.8441	251.2468	0.015047	614.65	38.79037	1096.546
2012	193.4591	387.8161	0.098108	819.32	48.61204	1449.305
2013	195.4322	527.306	0.127429	682.0137	59.30499	1464.184
2014	197.9022	651.2055	0.592519	787.6358	70.18676	1707.523
2015	197.922	832.9722	4.870077	776.1513	77.93646	1889.852
2016	199.2501	1035.329	10.65133	594.3875	89.45168	1929.07

Cont. table 1.

2017	199.1066	1166.876	14.22726	456.4537	101.2122	1937.876
2018	200.943	1174.195	25.83732	458.5745	104.2688	1963.819
2019	200.6005	1224.5	61.10688	553.8394	106.6074	2146.654
2020	199.6951	1294.331	168.3505	596.1096	121.7237	2380.21
2021	199.8544	1422.026	338.3016	550.1651	142.9797	2653.327
2022	199.0943	1628.076	714.503	510.2406	145.9231	3197.837
2023	200.4808	1968.277	955.0377	490.5353	150.9079	3765.239

Source: https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

Based on the data presented in the table above, the share of energy from renewable sources is presented in Figure 1. On this basis, it is possible to determine the increasing trend of energy shares within the Electricity sector over the years 2004-2023.

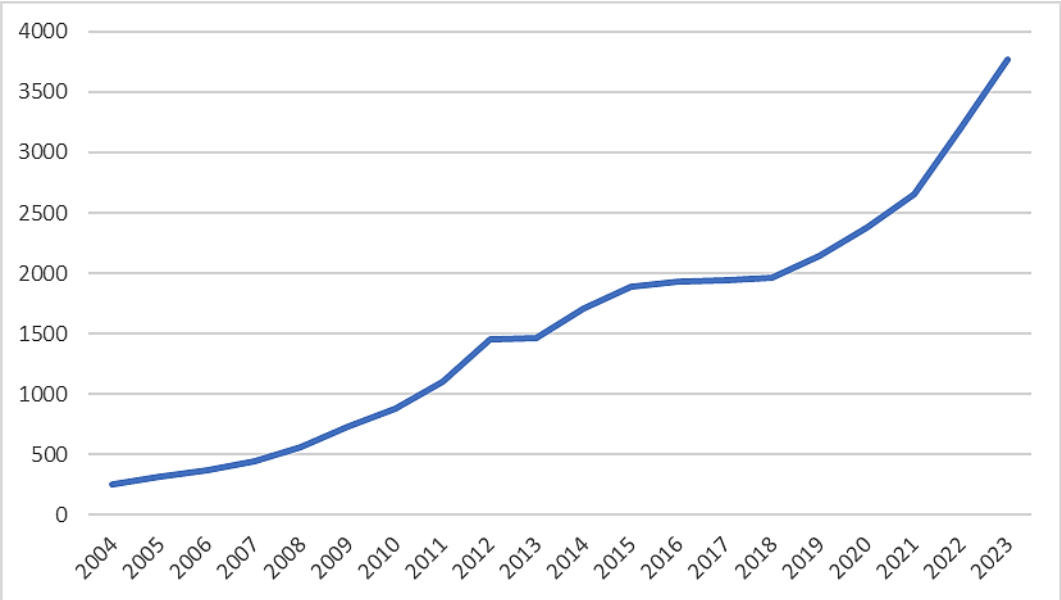

Figure 1. The share of energy from renewable sources in the Electricity sector in Poland.

Source: own study based on https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

Based on the chart above, significant increases can be observed yearly until 2012. After this period, until 2018, there was a period of slowdown in growth. Only after 2019 did the share increase return, but it was smaller than at the beginning of the analyzed period. The most significant increase in the share of energy occurred in 2019, recording an increase of 30.03% (an increase from 562.64 to 731.61 ktoe).

