



## Original research article

## Energy narratives in Europe: Exploring the link between online news and renewable energy production

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## ABSTRACT

In this study we examine the relationship between news media importance of different energy-related themes (ERTs) and the level of electricity generation from renewable sources in seven high-income European countries. In an era of rapid technological progress and growing environmental awareness, the media plays a crucial role in shaping public opinion and influencing public action. Our analysis measures the semantic importance of key ERTs in European online news by examining over 260,000 articles published over seven years, from 2014 to 2023. To identify the potential causal effect of media attention to ERTs on renewable electricity generation, we adopt an instrumental variable (IV) approach that addresses potential endogeneity in media reporting. Using text mining methods to quantify ERTs media importance in the news, we find that increased media importance of different ERTs is associated with increased renewable electricity production in the subsequent months. This delayed effect suggests the existence of an optimal window in which media influence can effectively drive renewable energy adoption.

## 1. Introduction

In an era marked by rapid technological advancements, environmental concerns, and global energy transitions, the role of the media in shaping public perception and policy discourse on energy-related themes has become increasingly vital. The dissemination of information through online news platforms has not only transformed how we access and consume news but has also amplified the impact of media on our understanding of critical issues, including those related to energy production, consumption, and sustainability [1–3].

Studies have consistently demonstrated that news media can profoundly influence public skepticism, policymaking, and how information is conveyed and disseminated throughout society [4]. The way the press covers topics related to energy usage and consumption is crucial, as it can significantly shape public perception and influence policymaking on this global issue [5,6].

Recent evidence highlights how media sentiment and communication play a crucial role in energy markets, particularly in influencing

price dynamics and the transition toward renewable energy sources [7]. Additionally, media-driven public awareness campaigns have been shown to influence residential electricity consumption and conservation behavior, underscoring the media's potential to affect energy efficiency outcomes through non-price measures [8].

This study draws on agenda-setting and framing theories [9,10] to understand the role of media in shaping public and institutional attention toward energy-related issues and renewable energy generation. According to the agenda-setting theory, editors, journalists, and broadcasters help construct social reality by deciding which events qualify as news and controlling how much attention each receives. Through this mechanism, the media can elevate an issue from private concern to public debate, shaping what audiences consider important [11,12]. In the context of renewable energy, heightened media attention to certain themes may prime citizens, policymakers, and businesses to recognize these topics as pressing and actionable [13]. As such, the importance of energy narratives in the media may serve as a sociocultural catalyst for adopting renewable technologies.

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To empirically test this effect, we quantify the importance of various energy-related themes discussed in online news from seven high-income European countries. We then examine how the media importance these themes receive relates to renewable electricity generation across countries and over time.

Mass media are a communication channel for scientists, experts, and businesses who want to educate the general public about sustainability [14]. Therefore, they not only contribute to increasing public awareness and consciousness but also generate a “common” understanding of energy themes for consumers and businesses [15]. Media can also increase the sense of individual responsibility for making sustainable choices [16]. By analyzing media narratives and their association with renewable electricity generation, our study adds a layer to understanding the complex socio-economic drivers of renewable energy development.

Our first analysis identified the energy-related themes central in online news across Europe. We uncovered the energy topics that attract the most public attention and discussion. Understanding these dominant themes allowed us to map the media landscape around energy issues, highlighting shifts in focus over time and the rise of new narratives. Most of the literature focuses on related but different topics, such as climate change [5,6,17] or single countries [18,19]. Additionally, the longitudinal analysis allowed us to examine the influence of the COVID-19 pandemic on these narratives. The pandemic drew increased attention to worldwide climate policy and energy themes [20]. For example, President Xi signaled a bold intention for China to become carbon neutral by 2060 [21]. We expected that news media communications would reflect these increased concerns.

Secondly, we examined whether increased media importance of energy themes is associated with renewable electricity production. Most of the public relies on news media for information, especially regarding scientific issues [22]. How the news covers energy themes matters considerably because such coverage can influence the public's perception and policymaking regarding this global phenomenon. By analyzing media coverage alongside Eurostat data on electricity production, we assessed how closely the importance of energy themes in the media aligned with actual trends in renewable electricity generation. This analysis helped us identify potential relationships between public discourse and energy transition outcomes, shedding light on previously underexplored sociocultural factors that may influence energy production from renewable sources.

## 2. Literature review

### 2.1. Theoretical background

A wide range of studies has investigated the role of media in influencing people's perceptions e.g., [23,24]. In this regard, communication theories (such as agenda-setting or framing theories) help to explain how media can influence public opinion by raising individual awareness.

Agenda-setting theory [9] posits that the media plays a central role in shaping public priorities by selecting which issues to highlight in the news. When the media chooses to include certain themes and not others in its coverage, it can elevate them from private awareness to public concern. Numerous studies have shown that sustained media attention toward specific themes can make the audience particularly involved in those themes [25]. Repetitive media coverage of specific topics influences how the public prioritizes those issues [25,26].

At the same time, media theories suggest that not only what the media talks about influences public perceptions, but also how it is discussed. In this regard, framing theory argues that “frames” (defined as interpretive structures that emphasize particular aspects of a theme) guide audience understanding and emotional responses [10]. In the energy domain, how a theme is framed (whether as an economic benefit, cost, or a matter of national investment) shapes how the public and policymakers interpret its relevance and implications [27].

To summarize, according to agenda-setting and framing theories, the media can shape public opinion and influence how people perceive issues. News coverage acts as a sociocultural driver, shaping perceptions of urgency, legitimacy, and feasibility. Drawing on these theories, our aim is twofold. First, we want to understand the level of importance that leading news sources in seven European countries assign to the topic of energy. This helps us assess whether the media elevates energy concerns to the level of a public issue. Second, we want to examine how this topic is portrayed. In other words, when energy is discussed, we want to understand which aspects receive the most attention (economic, implementation-related, or the types of energy sources). This helps us understand how the framing of the issue influences public perception.

