IBIMA Publishing
Communications of International Proceedings
https://ibimapublishing.com/p-articles/47NRG/2026/4717826/
Vol. 2026 (4), Article ID 4717826

Geopolitical Shocks and The Acceleration of Energy Transition. A Segmented Trend Analysis of Renewable Energy Deployment in France, Germany, Italy, And Poland (2004-2024)*

Arkadiusz WEREMCZUK and Leonard MILEWSKI

[1]Warsaw University of Life Sciences-SGGW
Department of Economics and Economic Policy, Institute of Economics and Finance
Nowoursynowska 166, 02-787 Warsaw, Poland
https://orcid.org/0000-0002-6839-8508

[2]University of Economics and Technology,
Jutrzenki 135, 02-231 Warsaw, Poland,
https://orcid.org/0000-0002-3742-5198

Correspondence should be addressed to: Arkadiusz WEREMCZUK, arkadiusz_weremczuk@sggw.edu.pl

*Presented at the 47th IBIMA International Conference, 29-30 June 2026, Madrid, Spain

Abstract

The 2022 invasion of Ukraine reframed renewable deployment in Europe as a question of energy security and sovereignty rather than only climate policy, prompting claims that geopolitical shocks accelerate the transition. Whether this rhetorical shift translated into a measurable change in the pace of renewable rollout — and whether the earlier 2014 Crimea shock did so - remains an open empirical question with direct relevance for REPowerEU and post-Green Deal policy design. Existing studies rely largely on policy reviews, investor surveys, or simple before-and-after comparisons of renewable shares. Such approaches conflate three distinct channels that can move the share simultaneously: faster renewable deployment, falling total energy consumption, and the 2021 RED I to RED II methodological revision. Few studies disentangle these forces using harmonised long-run series with explicit structural breaks. Using the harmonised SHARES 2024 dataset for France, Germany, Italy, and Poland over 2004–2024 (84 country-year observations), we estimate country-specific segmented trend models with ex ante breaks in 2014 and 2022 and a level shift for the 2021 methodological change. Models are fitted by OLS with HAC (Newey–West) standard errors for the renewable numerator, denominator, logit-transformed share, and three sectoral components (electricity, heating and cooling, transport). We find no common post-2022 acceleration. Only France re-accelerates in aggregate; Germany continues to decelerate; Italy shows no significant break; Poland slows sharply overall, although its renewable electricity expands rapidly while heating and cooling collapses. Rising shares often reflect falling consumption rather than faster deployment, suggesting Europe's transition is a multi-speed phenomenon shaped by national context.

Keywords: European Green Deal, RED I/RED II targets, renewable energy transition, geopolitical shocks

Introduction

Starting in the early 2000s, Europe pushed renewables mainly to fight climate change, link markets, improve technology. Over time, though, global tensions began shifting priorities. After 2014, security risks grew -

Cite this Article as: Arkadiusz WEREMCZUK and Leonard MILEWSKI Vol. 2026 (4) "Geopolitical Shocks and The Acceleration of Energy Transition. A Segmented Trend Analysis of Renewable Energy Deployment in France, Germany, Italy, And Poland (2004-2024)" Communications of International Proceedings, Vol. 2026 (4), Article ID 4717826, https://doi.org/10.5171/2026.4717826