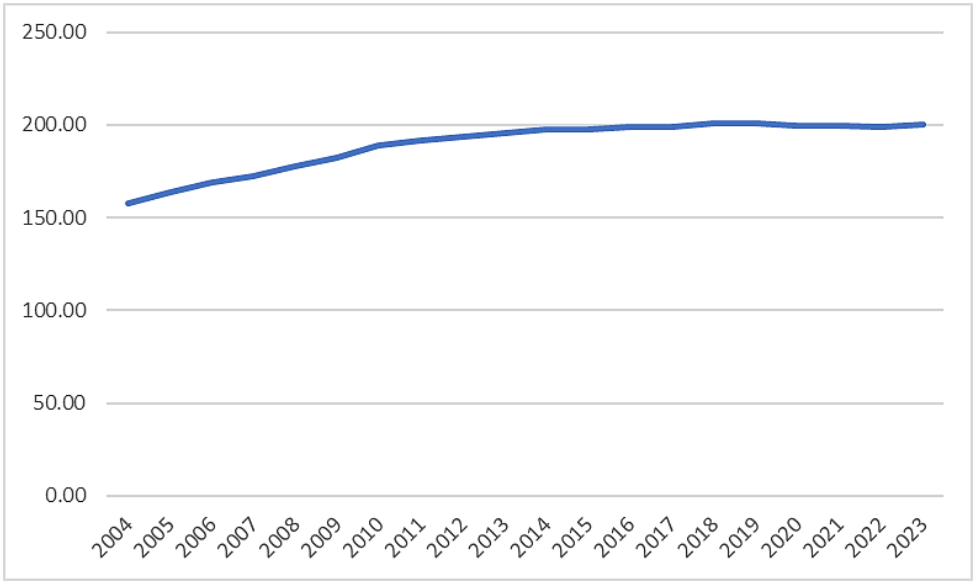

Figure 2. The share of energy from renewable sources as part of the Hydro source in Poland.

Source: own study based on https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

In the case of Hydro energy shares, from the beginning of 2023 can be observed (with a decreasing trend) until 2016. After this period, there were minimal year-to-year declines in Hydro energy shares. The most significant increase occurred in 2005 - 23.35% compared to 2004 (an increase from 157.95 to 163.99). From 2017 to 2022, there were decreases in shares or minimal increases - below 1%.

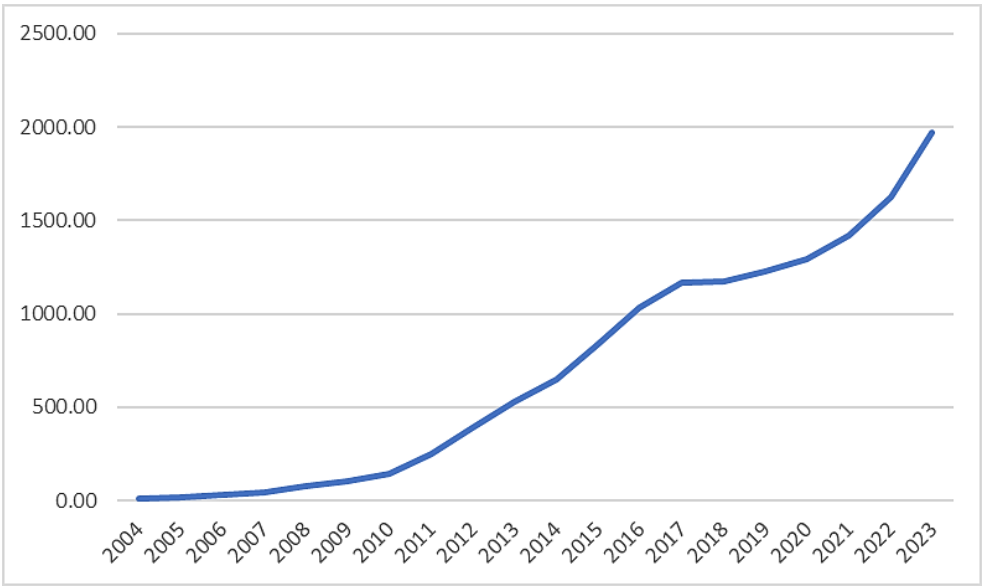

Figure 3. The share of energy from renewable sources as part of the Wind source in Poland.

Source: own study based on https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

An increase characterizes the share of energy in wind, which is quite uneven between the years 2004-2011, 2011-2018, and 2018-2023. The most significant increases can be observed in 2005 - an increase of 74.69% compared to 2004 (an increase from 10.01 to 17.48 ktoe) and

in 2011 – an increase of 71.85% in the share of energy compared to 2010 (an increase from 146.2 to 251.25 ktoe). The smallest increase took place in 2018 - an increase of 0.63% compared to 2017.