### 2.2. Media and energy related themes

The global climate change and environmental sustainability discourse has become increasingly central to public awareness and policy considerations in recent years [28]. As a complex and multifaceted issue, the coverage of climate-related themes in online news media has garnered significant attention from researchers [5,6,17–19,22].

Most of the existing literature has focused on issues related to climate change or global warming rather than energy issues. For example, Hase et al. [29] presented a comprehensive analysis of climate change coverage in news media across ten countries. They highlighted that news media attention varies across countries and is often influenced by political, scientific, and societal events. Moreover, they revealed a predominant emphasis on the societal dimension of climate change in news coverage. Anderegg & Goldsmith [30] explored the influence of high-profile media events on public perception of climate change. Their analysis employed web search term volumes to assess temporal patterns of interest in climate change, particularly in response to media events. Findings indicated that media events have short-term effects on public interest in climate change, with little impact on longer-term salience. News content was also analyzed from previous literature because of its importance for firms. Tavakolifar et al. [31] investigated the relationship between media attention and corporate commitment to climate change action. The authors showed that heightened media attention increases the likelihood of firms committing to take more action on climate change. Additionally, they highlighted the moderating effect of environmentally sensitive industries on this relationship. Their findings provide insights into how media attention can influence public discourse and corporate behavior regarding environmental issues, enhancing the relevance of news content investigation. Lopera and Moreno [32] delved into media coverage of climate science in Spanish newspapers. Their content analysis revealed a focus on the consequences rather than the causes of climate change, contributing to its characterization as a controversial and uncertain science. Lopera & Moreno's [32] findings highlighted the role of media framing in shaping public understanding of complex scientific topics.

On the other hand, past research on news media and energy topics is less extensive. Part of this narrower literature focuses on how news and expectations related to energy markets relate to economic or financial indicators [33]. However, given the growing importance of a rapid shift to alternative and sustainable energy sources, coupled with the media's influence on citizens' behavior, it is crucial to understand whether, how, and to what extent news media can truly impact renewable energy production. More similar to our research, Fabiani et al. [34] conducted a comprehensive analysis of online news in Italy to explore the societal awareness of energy storage systems. Their approach, employing text mining and network analysis on a corpus of over 143,000 energy-related articles, revealed the pivotal role of media coverage in increasing awareness and societal acceptance of energy storage solutions. Adopting a similar approach, Piselli et al. [35] focused on energy communities, a cross-disciplinary phenomenon with potential implications for energy transition and citizen engagement. They assessed the importance of energy-related themes in online news, highlighting the interplay

between media discourse and societal engagement in the broader context of sustainable energy transitions via participative actions, such as renewable energy communities implementation.

In terms of methodology, our work is closely related to that of Piselli et al. [35] and Fabiani et al. [34], as we both use text mining and semantic networks for news analysis. We build on their study by adopting a multi-country approach and focusing on broader energy topics rather than specific themes such as energy communities or energy storage. Additionally, we relate a news-based measure of the semantic importance of energy-related themes to renewable electricity production. This is motivated by existing literature highlighting the multifaceted influences on renewable energy development, implementation, and exploitation actions. For example, Saba and Biyase [36] found that socio-economic variables, such as governance indicators, institutional quality, and market dynamics, significantly shape renewable energy outcomes across European countries. Their work shows the importance of non-technical factors in driving renewable energy growth.

Contrary to the existing body of research that has predominantly centered on climate change news (or the impact of news on climate change public perception), our study places a distinct emphasis on energy-related themes. Energy production, consumption, and sustainability are critical components of the broader climate change discourse, as energy systems play a pivotal role in greenhouse gas emissions and environmental impacts. Lastly, we conduct a cross-country analysis, in contrast to the single-country analyses of previous studies, e.g., [17,18,37].

### 3. Methodology

To measure and compare the semantic importance of different energy-related themes (ERTs) in media discourse across countries, we selected widely read and well-established online newspapers for each country in our sample. These sources were chosen based on their national circulation and online availability, ensuring that they reflect the most influential voices in each country's media landscape. Our selection covers seven languages, English, Italian, Swedish, Spanish, German, French, and Greek, and includes some of the most important newspapers in terms of circulation.

Our focus is not to capture the full diversity of viewpoints across the media landscape but to analyze the energy discourse within the most widely circulated and consumed news sources. This choice reflects our specific objective: to examine the agenda-setting potential of dominant media outlets. Therefore, the results should be interpreted with this in mind. The selected sources likely reflect elite or mainstream perspectives rather than representing the full spectrum of public opinion. This decision aligns with prior work [29] and provides a consistent basis for cross-country comparison. Future research could build on this foundation by incorporating a broader and more diverse set of media outlets, such as regional news. Empirically, well-established news sources, often referred to as legacy media, have been shown to influence public attention significantly and remain among the most read online [38,39].

The news we collected from the Event Registry [40] – a platform that aggregates and processes global news articles using machine learning and natural language processing techniques – spans from January 2014 until December 2023, for Italy, Spain, Germany, the United Kingdom, Sweden, France, and Greece. The total amount of news we collected for each country, as well as the sources, are reported in Table 3.

Given that we are interested in energy-related articles, we first conducted a process of article filtering. This filtering process involved two distinct criteria. Firstly, we identified articles explicitly discussing energy themes using n-grams (sequences of one or more contiguous words) in the body or title of the article, such as “renewable energy” or “fossil fuel.” Secondly, we added to the corpus all the articles that contained the term “energy” alongside at least one additional general term related to energy, such as “battery” or “hydrogen”. Given the different languages in which articles were collected, we were supported

by additional experts from each country to translate each search term.