especially with Russia's actions stirring alarm. Then came the 2022 invasion of Ukraine, which hit hard: energy prices swung wildly, reliance on imports suddenly seemed dangerous. Because of this, clean power stopped being just about emissions. Instead, it started standing for stability, self-reliance, control over national systems. Scholars now see green energy as part of broader defense, less dependency, stronger independence (Goldthau & Youngs, 2023; Hille, 2023; Kuzemko et al., 2022; Proedrou, 2023; Tesfu, 2024; Vasylieva et al., 2025; Zolotarova & Lukash, 2025). Scholarship increasingly suggests geopolitical disruptions boost renewable energy adoption, mainly because local power options become more appealing when global tensions rise. Because of this shift, policies favoring wind, solar, batteries, heat pumps, and similar clean solutions gained momentum after 2022, especially within Europe. Seen another way, security concerns began shaping climate strategies around that time, evident in programs like REPowerEU and various national moves to cut reliance on Russian fossil supplies (Goldthau & Youngs, 2023; Pavlenko & Cherp, 2025). Yet findings show these shifts do not follow a straight path, nor unfold the same everywhere. For some nations, sudden shortages led to brief returns to coal, expanded LNG imports, or extended use of existing nuclear plants just to keep lights on. Meanwhile, different obstacles emerged elsewhere - strained electricity networks, limited storage capacity, scarce raw materials, and slow permitting processes slowed progress down (Borowski, 2022; Herranz-Surrallés, 2024; Jing, 2023; Kosowski, 2024; Urbano et al., 2023). So even though international crises push many governments toward faster green transitions, actual outcomes differ widely depending on context and readiness. Such variety matters most when looking at Europe. Lately, studies portray the continent's shift toward clean energy as uneven - moving at different speeds country by country, shaped less by shared goals than by differences in governance strength, natural advantages, grid conditions, market setups, and policy choices (Perez et al., 2019; Sattich et al., 2022). Findings on disparities inside EU regions now show overall gains can happen alongside lasting geographic divides - not just between nations, but within them too, revealing how joint objectives rarely produce uniform change(Weremczuk et al., 2025; Weremczuk & Milewski, 2025). That view holds special weight when tracking renewable metrics, since comparable rises in green energy shares might stem from distinct causes: rapid additions of wind or solar, shrinking demand, or some mix. So what needs testing isn't merely if renewables grew, rather whether their rollout quickened precisely when global tensions shifted dramatically. Particular concerns stand out when looking at France, Germany, Italy, and Poland - each showing different ways of organizing energy across the EU. Although Germany already had a well-developed Energiewende approach, it moved faster during the latest crisis by simplifying permit processes, pushing forward wind projects, while seeing notable increases in rooftop solar, household battery systems, and electric heating units (Maliszewska-Nienartowicz, 2024; Thimet & Mavromatidis, 2022; Van Ouwerkerk et al., 2024). Meanwhile, France continues to rely heavily on nuclear-generated electricity, meaning adjustments in how power flows - and coordination between atomic plants and green sources - shape much of its current planning (Lebrouhi et al., 2022; Thimet & Mavromatidis, 2022).). In Italy's situation, favorable conditions exist for sun- and wind-based generation, yet inconsistent rules and scattered decision-making have led to bursts of progress followed by stretches of delay (Ahmed et al., 2025; Esposito & Romagnoli, 2023; Frilingou et al., 2023). As for Poland, dependence on coal still defines its past, however installations of clean technologies - particularly photovoltaic arrays and turbines - have grown quickly even with outdated infrastructure, legal hurdles, and deep-rooted obstacles; alongside these shifts, plant-derived fuel maintains a role in altering the country's energy makeup (Aydin et al., 2024; Bórawski et al., 2022; Kazak et al., 2023; Kulpa et al., 2022; Weremczuk, 2025). Geopolitical disruptions likely influence renewable energy growth, given what studies have shown so far - yet two gaps remain in how we analyze them. While recent findings emphasize policy shifts or investor reactions following events after 2022, they often miss broader patterns showing whether such shocks changed the pace of renewable rollout over extended periods. Another point: rising percentages of renewables in the mix might reflect shrinking overall energy demand during downturns, not actual expansion in clean infrastructure. When markets face strain, this difference becomes central to accurate interpretation. Because of this, newer research examining trends through structural break tests - and focusing on system resilience - argues against drawing conclusions solely from start-and-end comparisons across time (Weremczuk & Grębowiec, 2025). Looking back at these events, the study explores how the geopolitical disruptions in 2014 and 2022 linked to shifts in renewable energy patterns across France, Germany, Italy, and Poland between 2004 and 2024. Based on standardised SHARES figures, a split trend approach helps separate impacts related to numerators, denominators, and overall shares - while also broadening scrutiny to power, thermal uses, and mobility sectors. Throughout, adjustments account for changes in measurement methods that emerged in 2021.

Materials and Methods

Looking back at two decades, the research checks if big global political events linked to shifts in how fast renewables spread across four European nations. Data comes straight from national records between 2004 and 2024, pulled from a specific section of the SHARES 2024 report labeled "Summary results." Instead of forecasts or projections, only actual yearly figures make it into the analysis - future estimates found in the file stay out. From France to Poland, each nation contributes an equal number of time points, forming a clean set of information. Altogether, that adds up to 84 distinct entries, one per country every year, making comparisons more stable. Though gathered from shared sources, values stand separate, tied closely to real policy movements during moments of world tension.

Each country-year draws data from labeled series within the workbooks. Indicators on renewable energy use - standardised across nations - are available through the SHARES database. These metrics reflect renewables' share in total final energy consumption:

- Total (RES numerator),
- Total (RES denominator),
- RES [%],
- (a) electricity,
- (b) heating and cooling,
- (c) transport.

Fractional forms appear in the data, even though labels show percent signs - this format shapes how models interpret them. Handling stays consistent because decimal values fall strictly between zero and one.

A notable aspect of the dataset appears in the shift in methodology recorded between 2020 and 2021. Although earlier figures through 2020 rely on guidelines set by Directive 2009/28/EC (RED I), those beginning in 2021 apply updated criteria under Directive (EU) 2018/2001 (RED II), as noted in the SHARES records. Because of this transition, the analysis includes a specific adjustment for the regulatory update at 2021 - drawing conclusions beyond that point only tentatively.Outcome variables and transformations

The main dependent variable is the total volume of renewable energy entering gross final energy consumption:

$$R_{i,t} > 0,$$

where $R_{i,t}$ denotes Total (RES numerator) for country i in year t, measured in ktoe.