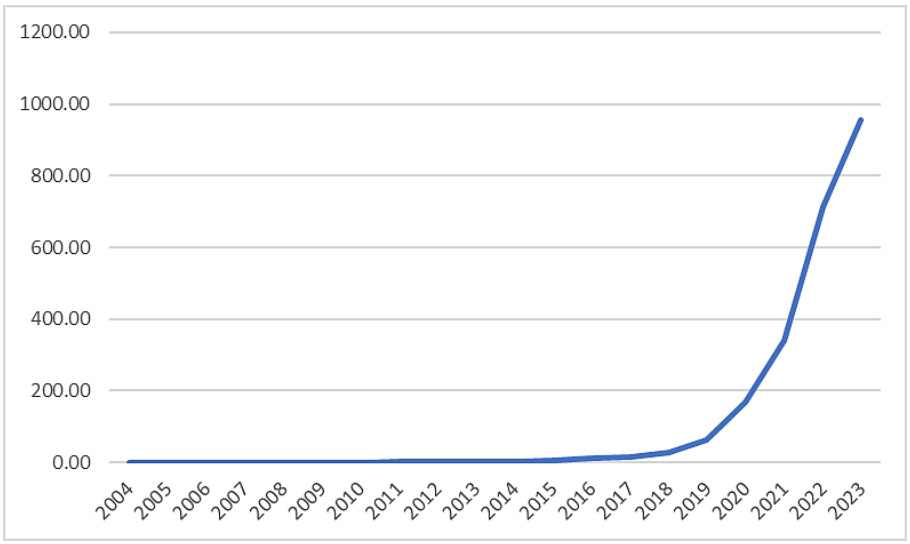

Figure 4. The share of energy from renewable sources as part of the Solar source in Poland.

Source: own study based on https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

The shares of energy from renewable sources under Solar were zero until 2010; the first indications of obtaining energy from this source were recorded only in 2011. A share increase can be observed during this period - from 0 in 2010 to 995.04 ktoe in 2023.

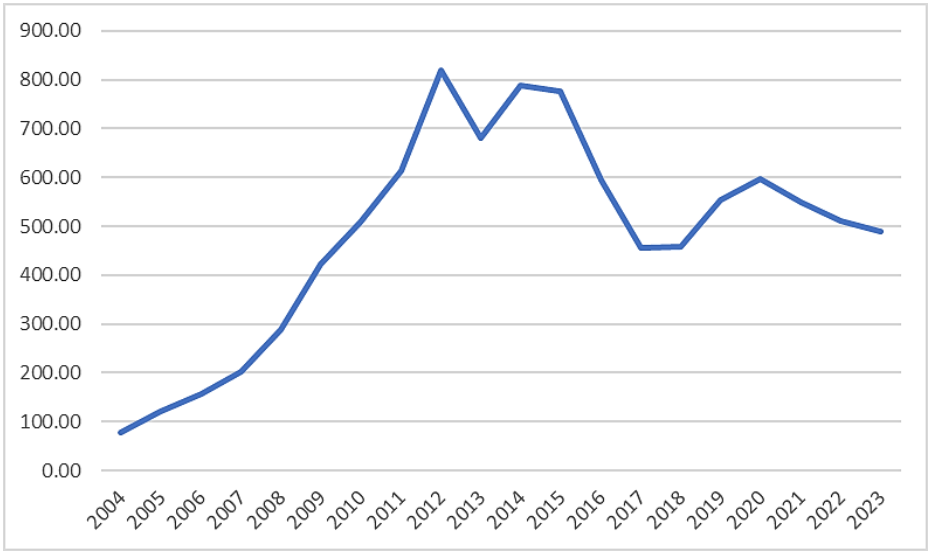

Figure 5. The share of energy from renewable sources solid biofuels in Poland.

Source: *own study based on* https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

The graph of the energy share from Solid biofuels shows an increase, reaching its maximum value in 2012 (819.32 ktoe). After this period, the energy share values started to decline and then stabilized with some fluctuations. The largest increase took place in 2005—an increase of 56.12% compared to 2004. The largest decrease in energy from Solid biofuels was recorded in 2016 - 23.42% compared to 2015.