#### 3.1. Evaluating semantic importance

After filtering the articles, we leveraged the Semantic Brand Score (SBS) to quantify the importance of ERTs in their content. The SBS is a metric for capturing the importance and memorability of words and concepts within large text corpora [41]. This indicator encompasses three key dimensions – prevalence, diversity, and connectivity – briefly summarized in this section. According to these metrics, the importance attributed to a word is high when (i) it has frequent mentions, denoting prevalence; (ii) it exhibits diverse and more distinctive textual associations, reflecting diversity; and (iii) it can act as a bridge across different discourse themes (connectivity). Prevalence measures the frequency with which a specific word or set of words appears in a corpus. A higher prevalence suggests that a term is more frequently featured in public discourse, increasing its visibility. Frequent exposure to certain words enhances recognition and recall, making these concepts more salient in the reader's mind. Diversity assesses the variety and distinctiveness of the terms linked to each word/concept under analysis, while connectivity gauges a word or concept's capacity to bridge various discourse topics. The formulas for calculating diversity and connectivity draw inspiration from centrality metrics within social network analysis, specifically distinctiveness centrality and weighted betweenness centrality, respectively [42,43]. These calculations necessitate an initial transformation of the text documents into a network of co-occurring words after text preprocessing, carried out using the SBS BI web app [44]. Text preprocessing involves multiple steps to standardize and clean up the text, including the removal of stopwords (common words such as ‘and’ or ‘the’ that carry little semantic value), punctuation, and special characters. The text is also converted to lowercase to ensure uniformity and avoid duplicate entries due to case differences. Additionally, words are stemmed – a process that reduces words to their root form (e.g., ‘running’ to ‘run’) – to consolidate variations of the same term [45]. While root stemming is commonly used for English, we acknowledge that it may be less effective in capturing morphological nuances in other languages within our corpus, such as Italian, German, French, and Spanish. In these cases, lemmatization or dictionary-based stemming could offer greater linguistic precision. However, they typically require more computational resources and language-specific tools. Given that we did not observe substantial differences in the final outputs across languages, we used stemming for consistency and efficiency. However, future research could further explore these alternatives to assess their potential benefits. Finally, the text is tokenized, meaning it is split into individual words or meaningful units, enabling the construction of a structured network of word co-occurrences.

Following previous research [34], we measured the semantic importance of 15 ERTs reported in Table 1. Thanks to the help of two experts who worked independently, we created a dictionary of words for each of the 15 ERTs. Some of them are reported in Table 1 as examples. We grouped each ERT into a macro category based on its semantic content. Given that some topics often appear in similar contexts (for example, renewable energy sources like geothermal and hydroelectric frequently appear together in news coverage), their respective ERTs are assigned to the same category. We use these macro categories in the regression models, presented in Section 4.2, to account for the high correlation of ERTs assigned to the same category.

Given the multilingual nature of our news corpus, we also translated the terms for each ERT with the help of expert native speakers from each country. The selected ERTs are designed to explore the interconnections among various facets of energy aspects, encompassing general renewables and their specific technologies (e.g., geothermal energy, hydroelectric energy, solar energy, and wind energy), implementation categories (e.g., plant, building, electric mobility, and energy communities), relevant economic aspects (e.g., cost and savings), and other pertinent dimensions that illuminate the multifaceted nature of energy-

**Table 1**  
Energy-related themes by category.

Category	ERTs	Rationale for aggregation
Energy	Renewables Geothermal Energy Wind Energy Solar Energy Hydro Energy Hydrogen	This category encompasses the primary renewable energy sources, which play a crucial role in the global shift away from fossil fuels.
Implementation	Plant Building Electric Mobility Energy Community	These ERTs focus on how energy is produced, distributed, and utilized within different infrastructures, capturing key sectors where energy transition policies and technologies are applied.
Economics	Cost Savings	Energy costs and savings are critical for policy discussions, investment decisions, and consumer adoption, making economic considerations a distinct category in energy discourse.
Transition	Environmental Sustainability Efficiency Self-Consumption	These themes reflect systemic changes necessary for an effective energy transition, focusing on environmental impact, technological advancements, and decentralized energy production.

related discussion and impacts (e.g., sustainability, energy transition).

The ERTs in the renewables category represent different renewable energy sources, such as geothermal, wind, solar, hydro, and hydrogen. These ERTs reflect the role of clean energy technologies in the energy transition and their presence in public discourse. The ERTs in the implementation category focus on different ways energy systems are integrated into infrastructure and society. For example, plant and building ERTs highlight energy production and efficiency in industrial and residential/business contexts. The electric mobility ERT encompasses discussions on electric vehicles and charging infrastructure, while the energy communities ERT refers to decentralized, community-driven energy initiatives. The ERTs in the economics category capture the financial aspects of energy-related discussions. The cost ERT reflects concerns about energy prices, production expenses, and market fluctuations, while the savings ERT is about energy efficiency, household savings, and cost reduction. The ERTs in the transition category include broader environmental and systemic concepts that define the shift toward cleaner energy. The environmental sustainability ERT covers discussions on reducing carbon footprints and promoting green policies. The efficiency ERT focuses on technological advancements and policies aimed at optimizing energy use. Lastly, the self-consumption ERT refers to individuals or organizations generating and using their own energy, often linked to decentralized renewable energy systems.

### 3.2. Exploring the relationship between news content and energy data

To explore the relationship between news content and renewable electricity production, we related the semantic analysis to a set of key macroeconomic energy variables, all obtained from Eurostat. Previous studies used Eurostat data for different purposes. For example, Pacesila et al. [45] used Eurostat energy data to scrutinize the renewable energy sector within the European Union. Vasylieva et al. [46] employed Eurostat data on greenhouse gas emissions and renewable energy to analyze the interplay between economic growth, corruption, and the environmental aspect of sustainable development. Bilan et al. [47] utilized Eurostat and World Bank data to explore the relationship between a country's renewable energy sources, CO2 emissions, macroeconomics, political stability, and GDP. Moreno et al. [48] delved into the determinants of electricity prices. In contrast to Vasylieva et al. [46], Soava et al. [49] discovered a positive impact of renewable energy consumption on economic growth. Lastly, Tsemekidi Tzeiranaki et al. [50] investigated residential energy consumption trends and status.