The baseline specification uses the natural logarithm:

$$y_{i,t} = \ln(R_{i,t}).$$

This transformation is appropriate because the series is strictly positive for all observations and because the time-trend coefficients can be interpreted as approximate proportional growth rates in renewable energy deployment.

To distinguish changes in physical deployment from changes in the share measure, the overall renewable energy share is analysed as a secondary outcome:

$$S_{i,t} \in (0,1),$$

where $S_{i,t}$ corresponds to RES [%] expressed as a fraction.

Because $S_{i,t}$ is bounded, the preferred transformation is the logit:

$$z_{i,t} = \ln\left(\frac{S_{i,t}}{1 - S_{i,t}}\right).$$

As an additional robustness check, the logarithm of the share is also considered:

$$\ell_{i,t} = \ln(S_{i,t}).$$

The use of both deployment and share measures is methodologically important. A rise in the renewable share may reflect faster growth of renewable energy, a decline in total energy use, or a combination of both. For this reason, the main interpretation of "acceleration" is based on $R_{i,t}$, while $S_{i,t}$ is used as a supplementary indicator.

To separate numerator-driven from denominator-driven changes, the segmented trend analysis is also applied to:

$$D_{i,t} = \text{Total (RES denominator)},$$

using the transformation:

$$d_{i,t} = \ln(D_{i,t}).$$

Estimating the models for $y_{i,t}$, $d_{i,t}$, and $z_{i,t}$ makes it possible to determine whether any post-shock increase in the renewable share reflects accelerated renewable deployment, changes in total gross final energy consumption, or both.

As an extension, the same framework is estimated for sector-specific renewable deployment:

- electricity: $R^{E}_{i,t}$, corresponding to (a) electricity,
- heating and cooling: $R^{HC}_{i,t}$, corresponding to (b) heating and cooling,
- transport: $R^{T}_{i,t}$, corresponding to (c) transport.

Because these series are strictly positive throughout the estimation sample, they are modelled in logarithms:

$$y^{E}_{i,t} = \ln(R^{E}_{i,t}), \quad y^{HC}_{i,t} = \ln(R^{HC}_{i,t}), \quad y^{T}_{i,t} = \ln(R^{T}_{i,t}).$$

This sectoral decomposition allows the analysis to identify whether any change in trend was broad-based or concentrated in a particular segment of the energy system.

Segmented trend design

The empirical strategy is based on a segmented trend model that tests whether the slope of renewable energy deployment changed around two ex ante defined geopolitical turning points:

- 2014, associated with the post-Crimea deterioration of the European geopolitical environment,
- 2022, associated with the full-scale Russian invasion of Ukraine and the subsequent energy-security shock.

To operationalise the segmented trend, let:

$$T_t = t - 2004,$$

so that $T_t = 0$ in 2004, $T_t = 1$ in 2005, and so forth. Two slope-change variables are then defined as:

$P_{2014,t} = \max(0, t - 2014)$, $P_{2022,t} = \max(0, t - 2022)$.

These variables equal zero prior to the respective break year and increase linearly thereafter. The specification therefore allows the post-2014 and post-2022 slopes to differ from the pre-2014 baseline trend.

In addition, a dummy variable is introduced to account for the documented 2021 change in SHARES methodology:

$$M_t = \begin{cases} 1 & \text{for } t \geq 2021, \\ 0 & \text{for } t \leq 2020. \end{cases}$$

This term is included as a level shift rather than as an unrestricted structural break in slope, because its primary function is to absorb the change in measurement regime between RED I-based and RED II-based calculations.

Country-specific segmented trend model

The principal specification is estimated separately for each country:

$$y_{i,t} = \alpha_i + \beta_{1i} T_t + \beta_{2i} P_{2014,t} + \beta_{3i} P_{2022,t} + \theta_i M_t + \varepsilon_{i,t}.$$

In this formulation:

- α_i is the country-specific intercept,
- β_{1i} is the baseline annual trend in 2004-2014,
- β_{2i} captures the change in slope after 2014,
- β_{3i} captures the additional change in slope after 2022,
- θ_i captures the level shift associated with the 2021 methodological change.

The implied annual slopes for the three segments are:

$\text{slope}_{2004\text{-}2014} = \beta_{1i}$, $\text{slope}_{2015\text{-}2022} = \beta_{1i} + \beta_{2i}$, $\text{slope}_{2023\text{-}2024} = \beta_{1i} + \beta_{2i} + \beta_{3i}$.

Given the annual coding of the piecewise variables, the post-2022 coefficient is interpreted as the incremental change in trend associated with the 2022 geopolitical shock. Evidence of acceleration in renewable deployment is supported when:

$$\beta_{3i} > 0.$$

A negative value of β_{3i} indicates deceleration, whereas a statistically indistinguishable coefficient suggests no detectable change in trend.