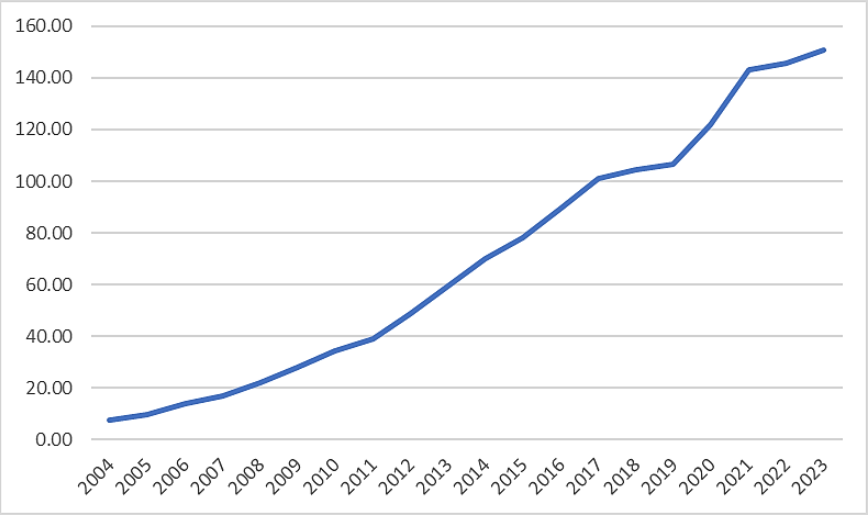

Figure 6. The share of energy from renewable sources as part of the All other renewable sources in Poland.

Source: own study based on https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

All other renewable energy shares are characterized by a gradual and quite regular increase from 7.40 to 150.91 ktoe. The largest increase took place in 2006—an increase of 43.89% compared to 2005.

Table 2 presents the shares of energy from renewable sources, divided into components of the electricity sector, and the estimated percentage changes from year to year are prese ted. The presented results can be used for a broader analysis compared to the analysis in Figure 1-6.

Table 2.
Values of shares of energy from renewable sources, along with the percentage change from year to year, divided into factors of the Electricity sector in Poland

Year	Electricity	percentage change	Hydro	percentage change	Wind	percentage change	Solar	percentage change	Solid biofuels	percentage change	All other renewables	percentage change
2004	252.45	-	157.95	-	10.01	-	0.00	-	77.10	-	7.40	-
2005	311.40	23.35%	163.99	3.83%	17.48	74.69%	0.00	-	120.37	56.12%	9.57	29.28%
2006	368.36	18.29%	169.06	3.09%	27.96	59.95%	0.00	-	157.58	30.92%	13.77	43.89%
2007	437.42	18.75%	172.56	2.07%	45.12	61.38%	0.00	-	202.95	28.79%	16.79	21.92%
2008	562.64	28.63%	177.93	3.11%	73.60	63.13%	0.00	-	289.20	42.49%	21.92	30.56%
2009	731.61	30.03%	182.12	2.36%	100.10	36.00%	0.00	-	421.68	45.81%	27.70	26.42%
2010	877.00	19.87%	188.71	3.62%	146.20	46.05%	0.00	-	507.76	20.41%	34.33	23.92%
2011	1096.55	25.03%	191.84	1.66%	251.25	71.85%	0.02	-	614.65	21.05%	38.79	12.99%
2012	1449.31	32.17%	193.46	0.84%	387.82	54.36%	0.10	552.00%	819.32	33.30%	48.61	25.32%
2013	1464.18	1.03%	195.43	1.02%	527.31	35.97%	0.13	29.89%	682.01	-16.76%	59.30	22.00%

Cont. table 2.

2014	1707.52	16.62%	197.90	1.26%	651.21	23.50%	0.59	364.98%	787.64	15.49%	70.19	18.35%
2015	1889.85	10.68%	197.92	0.01%	832.97	27.91%	4.87	721.93%	776.15	-1.46%	77.94	11.04%
2016	1929.07	2.08%	199.25	0.67%	1035.33	24.29%	10.65	118.71%	594.39	-23.42%	89.45	14.78%
2017	1937.88	0.46%	199.11	-0.07%	1166.88	12.71%	14.23	33.57%	456.45	-23.21%	101.21	13.15%
2018	1963.82	1.34%	200.94	0.92%	1174.20	0.63%	25.84	81.60%	458.57	0.46%	104.27	3.02%
2019	2146.65	9.31%	200.60	-0.17%	1224.50	4.28%	61.11	136.51%	553.84	20.77%	106.61	2.24%
2020	2380.21	10.88%	199.70	-0.45%	1294.33	5.70%	168.35	175.50%	596.11	7.63%	121.72	14.18%
2021	2653.33	11.47%	199.85	0.08%	1422.03	9.87%	338.30	100.95%	550.17	-7.71%	142.98	17.46%
2022	3197.84	20.52%	199.09	-0.38%	1628.08	14.49%	714.50	111.20%	510.24	-7.26%	145.92	2.06%
2023	3765.24	17.74%	200.48	0.70%	1968.28	20.90%	955.04	33.66%	490.54	-3.86%	150.91	3.42%