We obtained monthly data on net electricity production by fuel type from Eurostat. Our selection focused on renewable energy sources, including hydropower (RA100), geothermal (RA200), wind (RA300), solar (RA400), and a residual category encompassing all other renewable sources (RA500\_5160). We standardized each value based on the total energy generated in each country from any energy source in a specific month. Eurostat provides country-level monthly estimates of net electricity production by fuel type, also ensuring cross-country and temporal comparability through a standardized consistent methodology. The data are sourced from the national administrations responsible for energy statistics, including national statistical institutes, ministries, energy agencies, and professional associations, depending on the reporting country and process. Additionally, we obtained a set of control variables for each country (listed in Table 2) from CEIC, a global provider of economic and financial data.<sup>1</sup> CEIC offers in-depth time series data on macroeconomic indicators such as GDP, inflation, trade, employment, financial markets, and sector-specific trends.

After merging the macroeconomic data with SBS values, our time span ranged from 2016 to 2022. This coverage reflects the period for which both consistent monthly macroeconomic indicators and textual news measures are available across all countries in the sample.

To explore the relationship between the semantic importance of ERTs and renewable energy production, we conducted a panel analysis. We examined whether heightened media importance to ERTs correlates with renewable electricity production. Given that most of the public relies on mass media for information about scientific issues such as energy-related themes [22], it is plausible to assume that when the news focuses on such subjects, citizens and firms will be more likely to adopt a more energy-conscious behavior because of the influence of such coverage on public perception [5,6]. In particular, we used the following model:

$$REN_{it} = \alpha_i + \beta \log(1 + ERTs_{it-n}) + \gamma X_{it} + \delta_i + \delta_t + \epsilon_{it} \quad (1)$$

where  $REN_{it}$  represents the amount of electricity generated from renewable sources with respect to the total electricity generation for country  $i$  at month  $t$ . Our main explanatory variables are  $ERTs_{it-n}$ , measured with monthly frequency. We estimated four models using variables that represent the main macro categories, *Energy*, *Implementation*, *Economics*, and *Transition*, calculated by summing their individual ERT SBS scores. We used lagged values for each ERT category up to one year to explore the immediate and delayed effects of media coverage on renewable energy outcomes. Using lagged values enables us to test whether the association between renewable electricity production and news content is contemporaneous or delayed, reflecting a more

**Table 2**  
Variable descriptions and data sources.

Variables	Description	Sources	Type
Renewables	The sum of different types of electricity generation from renewables sources (Eurostat codes: nrg.cb.pem.ra100, nrg.cb.pem.ra200, nrg.cb.pem.ra300, nrg.cb.pem.ra400, nrg.cb.pem.ra500_5160).	Eurostat	Dependent variable
News articles	All the corpus includes the Title and Body of news articles.	Event Registry	Explanatory variables
Trade	Trade (% of GDP)	CEIC	Control variables
Indu	Industrial production, value added (% of GDP).	CEIC	
GDP	GDP per Capita.	CEIC	

<sup>1</sup> <https://www.ceicdata.com>.



gradual influence on renewable energy decisions and outcomes.

Regarding our independent variables of interest, due to the highly skewed nature of the SBS values toward zero, we applied a logarithmic transformation, taking the log of 1 plus the raw values.<sup>2</sup> This transformation mitigates the impact of extreme values and allows for a more robust estimation of the effects of media coverage on renewable energy outcomes. To control for potential confounders, we included a set of time-varying country-level covariates,  $X_{i,t}$ , consisting of GDP per capita, industrial production as a percentage of GDP, and trade as a percentage of GDP. We selected these control variables based on previous literature and their relevance to economic conditions that could influence renewable energy production [36]. Industrial production and trade are available monthly, while GDP per capita is recorded quarterly. To ensure consistency, we interpolate the GDP data to match the monthly frequency of the other variables. We employed country-fixed effects,  $\delta_i$ , to account for unobserved heterogeneity across countries that may influence renewable energy generation but remain constant over time, such as geographic and institutional factors. Similarly, time fixed effects,  $\delta_t$ , control for global shocks and trends that might affect all countries uniformly, including technological advances in renewable energy and broader shifts in environmental policy.

Given the panel structure of our data, we clustered the standard errors at the country level to account for potential serial correlation within countries, as shocks to renewable energy production may persist over time within a country. By clustering the error terms,  $\epsilon_{i,t}$ , we ensure that our standard errors are robust to within-country correlation, mitigating the risk of overstating the significance of our coefficients. All the variables used in this research are listed in Table 2.

### 3.3. Endogeneity concerns

The observed correlation between media importance and renewable energy production could suffer from endogeneity. It is plausible that increases in renewable energy production may lead to more media attention (reverse causality) or that both variables respond to omitted time-varying shocks, such as changes in national energy policy or international events. We adopt an instrumental variables (IV) approach to address these concerns.

We use the World Press Freedom Index (WPFI) as an instrument for the SBS variables of media importance. The WPFI, published annually by Reporters Without Borders, measures the degree of journalistic freedom in each country [51]. In countries with greater press freedom, journalists are more likely to independently report on public-interest issues, including energy-related topics, thus exogenously increasing the visibility of such topics in the media [52]. Second, conditional on economic and institutional controls, press freedom should not directly affect renewable electricity production except through its influence on media narratives.

We use a two-stage least squares (2SLS) approach to estimate the effect of each SBS cluster. In the first stage, we regress the endogenous variable (i.e., the SBS values) on the WPFI scores. We then use the resulting fitted values as explanatory variables in the second-stage regression. In this second stage, the dependent variable is the share of renewable energy, while the main explanatory variables are the fitted SBS values from the first stage, including lags from 0 to 12. To ensure robust inference we compute standard errors using the wild bootstrap method clustered at the country level. This approach provides more reliable inference in the 2SLS setting [53].