The same specification is estimated for:

- $y_{i,t} = \ln(\text{Total (RES numerator)})$ as the baseline model,
- $d_{i,t} = \ln(\text{Total (RES denominator)})$,
- $z_{i,t} = \text{logit(RES share)}$,
- $y_{i,t}^{E}$, $y_{i,t}^{HC}$, and $y_{i,t}^{T}$ for the sectoral extension.

Comparative pooled specification

To complement the country-specific results, a pooled four-country model with country fixed effects is estimated:

$$y_{i,t} = \alpha + \mu_i + \beta_1 T_t + \beta_2 P_{2014,t} + \beta_3 P_{2022,t} + \theta M_t + u_{i,t},$$

where μ_i denotes country fixed effects capturing time-invariant cross-country differences in scale, energy structure, geography, and institutional context.

Because the main research interest concerns whether countries followed different post-shock trajectories, a richer specification allows heterogeneous slope changes by country:

$$\begin{aligned} y_{i,t} = \alpha + \mu_i + \beta_1 T_t + \sum_{j=1}^{3} \gamma_j \left(C_{j,i} \times T_t\right) + \beta_2 P_{2014,t} + \sum_{j=1}^{3} \delta_j \left(C_{j,i} \times P_{2014,t}\right) + \beta_3 P_{2022,t} \\ + \sum_{j=1}^{3} \phi_j \left(C_{j,i} \times P_{2022,t}\right) + \theta M_t + u_{i,t}, \end{aligned}$$

where $C_{j,i}$ are country indicators, with one country omitted as the reference category. This specification makes it possible to test whether France, Germany, Italy, and Poland differed in their baseline trends and in their post-2014 and post-2022 trend changes.

Given the four-country panel, the pooled model is used primarily for comparative description, while inferential emphasis is placed on the country-specific time-series estimations. Country-specific segmented trend models are estimated by OLS with HAC (Newey–West) standard errors to account for plausible serial correlation and heteroskedasticity in short annual series. Pooled specifications are estimated by OLS with country fixed effects and treated as a secondary check rather than the main basis for substantive inference. The segmented trend framework is interpreted as an interrupted-trend design rather than a fully structural causal model, so the results are read as evidence of trend acceleration, deceleration, or stability associated with geopolitical shocks, not as exact causal effects.

Robustness strategy

The robustness analysis follows five steps.

First, the segmented trend model is estimated using alternative dependent variables:

1. $\ln(\text{Total (RES numerator)})$ as the baseline deployment measure,
2. $\text{logit}(\text{RES share})$ as the preferred bounded-share specification,
3. $\ln(\text{RES share})$ as an additional transformation check.

Second, the numerator and denominator are analysed separately. This decomposition verifies whether changes in the renewable share stem from stronger renewable deployment, lower total gross final energy consumption, or both.

Third, the models are re-estimated for the three sectoral components: electricity, heating and cooling, and transport. This permits identification of sector-specific acceleration patterns.

Fourth, sensitivity to the 2021 methodological discontinuity is assessed by estimating:

- the baseline specification with the post-2021 dummy M_t,
- a restricted specification excluding 2021,
- and descriptive pre-break and post-break summaries for 2004-2020 and 2021-2024.

Fifth, the substantive conclusions are considered robust only if the sign and general magnitude of the post-2014 and post-2022 slope changes are qualitatively consistent across the deployment, denominator, and share-based specifications.

Results

From 2004 to 2024, data were collected yearly on four nations, producing 84 total country-year entries. Though each nation saw strong growth in renewable energy, how fast and how it unfolded was far from uniform. Renewable capacity expanded beyond double everywhere - France rose 117.3%, Germany jumped 210.8%. Italy recorded an increase of 158.4%; Poland reached 210.1%. Yet shifts in the baseline measure behind the RES metric varied significantly between these economies. Energy use dropped sharply in France - down 12.8 percent - while Germany saw a steeper fall at 14.2 percent, followed by Italy with a 15.7 percent reduction; yet Poland moved opposite, recording a rise of 20.1 percent. Despite these shifts, each country expanded its reliance on renewables: France jumped from 9.319 to 23.229 percentage points. Germany's share climbed from 6.207 up to 22.474, whereas Italy advanced from 6.316 to 19.370. Poland, even amid higher consumption, pushed its renewable portion from 6.882 to 17.770.