Source: own study based on https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

Based on the data presented in Table 1, forecasts for the share of energy from renewable sources in the Electricity sector were estimated for the following years. Due to the upward nature of the time series, an analytical model is presented. In order to compare the results, the analysis was based on five functions: linear, polynomial, power, logarithmic, and exponential. In the further part of the analysis, the error values described by the formulas were determined (1)-(4) (Zeliaś, Pawełek, Wanat, 2022).

a) Mean Absolute Error

$$\boldsymbol{MAE = \frac{1}{n} \cdot \sum_{i=1}^{n} |y_t - \hat{y}_t|} \tag{1}$$

b) Mean Absolute Percentage Error

$$\boldsymbol{MAPE = \frac{1}{n} \cdot \sum_{i=1}^{n} \left| \frac{y_t - \hat{y}_t}{y_t} \right| \cdot 100\%} \tag{2}$$

c) Root Mean Squared Error

$$\boldsymbol{RMSE = \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} (y_t - \hat{y}_t)^2}} \tag{3}$$

d) Root mean Squared Percentage Error

$$\boldsymbol{RMSPE = \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} \left(\frac{y_t - \hat{y}_t}{y_t} \right)^2} \cdot 100\%} \tag{4}$$

Table 3 below presents the values of the estimated forecasts for 2024-2028, the error values of these forecasts, the standard error of model estimation, and the coefficient of determination.

Table 3.

Forecasted values of energy shares from renewable sources along with estimated errors, standard error of model estimation, coefficient of determination for Poland

	Linear model	**Polynomial model**	**Power model**	**Logarithmic model**	**Exponential model**
Trend function	$\hat{y} = 163.17x - 157.13$	$\hat{y} = 3.91 \cdot x^2 + 81.14x + 143.63$	$\hat{y} = 155.47x^{0.97}$	$\hat{y} = 1062.8 \ln(x) - 693.6$	$\hat{y} = 301.25 \cdot e^{0.132x}$
Forecast 2024	3269.360	3570.121	2953.824	2542.120	4814.083
Forecast 2025	3432.526	3819.219	3089.754	2591.561	5493.225
Forecast 2026	3595.692	4076.129	3225.480	2638.804	6268.178
Forecast 2027	3758.858	4340.851	3361.012	2684.037	7152.456
Forecast 2028	3922.024	4613.385	3496.359	2727.422	8161.483
MAE	163.520	147.332	168.264	358.914	262.033
MAPE	15.72%	9.85%	13.41%	47.75%	18.00%
RMSE	218.898	185.807	266.016	473.682	317.827
RMSPE	26.18%	11.11%	17.63%	93.01%	19.87%

Cont. table 3.

Standard error of model estimation	230.739	201.535	280.405	499.305	335.019
Coefficient of determination	0.9487	0.963	0.9469	0.7595	0.9343

Source: own study based on https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

Based on the estimated forecast errors, the polynomial model shows the minor errors for all measures: MAE = 147.332 ktoe (the forecast values differ on average by about 147.332 ktoe from the actual values), MAPE = 9.85% (the average forecast error of the model is approximately 9.85% of the actual energy share values), RMSE = 185.807 ktoe (on average, the forecasts differ from the actual values by approximately 185.807 ktoe), RMSPE = 11.11% (on average, this model's forecasts differ from the actual values by 11.11%), which suggests that it fits the data best. In terms of the MAE error and RMSE error values, the linear model obtained the second lowest value - MAE = 163.52, RMSE = 218.898, and the power model had the third lowest value - MAE = 168.264, RMSE = 266.016. Due to the MAPE and RMSPE error, the second smallest value was obtained for the power model: MAPE = 13.41%, RMSPE = 17.63%, while the third smallest value of the MAPE and RMSPE error was obtained for the linear model: MAPE = 15.72%, RMSPE = 26.18%. The logarithmic and exponential models obtained the poorest results due to the errors adopted for model evaluation, the standard error of model estimation, and the coefficient of determination.

3. Analysis of the share of energy from renewable sources in the Electricity sector in the European Union

The rest of the article is devoted to analyzing the shares of energy from renewable sources in the Electricity sector throughout the European Union. Table 4 below presents the share of individual energy sources within the analyzed Electricity sector.