<sup>2</sup> Since the SBS metric comes from the aggregation of counting variable, its skewed distribution is expected. Count-based data often exhibit a right-skewed pattern, as many observations cluster near zero while a smaller number have substantially higher values.

## 4. Results and discussion

### 4.1. Descriptive statistics

This subsection offers a descriptive overview of the general patterns and shifts in the semantic importance of energy-related themes (ERTs) across time and countries, as captured by the Semantic Brand Score (SBS).

Table 3 presents the ratio of energy-related articles to total articles published in each country. This ratio in Germany is 2.20, while Spain and France have a notably higher ratio of 4.73 and 4.50, suggesting a heightened emphasis on energy themes in the media discourse. Italy also shows strong engagement with energy-related content, with a ratio of 4.53. Sweden demonstrates an emphasis on energy issues with a ratio of 2.86, while the United Kingdom and Greece have a lower ratio of 1.63 and 1.96, indicating a relatively lower proportion of energy-related articles in the analyzed newspapers. These ratio variations provide an initial glimpse into the differing levels of attention given to energy-related themes in online news across the selected countries.

In Fig. 1, we present the total SBS values for each of the 15 ERTs throughout the entire period, categorized by country. A higher SBS value for a country implies that the ERTs discussed in the articles are more important and interconnected for that country compared to those with lower SBS values.

The figure shows that three countries - Italy, Spain, and the UK - demonstrate significantly higher SBS values than Germany, Sweden, Greece, and France. Although the percentage of articles related to energy topics in the UK is rather low compared to the other countries analyzed (1.63 %), energy topics show to be semantically important, appearing frequently and in diverse contexts within the media landscape. The heightened SBS values in Italy, Spain, and the UK suggest a stronger emphasis on energy-related discussions. This stronger emphasis indicates deeper media attention in these countries. Conversely, the lower values displayed for Sweden, France, and Greece indicate a lower focus on ERTs.

In Fig. 2, we report a longitudinal analysis of each category of ERTs to see how they evolve over time in an aggregate manner for all countries. The Energy category encompasses ERTs related to various renewable energy sources, from wind to solar energy. Implementation pertains to the practical application of renewable energy sources, such as electric mobility. Economics covers costs and savings, while Transition encompasses crucial concepts tied to energy and green transitions, including environmental sustainability, efficiency, and self-consumption.

A notable trend shift becomes evident, particularly before and after 2019/20. On the left side of the figure (before 2019), the dominant

**Table 3**  
Newspaper description.

Country	Online news source	Total number of articles	Number of filtered articles	Filtered articles / total articles
Italy	Il Corriere della Sera	774,335	35,051	4.53 %
Spain	La Repubblica	1,447,544	68,496	4.73 %
France	La Vanguardia	1,086,917	48,985	4.50 %
Uk	El País	3,895,014	63,318	1.63 %
Germany	Le Figaro	1,319,954	29,000	2.20 %
Greece	Quest Le Monde	331,555	6518	1.96 %
Sweden	BBc	204,011	5842	2.86 %
	Daily Mail			
	Bild			
	Der Spiegel			
	iefimerida			
	Dagens Nyheter			

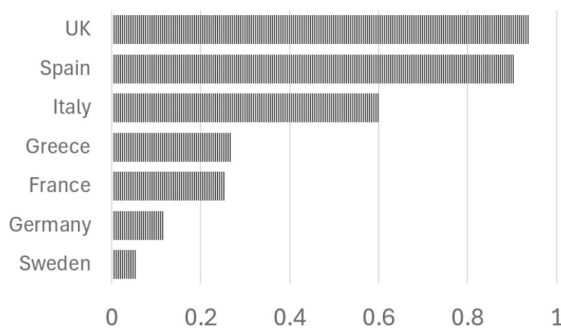


Fig. 1. Semantic Brand Score (SBS) values for 15 ERTs across seven countries over the full study period.

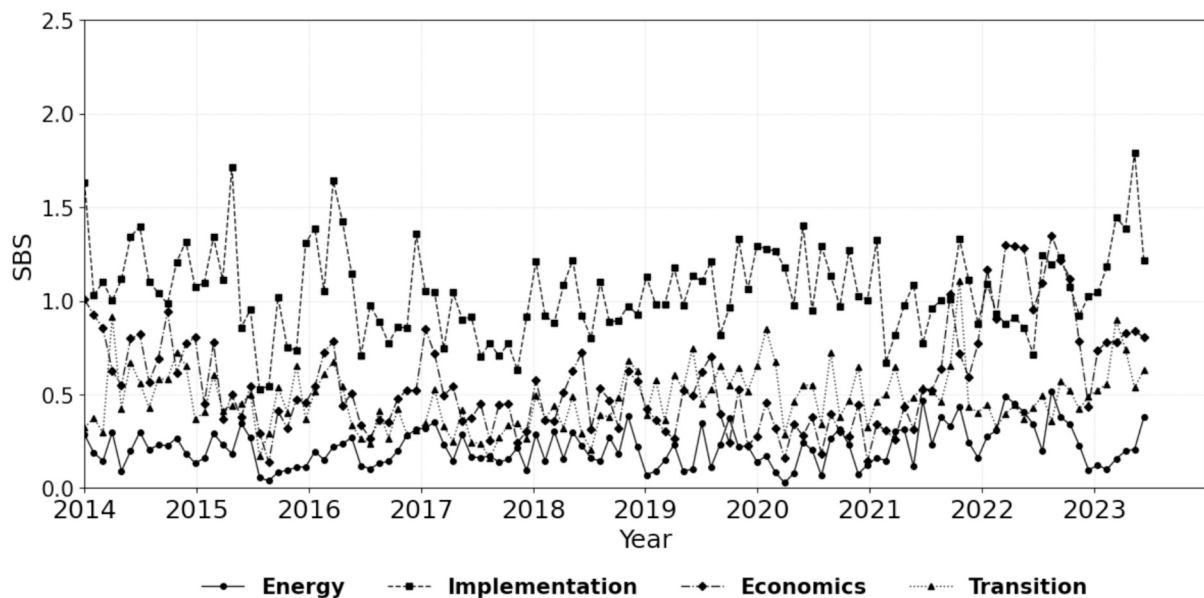


Fig. 2. Monthly SBS values for four categories of energy-related themes (ERTs) across all countries from 2014 to 2023.

theme is Implementation. However, post-pandemic, a significant upward trend emerges first in the Transition category, with a notable spike at the end of 2021, and a notable surge in the Economics category, suggesting higher concern in news media content related to these themes.