Table 1. Endpoint comparison, 2004 vs 2024

Country	RES numerator 2004 (ktoe)	RES numerator 2024 (ktoe)	Change numerator (%)	RES denominator 2004 (ktoe)	RES denominator 2024 (ktoe)	Change denominator (%)	RES share 2004 (%)	RES share 2024 (%)	Change share (pp)
France	15,327.7	33,299.8	117.3	164,480.2	143,355.9	-12.8	9.319	23.229	13.910
Germany	14,244.2	44,270.9	210.8	229,493.6	196,985.0	-14.2	6.207	22.474	16.267

Country	RES numerator 2004 (ktoe)	RES numerator 2024 (ktoe)	Change numerator (%)	RES denominator 2004 (ktoe)	RES denominator 2024 (ktoe)	Change denominator (%)	RES share 2004 (%)	RES share 2024 (%)	Change share (pp)
Italy	8,680.9	22,432.4	158.4	137,445.1	115,807.1	-15.7	6.316	19.370	13.055
Poland	4,209.3	13,051.4	210.1	61,161.9	73,446.2	20.1	6.882	17.770	10.888

Source: Author's own calculations based on the integrated RES dataset (2004-2024).

To begin with, researchers analyzed trends in renewable energy growth individually per nation based on the natural log of total RES values. Following that, changes in slope were introduced into the model specifically for periods after 2014 and beyond 2022. Meanwhile, a separate adjustment accounted for sudden shifts between 2021 and 2024 due to revisions in how data was collected. Although all nations showed steady increases prior to 2014, patterns diverged afterward. For instance, France experienced consistent expansion before 2014, marked by an estimate of 0.0448 at high significance. Then again, its pace dipped slightly yet noticeably following 2014, registering a decline of 0.0140. Yet starting in 2022, upward momentum resumed - this time rising by 0.0160 with strong statistical support. On the contrary, Germany started stronger than others, growing at 0.0726 annually before 2014. Despite this head start, progress weakened sharply once past 2014, dropping by nearly 0.0469. Even so, from 2022 onward, movement turned more downward - but just barely crossing conventional thresholds for confidence. Before 2014, Italy saw steady growth - its rise clear in the numbers (\beta_1=0.0787, p<0.001). After that point, progress slowed sharply (\beta_2=-0.0842, p<0.001). Since 2022, changes have been minimal, barely registering at all (\beta_3=0.0073, p=0.529). Unlike others, Poland did not slow down notably after 2014 (\beta_2=0.0086, p=0.570). What stands out is its drop after 2022 - a steep fall confirmed by data (\beta_3=-0.0704, p<0.001).

Table 2. Country-specific segmented trend estimates for (\ln(\text{Total RES numerator}))

Country	β1	SE(β1)	p	β2	SE(β2)	p	β3	SE(β3)	p	θ2021	p	R^2
France	0.0448	0.0040	<0.001	-0.0140	0.0067	0.037	0.0160	0.0048	<0.001	0.0570	<0.001	0.9534
Germany	0.0726	0.0077	<0.001	-0.0469	0.0135	<0.001	-0.0172	0.0096	0.071	0.0510	0.059	0.9743
Italy	0.0787	0.0084	<0.001	-0.0842	0.0146	<0.001	0.0073	0.0116	0.529	0.0394	0.092	0.9460
Poland	0.0647	0.0064	<0.001	0.0086	0.0152	0.570	-0.0704	0.0181	<0.001	-0.0834	0.128	0.9674

Source: Author's own calculations based on the integrated RES dataset (2004-2024). *Notes: (\beta_1) = baseline trend (2004-2014); (\beta_2) = change in slope after 2014; (\beta_3) = additional change in slope after 2022; (\theta_{2021}) = post-2021 level shift. HAC/Newey-West standard errors.*

Though measured differently across nations, patterns in renewable expansion emerge clearly when viewed year by year. France saw gains of 4.58% between 2004 and 2014; afterward, the pace dipped to 3.13% until 2022 before rising again - to 4.79% - in the last period. Germany started high with 7.53%, yet slowed steadily: first to 2.61%, then down further to just 0.85%. After an initial rise in Italy of 8.19%, activity turned negative at –0.55%, barely climbing back to 0.18% later on. Poland expanded rapidly early, posting 6.69%, accelerated slightly to 7.61%, but ended weakly with only 0.29%.

Table 3. Implied annual growth rates by segment for (\ln(\text{Total RES numerator}))

Country	Growth 2004-2014 (%)	Growth 2015-2022 (%)	Growth 2023-2024 (%)
France	4.58	3.13	4.79
Germany	7.53	2.61	0.85
Italy	8.19	-0.55	0.18
Poland	6.69	7.61	0.29

Source: Author's own calculations based on the integrated RES dataset (2004-2024).