Table 4.
The share of energy from renewable sources in the Electricity sector in UE

Year	Hydro	Wind	Solar	Solid biofuels	All other renewables	Sum
2004	29209.01	4783.324	59.40782	3116.968	1936.829	39105.54
2005	29309.81	5733.508	125.4246	3489.555	2263.442	40921.74
2006	29180.54	6783.305	214.0559	3883.316	2649.352	42710.57
2007	29259.99	8180.863	324.5509	4098.627	3183.681	45047.72
2008	29202.98	9568.501	639.5203	4572.556	3534.408	47517.97
2009	29308.17	10978.45	1212.724	4930.917	3945.422	50375.68
2010	29628.52	12442.35	1996.91	5587.447	4530.596	54185.83
2011	29632.79	13968.62	4066.082	5772.239	5012.31	58452.04
2012	29507.67	15574.03	6034.099	6196.926	5760.286	63073.01
2013	29516.8	17280.99	7231.683	6062.111	6439.401	66530.98

Cont. table 4.

2014	29462.78	18995.78	8097.036	6080.291	6906.297	69542.18
2015	29663.73	21455.14	8672.237	6194.86	7262.37	73248.33
2016	29596.59	23384.59	8687.407	6223.371	7392.303	75284.26
2017	29462.59	25710.3	9280.453	6385.329	7459.23	78297.89
2018	29559.81	27524.33	9718.66	6556.527	7447.706	80807.04
2019	29509.63	29954.82	10643.44	6926.871	7460.777	84495.53
2020	29685.34	32367.68	12465.55	7139.495	7512.742	89170.81
2021	29817.04	34930.84	14123	7499.54	7651.319	94021.73
2022	29673.64	37263.96	18106.02	6869.266	7465.675	99378.56
2023	27724.68	38256.98	20801.75	5590.294	6813.437	99187.14

Source: https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of% 20renewable%20energy%20sources%20.

Figure 7 presents the total share of energy from renewable sources. Visual analysis allows us to determine the increasing nature of the energy share over the years 2004 - 2023, with some random fluctuations.

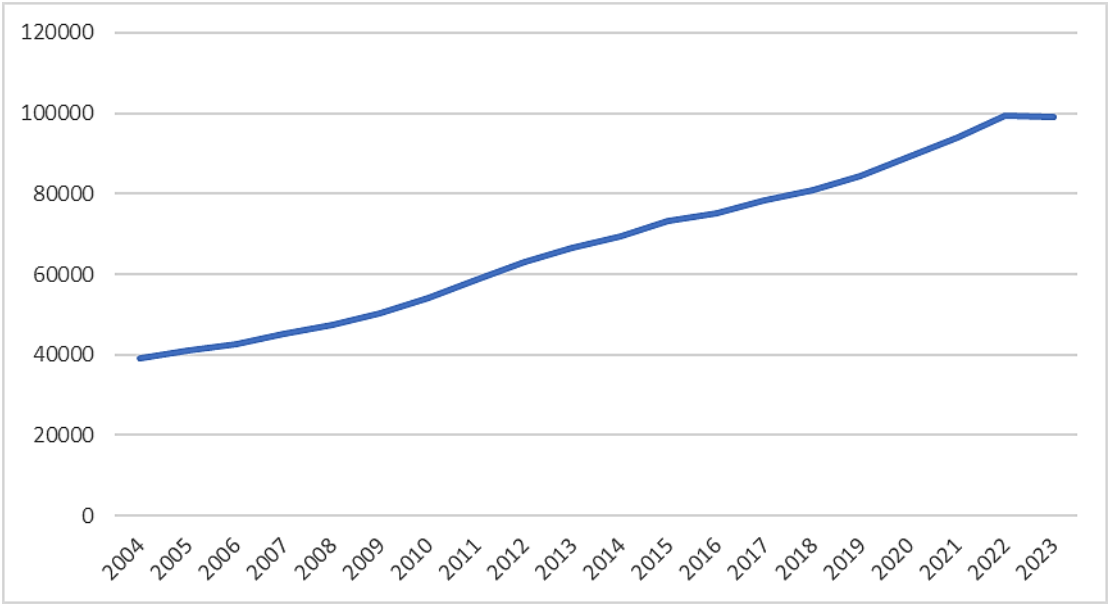

Figure 7. The share of energy from renewable sources in the Electricity sector in UE.