This important shift in media narratives becomes more evident by splitting the analysis for the years before and after the pandemic, as reported in Fig. 3, showing the average values of all SBS for all ERTs before and after December 2019.<sup>3</sup> Looking at the figure, it is evident that the importance of energy-related topics witnessed a substantial surge across all the European nations included in our study. This amplified focus on energy matters can be explained by different factors that occurred during and after the pandemic.

First, the shutdowns during 2020 have led to an unprecedented reduction in the demand for energy transportation and electricity; by mid-April of 2020, energy demand in countries under full lockdown had fallen by 25 % compared to average consumption in 2019 [54]. This led to a crash in oil prices, which declined by 85 % between January 22, 2020, and April 21, 2020; oil futures even went negative briefly in May 2020. Besides economic factors that can explain the rise in ERTs' importance in the news, the global use of renewable energy in all sectors

increased by 1.5 %, while renewable electricity generation increased by almost 3 % in the first quarter of 2020 relative to the same period in 2019 [54]. Additionally, numerous actions were taken by the European Union, which allocated €225 billion from its recovery fund to the energy transition, emphasizing green recovery initiatives.

Among the countries analyzed, Greece exhibited the most substantial growth, with an 85 % increase, rising from 8.58 to 57.56. Italy follows with a 58 % increase, more than doubling its pre-pandemic coverage (37.74 to 89.88). Germany and Sweden also showed notable growth, with 48 % and 46 % increases, respectively. Spain and France displayed more moderate rises, with 34 % and 19 % increases, respectively. The United Kingdom, however, experienced the smallest shift, with an increase of only 5.8 % (84.16 to 89.33), indicating a relatively stable level of media attention to energy topics before and after the pandemic.

#### 4.2. Regression analysis

In Table 4, we report the results of panel regression models estimated according to eq. (1) using the IV approach to explore the relationship between ERTs' media importance and renewable electricity production. We estimated each model by lagging the main explanatory variables up to one year for each category. Given the high correlation between the SBS of each ERT, we did not include a model with all ERTs to avoid collinearity issues. Instead, we applied Principal Component Analysis to derive a single coefficient from the SBS of *Energy*, *Implementation*, *Economics* and *Transition*. In the fifth model, we included the first factor, which we call *ERT Factor* in Table 4, as it explains 83 % of the variation in the data as the main explanatory variable.

To assess the instruments' strength, we report the F-statistics from the first-stage regressions, in the bottom part of Table 4. All values exceed the conventional threshold of 10, ranging from 24.05 to 286.92, indicating that our instruments are not weak and provide sufficient explanatory power for the endogenous variables.

The regression results in Table 4 show a significant association between the media importance of ERTs and renewable electricity production within countries. The first key finding is that, on average, increased media importance of ERTs had a positive but delayed effect on renewable energy production at the national level. This pattern is reinforced by the positive coefficients reported in Column 5, where we used the first principal component of all ERTs. We find only one instance

<sup>3</sup> To calculate the post-COVID values, we excluded data after February 2022, which coincides with the start of the Russian invasion of Ukraine.

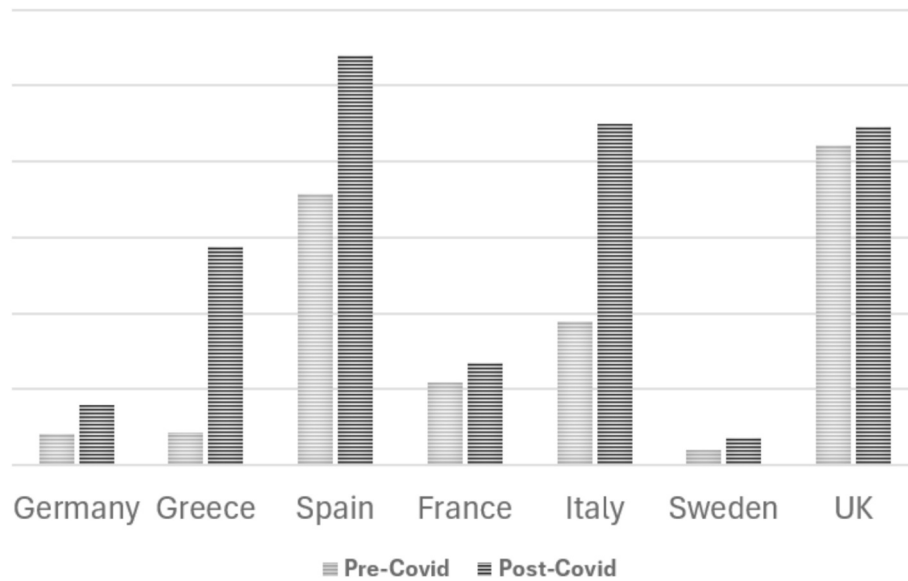


Fig. 3. Average semantic importance of energy-related themes (ERTs) before and after the COVID-19 pandemic.

Table 4

Instrumental variable regression results.