The findings suggest the years following 2022 did not bring uniform gains in renewable expansion among the four nations. Instead, France saw a return to faster progress. Meanwhile, Germany kept slowing down. In Italy, there was no clear statistical change overall. Poland experienced a notable drop in pace. To check if these trends stem from actual shifts in renewable installation or from adjustments in how the RES metric is calculated, researchers applied the segmented regression again - this time using the logarithm of the total RES denominator and the logit version of the renewable share. Insights emerged through this split analysis. For France, the rise in renewables after 2022 aligns with both higher output in new projects and shrinking energy demand: coefficient \(\beta_3\) appears positive and significant for the share measure (0.0406, \(p<0.001\)), whereas the denominator reveals a sharper downward trend (-0.0131, \(p=0.041\)). Although Germany's renewable fraction increased slightly post-2022 (\(\beta_3=0.0275\), \(p=0.019\)), such movement happened even though new installations showed little momentum; instead, it owes largely to steeper declines in total consumption (\(\beta_3=-0.0387\), \(p<0.001\)). After 2022, Italy sees no meaningful shift in either the count or its proportion. Though Poland experiences a notable slowdown in both values that make up the ratio, the resulting share remains effectively unchanged - suggesting counterbalancing forces instead of directional momentum.

Table 4. Post-2022 decomposition: numerator, denominator, and renewable share

Country	β3 numerator	p num	Post-2022 numerator growth (%)	β3 denominator	p den	Post-2022 denominator change (%)	β3 share (logit)	p share
France	0.0160	<0.001	4.79	-0.0131	0.041	-2.40	0.0406	<0.001
Germany	-0.0172	0.071	0.85	-0.0387	<0.001	-4.10	0.0275	0.019
Italy	0.0073	0.529	0.18	0.0026	0.704	-0.99	0.0025	0.823
Poland	-0.0704	<0.001	0.29	-0.0543	<0.001	-3.04	-0.0173	0.277

Source: Author’s own calculations based on the integrated RES dataset (2004-2024). Notes: “Post-2022 numerator growth (%)” and “Post-2022 denominator change (%)” refer to the implied annual rate in the terminal segment (2023-2024). The coefficient (\beta_3) is the incremental slope change after 2022.

The sectoral extension further clarifies the source of post-2022 heterogeneity. France records a significant positive post-2022 slope change in renewable electricity ((\beta_3=0.0138), (p<0.001)), no significant break in heating and cooling, and a positive but only marginally significant shift in transport ((\beta_3=0.1094), (p=0.098)). Germany shows a statistically significant post-2022 slowdown in both electricity ((\beta_3=-0.0232), (p<0.001)) and heating and cooling ((\beta_3=-0.0324), (p=0.032)), while the transport coefficient is positive but not significant. Italy presents a mixed picture: the post-2022 break is not significant in electricity or heating and cooling, but transport exhibits a positive coefficient close to conventional significance thresholds ((\beta_3=0.0997), (p=0.057)). Poland displays the strongest sectoral divergence of all four countries: a very large and significant positive post-2022 shift in electricity ((\beta_3=0.1926), (p<0.001)), combined with a very large and significant negative shift in heating and cooling ((\beta_3=-0.1864), (p<0.001)). Transport in Poland remains positive but statistically insignificant.

Table 5. Sectoral post-2022 slope changes

Country	β3 electricity	p elec	Post-2022 electricity growth (%)	β3 heating/cooling	p hc	Post-2022 heating/cooling growth (%)	β3 transport	p trans	Post-2022 transport growth (%)
France	0.0138	<0.001	6.11	0.0029	0.605	3.48	0.1094	0.098	7.25
Germany	-0.0232	<0.001	3.59	-0.0324	0.032	-3.54	0.0532	0.106	4.86
Italy	0.0133	0.268	3.59	-0.0211	0.387	-4.38	0.0997	0.057	6.12
Poland	0.1926	<0.001	24.23	-0.1864	<0.001	-9.07	0.0922	0.239	5.26

Source: Author’s own calculations based on the integrated RES dataset (2004-2024).

The pooled four-country specification confirms this heterogeneous picture. In the common-slope fixed-effects model for (\ln(\text{Total RES numerator})), the baseline time trend is positive and highly significant ((\beta_1=0.0652), (p<0.001)), the post-2014 slope shift is negative and significant ((\beta_2=-0.0341), (p=0.001)), but the post-2022 slope shift is not statistically significant ((\beta_3=-0.0161), (p=0.647)). Allowing country-specific trend interactions raises the fit from (R^2=0.974) to (R^2=0.989), and a joint Wald test strongly rejects homogeneous slopes across countries ((\chi^2(9)=294.19), (p<0.001)). Thus, the pooled evidence supports the conclusion that there was no common post-2022 acceleration pattern, but rather a set of country-specific responses. Finally, sensitivity checks around the 2021 methodological break show that the main qualitative conclusions are not solely an artefact of the SHARES regime change. When 2021 is excluded from the baseline numerator model, the post-2022 slope change remains positive and significant in France ((\beta_3=0.0284), (p=0.010)) and negative and significant in Poland ((\beta_3=-0.0796), (p=0.018)). Germany's post-2022 deceleration becomes statistically insignificant ((\beta_3=-0.0084), (p=0.618)), while Italy remains insignificant ((\beta_3=0.0206), (p=0.149)). Taken together, these results indicate that the geopolitical shocks of 2014 and 2022 were associated with a highly differentiated restructuring of renewable deployment trajectories, rather than a uniform acceleration of the energy transition across the four countries.