Source: *own study based on* https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short% 20assessment%20of%20renewable%20energy%20sources%20.

Based on the visual assessment and determining the increasing nature of the data, an analytical model was proposed to forecast the share of energy from renewable sources in the Electricity sector for the years 2024-2028. The analysis was based on five functions: linear, polynomial, power, logarithmic, and exponential. Table 5 presents the calculated forecast values based on the mentioned trend line functions, error values, standard error of model estimation, and coefficient of determination.

Table 5.
Forecasted values of the shares of energy from renewable sources within the Electricity sector along with estimation errors, standard error of model estimation, and coefficient of determination for the EU

	Linear model	**Polynomial model**	**Power model**	**Logarithmic model**	**Exponential model**
Trend function	$\hat{y} = 3342.6x + 32470$	$\hat{y} = 28.274x^2 + 2748.9x + 34647$	$\hat{y} = 30447x^{0.35}$	$\hat{y} = 22190\ln(x) + 20596$	$\hat{y} = 37712 \cdot e^{0.05x}$
Forecast 2024	102665.377	104842.457	90057.249	88154.332	111050.566
Forecast 2025	106008.010	108807.113	91561.972	89186.612	116911.173
Forecast 2026	109350.644	112828.317	93023.280	90172.998	123081.070
Forecast 2027	112693.277	116906.068	94444.235	91117.397	129576.578
Forecast 2028	116035.910	121040.366	95827.566	92023.237	136414.882
MAE	1217.811	1124.493	4726.478	6650.212	1759.675
MAPE	2.08%	1.80%	7.53%	11.26%	2.60%
RMSE	1530.827	1281.294	5864.219	8055.092	2253.087
RMSPE	2.84%	2.10%	9.38%	15.09%	3.08%
Standard error of model estimation	1613.634	1389.759	6181.430	8490.813	2374.963
Coefficient of determination	0.9937	0.9956	0.8956	0.8264	0.9893

Source: *own study based on* https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

Analyzing the values of the errors obtained, the polynomial model shows the best fit: MAE = 1124.493 ktoe (the predicted values differ on average by about 1124.493 ktoe from the actual values), MAPE = 1.80% (the average error of the model forecasts is about 1.80% of the actual values of the energy share, this is very low error rate, suggesting that this model's predictions are accurate), RMSE = 1281.294 ktoe (on average, the forecasts differ from the actual values by approximately 1281.294 ktoe) and RMSPE = 2.10% (the forecasts of this model on average differ from the actual values by 2.10% - a very low level of error). Guided by the error minimization criterion, the forecast values of the share of energy from renewable sources within the Electricity sector are: 104842.457 ktoe (2024), 108807.113 ktoe (2025), 112828.317 ktoe (2026), 116906.068 ktoe (2027), 121040.366 ktoe (2028). The second model with the lowest error value is the linear model with error values at the following levels: MAE = 1217.811, MAPE = 2.08%, RMSE = 1530.827 and RMSPE = 2.84%. The third model with the most minor errors is the exponential model: MAE = 1759.675, MAPE = 2.60%, RMSE = 2253.087 and RMSPE = 3.08%. The logarithmic model achieved the highest error values.

Table 6.
The relative share of energy obtained from renewable sources in Poland to the share of energy obtained in the EU

	Hydro	Wind	Solar	Solid biofuels	All other renewables
2004	0.541%	0.209%	0.000%	2.474%	0.382%
2005	0.560%	0.305%	0.000%	3.449%	0.423%
2006	0.579%	0.412%	0.000%	4.058%	0.520%
2007	0.590%	0.552%	0.000%	4.952%	0.527%
2008	0.609%	0.769%	0.000%	6.325%	0.620%
2009	0.621%	0.912%	0.000%	8.552%	0.702%
2010	0.637%	1.175%	0.000%	9.087%	0.758%
2011	0.647%	1.799%	0.000%	10.648%	0.774%
2012	0.656%	2.490%	0.002%	13.221%	0.844%
2013	0.662%	3.051%	0.002%	11.250%	0.921%
2014	0.672%	3.428%	0.007%	12.954%	1.016%
2015	0.667%	3.882%	0.056%	12.529%	1.073%
2016	0.673%	4.427%	0.123%	9.551%	1.210%
2017	0.676%	4.539%	0.153%	7.148%	1.357%
2018	0.680%	4.266%	0.266%	6.994%	1.400%
2019	0.680%	4.088%	0.574%	7.996%	1.429%
2020	0.673%	3.999%	1.351%	8.349%	1.620%
2021	0.670%	4.071%	2.395%	7.336%	1.869%
2022	0.671%	4.369%	3.946%	7.428%	1.955%
2023	0.723%	5.145%	4.591%	8.775%	2.215%