	Dep. variable: renewable electricity generation				
	Energy	Implementation	Economics	Transition	ERT Factor
Lag 0	0.001 (0.051)	−0.089 (0.108)	−0.028 (0.070)	−0.085 (0.093)	−0.021 (0.038)
Lag 1	−0.019 (0.015)	0.011 (0.018)	−0.027 (0.021)	0.015 (0.015)	0.002 (0.008)
Lag 2	−0.013 (0.023)	−0.001 (0.028)	0.012 (0.027)	0.008 (0.025)	−0.002 (0.013)
Lag 3	0.009 (0.016)	0.006 (0.018)	<b>0.025*</b> (0.011)	0.014 (0.017)	0.005 (0.009)
Lag 4	− <b>0.010***</b> (0.006)	0.016 (0.012)	0.009 (0.010)	0.017 (0.011)	0.002 (0.006)
Lag 5	0.015 (0.010)	<b>0.028*</b> (0.014)	0.013 (0.014)	0.012 (0.013)	<b>0.009*</b> (0.006)
Lag 6	0.054 (0.032)	<b>0.063*</b> (0.047)	0.028 (0.030)	0.038 (0.036)	0.026 (0.021)
Lag 7	0.023 (0.022)	0.059 (0.033)	0.019 (0.026)	0.051 (0.029)	0.021 (0.015)
Lag 8	<b>0.051***</b> (0.010)	<b>0.059**</b> (0.014)	0.050 (0.020)	<b>0.058*</b> (0.014)	<b>0.027**</b> (0.006)
Lag 9	<b>0.036**</b> (0.013)	<b>0.038*</b> (0.015)	0.033 (0.015)	0.042 (0.012)	<b>0.018*</b> (0.006)
Lag 10	−0.016 (0.012)	0.019 (0.012)	0.005 (0.010)	0.023 (0.012)	0.002 (0.006)
Lag 11	0.026 (0.019)	0.015 (0.025)	0.014 (0.021)	0.005 (0.024)	0.009 (0.012)
Lag 12	0.007 (0.024)	0.047 (0.035)	0.014 (0.028)	0.049 (0.035)	0.013 (0.016)
Sum	0.165*** (0.032)	0.272** (0.022)	0.168** (0.036)	0.248*** (0.017)	0.106** (0.019)
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
IV	Yes	Yes	Yes	Yes	Yes
F (First Stage)	286.92	24.05	48.75	41.97	60.83
N	536	536	536	536	536

Note. Standard errors in parentheses. \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

in which the coefficient is negatively associated with renewable energy: the *Energy* ERT at a 4-month lag. However, this result is not corroborated by any other energy-related topic (ERT) in the remaining columns of Table 4.

Given the lack of consistency across specifications, we consider this isolated finding insufficiently robust to support the conclusion that

media attention to energy issues exerted a negative short-term effect on renewable electricity production. Nevertheless, this result opens a valuable avenue for future research. One promising direction would be to incorporate additional textual variables, such as sentiment or tone, to examine whether the framing of energy-related narratives is predominantly negative or positive. Prior research in communication studies

showed that negative news content tended to attract more attention and spread more rapidly than positive content, particularly in the digital age [55,56]. This phenomenon may prompt short-term behavioral responses from firms, policymakers, or citizens in terms of energy usage. However, these responses are unlikely to be sustained if the narrative shifts or if structural conditions do not reinforce the initial media signal. Future work could explore whether such negative media framing contributes to volatility in renewable energy investment, public support, or implementation outcomes in the short term, before giving way to longer term effects.

The second key finding related to the timing of media influence: the temporal impact of media narratives on renewable production varied by ERT, that is, by what media framed when discussing energy topics. Specifically, we find that narratives about *Energy* and *Transition* tend to have longer-term effects, with statistically significant coefficients emerging at lags 8 and 9. In contrast, the *Implementation* ERT shows effects at both shorter (lags 5 and 6) and longer lags (8 and 9), suggesting more immediate responsiveness. The *Economics* cluster exhibits the shortest lagged effect, with a significant coefficient appearing at lag 3, indicating that economic concerns might have shaped public or institutional behavior more rapidly.

As shown in Table A1, the within-country standard deviation of SBS variables, which captures temporal variation within each country over time, ranges from 0.55 (*Implementation*) to 0.60 (*Transition*). From an economic perspective, a one standard deviation increase in the SBS from its mean is associated with an increase in renewable electricity production of approximately 1.13 percentage points for *Energy*, 0.99 for *Implementation*, 0.45 for *Economics*, and 1.05 for *Transition*. These values are economically meaningful, representing between 6 % and 15 % of the average level of renewable electricity production.

In Table 4, we report the cumulative effect of all lagged coefficients for each cluster. These effects were computed as linear combinations of the individual lag coefficients, capturing the total annual impact of media importance on renewable electricity production over the 12-month horizon. These linear combinations are all positive and statistically significant.

When we examine the cumulative coefficients in Table 4, and we consider annual standard deviations, we find that a one standard deviation increase in SBS from its mean is associated with an annual rise in renewable electricity generation ranging from 17 % to 49 % of its mean, with *Implementation* exerting the strongest effect. This suggests that, in the long run, *Implementation* is the most impactful media narrative for driving renewable production in terms of magnitude, while *Transition*, though still positive, had the smallest relative impact.

The delayed effect observed in coefficient estimates suggests that media coverage may not immediately impact renewable energy production but exerts its effect over time. This effect could be due to the time required for media narratives to influence policy decisions, investment strategies, or technological adoption. Recalling the agenda-setting theory, sustained media attention can elevate specific issues from private to public concern, thereby influencing collective priorities and action [9]. The observed growth in ERTs' semantic importance preceding changes in renewable energy generation may reflect deliberate communication strategies aimed at shaping public opinion and garnering support for particular energy policies. As such, media narratives not only inform but also help construct the sociopolitical environment necessary for renewable energy projects to advance, an effect that may take several months to materialize in measurable increases in electricity generation [57].

Compared to the *Economic* ERT, which shows a weaker but more immediate effect, the stronger effect of media importance for *Implementation*, *Energy* and *Transition* may suggest that practical considerations are more important drivers of renewable energy growth in the long term [58,59]. For example, news reports on successful renewable energy projects or infrastructure developments may provide the confidence needed to accelerate the adoption of renewable energy

technologies. Conversely, discussions about the economic sphere of renewable energy sources appear to have a faster impact on energy usage, though disappearing over time.