Conclusions

This research finds that the geopolitical disruptions in 2014 and 2022 failed to trigger consistent gains in renewable energy rollout across France, Germany, Italy, and Poland. Despite notable growth in renewables throughout 2004–2024 in each nation, closer analysis uncovers divergent paths after these events. Following 2022, only France demonstrates a clear statistical uptick in overall deployment speed. In contrast, Germany keeps slowing down; Italy displays no reliable shift in its trajectory. Meanwhile, Poland loses forward motion sharply after 2022. Thus, the evidence frames Europe's green shift not as a unified response to crises but as an uneven, variable-paced transformation. One main outcome of the study lies in separating shifts in renewable deployment from shifts in their overall share. After 2022, rises in renewable portions do not clearly signal quicker growth in renewables themselves. In France, higher shares stem from more installations alongside reduced total energy use. Yet in Germany, shrinking demand matters more than new renewable supply when explaining rising proportions. Italy sees little net movement across these factors. Meanwhile, in Poland, opposing forces balance out - growth in generation countered by increasing consumption. Such patterns reveal how apparent progress during turbulent times can hide divergent realities. Not every part of the energy sector changed equally after 2022. Shifts appeared mostly in specific areas, like France expanding its power supply, while Poland saw growing gaps between how it produces electricity versus heat and cooling. These patterns show that security concerns have boosted support for green energy across Europe. Yet such pressures did not erase long-standing national contrasts - differences in governance strength, infrastructure design, or practical barriers still shape outcomes. Geopolitical tensions act more like a filter than a push; their impact depends heavily on internal conditions within each country. Looking at trends through split indicators and ratio-based methods helps clarify how different forces influence renewable growth when crises hit. Still, shared goals across Europe rarely mean matching paces of change. National differences continue to steer how fast countries shift to renewables - geopolitical shocks notwithstanding.

Bibliography

- Ahmed, S., Hasan, M. M., Hossain, A. T., & Saadi, S. (2025). The comeback effect: Market responses to Trump's 2024 election victory. *Economics Letters*, *247*, 112170. https://doi.org/10.1016/j.econlet.2025.112170
- Aydin, M., Sogut, Y., & Erdem, A. (2024). The role of environmental technologies, institutional quality, and globalization on environmental sustainability in European Union countries: New evidence from advanced panel data estimations. *Environmental Science and Pollution Research International*, *31*, 10460-10472. https://doi.org/10.1007/s11356-024-31860-x
- Bórawski, P., Bełdycka-Bórawska, A., Holden, L., & Rokicki, T. (2022). The Role of Renewable Energy Sources in Electricity Production in Poland and the Background of Energy Policy of the European Union at the Beginning of the COVID-19 Crisis. *Energies*. https://doi.org/10.3390/en15228771

- Borowski, P. (2022). Mitigating Climate Change and the Development of Green Energy versus a Return to Fossil Fuels Due to the Energy Crisis in 2022. *Energies*. https://doi.org/10.3390/en15249289
- Esposito, L., & Romagnoli, G. (2023). Overview of policy and market dynamics for the deployment of renewable energy sources in Italy: Current status and future prospects. *Heliyon*, *9*. https://doi.org/10.1016/j.heliyon.2023.e17406
- Frilingou, N., Xexakis, G., Koasidis, K., Nikas, A., Campagnolo, L., Delpiazzo, E., Chiodi, A., Gargiulo, M., McWilliams, B., Koutsellis, T., & Doukas, H. (2023). Navigating through an energy crisis: Challenges and progress towards electricity decarbonisation, reliability, and affordability in Italy. *Energy Research & Social Science*. https://doi.org/10.1016/j.erss.2022.102934
- Goldthau, A., & Youngs, Richard. (2023). The EU Energy Crisis and a New Geopolitics of Climate Transition. *JCMS: Journal of Common Market Studies*. https://doi.org/10.1111/jcms.13539
- Herranz-Surrallés, A. (2024). The EU Energy Transition in a Geopoliticizing World. *Geopolitics*, *29*, 1882-1912. https://doi.org/10.1080/14650045.2023.2283489
- Hille, E. (2023). Europe's energy crisis: Are geopolitical risks in source countries of fossil fuels accelerating the transition to renewable energy? *Energy Economics*. https://doi.org/10.1016/j.eneco.2023.107061
- Jing, X. (2023). The Russia-Ukraine War and Energy Security: Impact and Policies, From a European Perspective. *Highlights in Business, Economics and Management*. https://doi.org/10.54097/hbem.v3i.4745
- Kazak, J., Chodkowska-Miszczuk, J., Chrobak, G., Mrówczyńska, M., & Martinát, S. (2023). Renewable energy creditors versus renewable energy debtors: Seeking a pattern in a sustainable energy transition during the climate crisis. *The Anthropocene Review*, *10*, 750-770. https://doi.org/10.1177/20530196221149111
- Kosowski, P. (2024). From Fossil Fuels to Renewables: Clustering European Primary Energy Production from 1990 to 2022. *Energies*. https://doi.org/10.3390/en17225596
- Kulpa, J., Olczak, P., Stecuła, K., & Sołtysik, M. (2022). The Impact of RES Development in Poland on the Change of the Energy Generation Profile and Reduction of CO2 Emissions. *Applied Sciences*. https://doi.org/10.3390/app122111064
- Kuzemko, C., Blondeel, M., Dupont, C., & Brisbois, M. (2022). Russia's war on Ukraine, European energy policy responses & implications for sustainable transformations. *Energy Research & Social Science*. https://doi.org/10.1016/j.erss.2022.102842
- Lebrouhi, B., Schall, E., Lamrani, B., Chaibi, Y., & Kousksou, T. (2022). Energy Transition in France. *Sustainability*. https://doi.org/10.3390/su14105818