Source: *own study based on* https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20

Below, in Figure 8, Poland's share in energy obtained from renewable sources in the Electricity sector, divided into energy sources, is visualized compared to the entire EU. The relative share of Poland's energy from the hydro source increased in subsequent years of the analyzed period, but it did not exceed 0.8% in any year (the largest share in 2023 at 0.723%). Poland's share of wind sources also shows an upward trend, but it is characterized by a higher percentage share: from 0.209% in 2004 to 5.145% in 2023. Obtaining energy from solar sources in Poland looks unfavorable because the energy level will be zero by 2010. After this period, there was an increase to 4.591% in 2023 (slightly less than the Wind source). The percentage share of energy from solid biofuels varies significantly. After an increase of 12.954% in 2014, it decreased to 9.551%, and the relative share remained at 6.994% - 8.775%. The relative share of energy from All other renewables showed an increasing trend, reaching the highest percentage level of 2.215%. It seems reasonable to extend the analysis of the achieved shares of energy from renewable sources about the actions taken or changes introduced by the authorities dealing with energy in Poland in order to better determine the trend in changes in the amount of energy obtained.

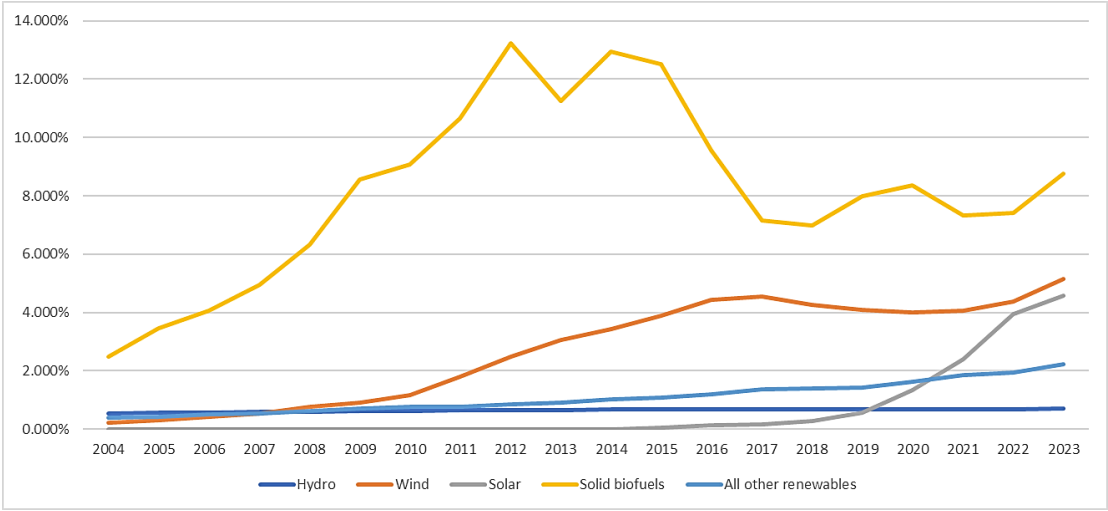

Figure 8. The relative share of energy obtained from renewable sources in Poland to the share of energy obtained in the EU.

Source: *own study based on* https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20.

4. Summary

Poland and the European Union consistently increase their share of renewable energy in the electricity sector. The analysis of the share of energy in Poland within RES indicates an increase in the share in hydro, wind, solar, and only solid biofuels after 2012, continuing the downward trend until 2017 and remaining at this level until 2023. Poland's share compared to the European Union:

- Poland took 10th place in the relative share of energy within the Electricity sector at the level of 2.82% (the most significant shares were Germany 22.83%, Spain 11.44% and France 11.44%),
- in 2022, Poland ranked 9th with a relative share of 3.22% (the most significant shares were Germany 22.61%, Spain 11.81% and France 11.43%),
- in 2023, Poland was in 8th place with a share of 3.8% (the most significant shares were Germany 23.35%, Spain 13.12% and France 12.21%).

For Poland to improve its situation in the context of renewable energy, it should take specific actions in various areas of energy, regulatory and investment policy, and the development of new technologies. It should also consider financial support and education.

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