## 5. Conclusion

The analysis of energy-related themes in mainstream national newspapers across seven European countries revealed notable differences regarding energy-related topics coverage in the European media landscape. While energy-related news constitutes a significant portion of the media discourse in some countries—such as France, where 4.5 % of news articles focus on energy—the Semantic Brand Score analysis indicates that the importance of energy-related terms is lower in France than in other countries, such as the UK. It follows that an analysis of the media message based on the sole number of articles covering a certain topic may not be sufficient to measure the degree of importance that a topic actually receives. Second, our descriptive analysis highlights the critical impact of the COVID-19 pandemic on media coverage of energy topics. In countries where energy discourse was already well-established and specific—such as the UK—the pandemic did not significantly alter the prominence of energy-related discussions. Conversely, energy issues gained significantly more media attention after 2020 in countries like Italy and Greece. This reinforces the empirical validity of our metric while highlighting the growing importance of the energy transition and sustainability themes after 2020. It also shows that the pandemic has significantly influenced news content [20]. Finally, our findings indicate that hydrogen is the most frequently discussed renewable energy source in online newspapers, surpassing other sources such as solar, hydropower, and wind energy.

Our regression analysis reveals a positive, yet delayed, relationship between ERT media importance and energy production from renewable sources. Specifically, our study finds that an increase in media coverage of energy-related topics is generally followed by a rise in renewable electricity production, with the most common lag ranging from 5 to 9 months across the majority of specifications. For example, when discussions around key energy themes—such as energy policy or implementation—intensify in the media, we observe a subsequent increase in renewable electricity production within a country. This finding is important as it suggests that the adoption of renewable energy is influenced not only by economic [59], policy [60], technological [57], environmental [61], or financial factors [62] but also by social variables. While previous research has predominantly focused on these traditional drivers, the role of news media in shaping energy transitions has been largely overlooked. Our study fills this gap by quantifying its impact. Few studies have examined the influence of mass media on the energy sector. Most existing research has focused on related but distinct topics, such as climate change, or has been limited to single-country analyses without integrating macroeconomic variables [17,35,63,64]. By addressing these gaps, our study provides a broader, cross-country perspective on the media's role in shaping renewable energy adoption.

Our study is particularly relevant for researchers and policymakers working toward the sustainable development goal of universal electricity access by 2030. It also holds significance for policy initiatives aimed at promoting energy-friendly technologies. This study contributes to the broader literature on the determinants of information diffusion [65–67]. Beyond its empirical findings, our study also offers a methodological contribution. We use a cost-effective big data approach to estimating the effects of nationwide news media information. Specifically, we implemented text mining and network analysis techniques to quantify the semantic importance of specific energy topics.

A first limitation of our analysis is its focus on mainstream national newspapers, omitting social media and other online sources that can influence public perception. Future research could incorporate a broader range of data sources to capture a more comprehensive discourse, for example using data from regional news. In addition, quasi-experimental designs could help disentangle the specific impact of



pandemic-related shocks on media coverage and energy-related developments. Future studies could employ additional causal inference techniques to isolate media effects better. Finally, as our analysis covers only seven high-income European countries, expanding to emerging economies could offer valuable perspectives on the media's role in energy transitions globally. Addressing these gaps would enhance our understanding of how media narratives influence energy policies and adoption patterns.

### CRedit authorship contribution statement

**Roberto Vestrelli:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Andrea Fronzetti Colladon:** Writing – review & editing, Writing – original draft, Supervision, Software, Resources, Methodology, Data curation, Conceptualization. **Claudia Fabiani:** Writing – review & editing, Conceptualization. **Anna Laura Pisello:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization.

### Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Financial support was provided by the European Union's Horizon 2020 program under grant agreement n 764025 (SWS-HEATING), n. 890345

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Professor Anna Laura Pisello, one of the co-authors of this paper, serves on the Editorial Board of this journal.

The authors declare that they have no other known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A

One of the primary concerns when applying the Semantic Brand Score (SBS) method to a multilingual corpus is ensuring its robustness in producing comparable results across different languages. Variations in SBS scores may stem from two main sources: first, the semantic shift or frequency change of keywords when translated into another language; and second, differences in syntactic structures and grammatical patterns across languages.

To empirically assess the robustness of SBS in a multilingual context, we conducted a controlled experiment using a sample of 100 news articles. Specifically, we randomly selected 100 English-language articles from our corpus and translated them into five additional languages—Italian, French, German, Greek, and Swedish—using the Helsinki-NLP machine translation models [68,69]. We then reapplied the SBS analysis to each translated corpus using a consistent subset of general-purpose keywords (translated into the respective languages): “hydrogen\*”, “geo\*”, “storag\*”, “plant\*”, “solar\*”, “batteri\*”, “fuel\*”. These terms were chosen to represent distinct semantic clusters relevant to the energy sector.

After computing the SBS values for each translated version, we calculated pairwise correlations between the resulting SBS scores. The analysis yields an average correlation coefficient of 0.68, indicating a reasonably strong alignment across languages. While machine translation inevitably introduces some level of semantic and structural distortion, these results suggest that the SBS methodology maintains satisfactory robustness in multilingual applications. Future research could further investigate cross-lingual comparability by expanding the keyword set, incorporating domain-specific terminology.

Table A1 shows summary statistics of the variables employed in the research.

**Table A1**  
Summary statistics.

Variable	N	Mean	Std.	Std. within
Renewable Electricity Generation	536	0.338	0.126	0.074
Energy	536	1.494	0.827	0.617
Economic	536	1.843	0.964	0.562
Transition	536	2.016	1.057	0.601
Implementation	536	2.266	1.051	0.557
Industrial production	536	0.050	0.072	0.009
GDP	536	2.104	3.498	0.232
Trade	536	−0.917	2.472	0.856

### Data availability

The authors do not have permission to share news data. All numerical data resulting from the analyses will be made available upon reasonable request to the first author.

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