- Maliszewska-Nienartowicz, J. (2024). Impact of Russia’s invasion of Ukraine on renewable energy development in Germany and Italy. *Utilities Policy*. https://doi.org/10.1016/j.jup.2024.101731
- Pavlenko, A., & Cherp, A. (2025). Do Energy Security Crises Accelerate Decarbonisation? The Case of REPowerEU. *Energies*. https://doi.org/10.3390/en19010200
- Perez, M. D. L. E. M., Scholten, D., & Stegen, K. S. (2019). The multi-speed energy transition in Europe: Opportunities and challenges for EU energy security. *Energy Strategy Reviews*. https://doi.org/10.1016/j.esr.2019.100415
- Proedrou, F. (2023). EU Decarbonization under Geopolitical Pressure: Changing Paradigms and Implications for Energy and Climate Policy. *Sustainability*. https://doi.org/10.3390/su15065083
- Sattich, T., Morgan, R., & Moe, E. (2022). Searching for energy independence, finding renewables? Energy security perceptions and renewable energy policy in Lithuania. *Political Geography*. https://doi.org/10.1016/j.polgeo.2022.102656
- Tesfu, E. I. (2024). The EU’s Energy Crisis: Shifting from Fossil Fuels to Renewable Solutions Amid Geopolitical Tensions. *International Journal of Advanced Multidisciplinary Research and Studies*. https://doi.org/10.62225/2583049x.2024.4.6.3482
- Thimet, P., & Mavromatidis, G. (2022). Review of model-based electricity system transition scenarios: An analysis for Switzerland, Germany, France, and Italy. *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2022.112102
- Urbano, E., Kampouropoulos, K., & Romeral, L. (2023). Energy Crisis in Europe: The European Union’s Objectives and Countries’ Policy Trends—New Transition Paths? *Energies*. https://doi.org/10.3390/en16165957
- Van Ouwerkerk, J., Cortés, M. C., Nsir, N., Gong, J., Figgener, J., Zurmühlen, S., Bussar, C., & Sauer, D. (2024). Quantifying benefits of renewable investments for German residential Prosumers in times of volatile energy markets. *Nature Communications*, *15*. https://doi.org/10.1038/s41467-024-51967-6
- Vasylieva, T., Derkacz, A., Popp, J., & Horsch, A. (2025). From energy dependency to energy security: How the war in Ukraine accelerated renewable deployment in Europe. *Economics & Sociology*. https://doi.org/10.14254/2071-789x.2025/18-3/13
- Weremczuk, A. (2025). Biomass As an Instrument of Sustainable Energy Transition in Poland. *Communications of International Proceedings*. https://doi.org/10.5171/2025.4516625
- Weremczuk, A., & Grębowiec, M. (2025). Segmented Trend Analysis of the Eu Renewable Energy Share with Stability Tests. *Communications of International Proceedings*. https://doi.org/10.5171/2025.4645025

- Weremczuk, A., Kotyza, P., & Wielechowski, M. (2025). Development and potentialof renewable energy sources in Poland. *Turystyka i Rozwój Regionalny*, (23), 123-133. https://doi.org/10.22630/TIRR.2025.23.12
- Weremczuk, A., & Milewski, L. (2025). Regional Divergence in the Development of Renewable Energy in the European Union. *Communications of International Proceedings*. https://doi.org/10.5171/2025.4541025
- Zolotarova, O., & Lukash, D. (2025). EU energy security amid geopolitical change. *Scientia Fructuosa*. https://doi.org/10.31617/1.2025(163)05