



A Review of Public Interest in Renewable Energy in the Visegrad Group Countries

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Abstract: *The issue of energy transition has become one of the most urgent in the global economy in recent years, with public opinion playing a significant role in shaping energy policies. This study examines public interest in renewable energy by focusing on keywords related to photovoltaic technologies in the Visegrad Group countries. We have used Google Trends and Semrush data to explore public interest in renewable energy during 2024 and over the five-year period 2020-2024. Based on the constructed distribution map of popularity scores, we found that rural and less urbanized areas showed significantly higher interest, while capital cities and industrial regions showed lower levels of engagement. Furthermore, an analysis of the dependencies of intent by country and intent by keyword type was conducted. The chi-square test confirms that targeted searches for photovoltaic-related information are statistically significant. Our results confirm that citizens of the Visegrad Group countries are actively seeking information about photovoltaics, with the strongest dependence observed in Poland, followed by Slovakia, Hungary, and the Czech Republic.*

1. INTRODUCTION

Since the beginning of 2022, respected journals and societies have been focusing on the analysis of the unprecedented energy shock that is literally changing the priorities of energy transformation in the world (World Energy Council, 2022, 2024; International Energy Agency, 2022). Whereas previously the goal was to counter global warming and pollution - which until 2022 was considered one of the most impressive challenges in the 21st (United Nations, 2022), with the beginning of the Russian invasion of Ukraine, energy security and accessibility have been threatened. The European Union (EU) is facing a common problem, but the consequences have been different for each member state, depending on the structure of the energy package, regional and economic conditions.

According to the World Energy Council (2021), European countries dominate the top positions in the 2021 Top Trilemma performers ranking, holding 10 out of 14 positions and 7 out of 10 positions in the Top 10 Rank Performers in Energy Security category. However, this is not the case for all EU countries, as there is a significant “gap” between northern, southern and eastern European countries (Haber et al., 2021; Bouzarovski & Tirado Herrero, 2017). Energy security, affordability, and environmental sustainability in the Visegrad countries, which include the Czech Republic, Poland, Hungary, and Slovakia, have always been critically considered due to the regional and historical context of these countries' dependence on fossil energy sources (Riepl & Zavorská, 2023; Jonek-Kowalska & Rupacz, 2024). Therefore, when the war broke out in 2022 and the energy crisis shook the world, it was clear that the Visegrad Group countries would be under particular pressure (Žuk et al., 2023).

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Difficult times call for difficult decisions. At the beginning of 2022, the world was still recovering from the Covid 19 crisis (Zakeri et al., 2022; Hussain et al., 2023). Economic problems, a growing energy crisis, and political instability created conditions of considerable tension in society. In such circumstances, public opinion and awareness can be a significant argument in support of energy policies or a significant obstacle (Kastrati et al., 2023; Dasgupta & De Cian, 2018). Thus, understanding public attitudes and awareness is crucial not only as a retrospective ('post facto') assessment of policy outcomes but also as a tool for planning socially responsive policies.

In order to study public opinion, it is becoming more and more common to analyze data from Internet users' search queries, posts and comments on social networks and blogs. These data are primary indications of the interests, opinions, and doubts of the population (Álvarez-García et al., 2023). In favor of this method of researching social opinion, the authors cite such arguments and advantages as the availability of large samples of data at a low cost and the availability of data for a long period of time, which allows for flexibility in choosing research methods and topics (Mellon, 2013; Álvarez-García et al., 2023). In particular, search term-based surveys are often used as an effective and statistically significant way to study public opinion on topics related to the environment, climate change and sustainability (Dabbous et al., 2023).

This paper addresses the issue of public interest in renewable energy sources in the Visegrad Group countries with the aim of assessing and identifying the current state and dependencies in the perception of this issue by the population across these countries. This study fills a research gap in understanding public acceptance and interest in renewable energy within the Visegrad Group countries. This problem has been studied only to a limited extent in this region, despite the growing global interest in these topics. By leveraging digital search data, the study offers an approach to assessing public interest in solar energy, providing insights for policymakers, businesses, and researchers. In addition, it highlights regional differences in interest in renewable energy and the characteristics of user interaction with content on this topic.

We examine the search intentions of residents in the Visegrad Group countries regarding photovoltaic energy. Additionally, we explore whether these intentions are influenced by factors such as governmental involvement, geographic location, and brand presence. Investigating public engagement and intention could provide valuable insights into local factors that affect renewable energy transitions, ultimately enriching the broader discourse on sustainable energy adoption in Central and Eastern Europe. The focus on photovoltaic technologies provides a concrete, localized picture of changing public attitudes toward renewable energy for households, thus providing information on the readiness of inhabitants to participate in the energy transition.

2. LITERATURE REVIEW

The European Union's climate goals, defined through policies, agreements, and regulations (e.g., the European Green Deal, Fit for 55, and the Climate Law), require member states to develop national strategies such as National Energy and Climate Plans (NECPs). Structural transformations in the energy, industrial, and transportation sectors resulting from NECPs lead to public debate about economic costs, technological feasibility, and societal impacts. Governments must solve potential social resistance, which can hinder policy implementation and lead to delays, project modifications, community opposition, and increased dependence on energy imports (Kost et al., 2021; Buchmayr et al., 2021). Thus, ensuring public acceptance and engagement may be crucial for achieving long-term sustainability goals.

According to [Batel et al. \(2013\)](#), effective implementation of renewable energy technologies requires a multilateral approach that actively involves social actors. Importantly, they distinguish between acceptance and support: acceptance refers to passive tolerance, while support implies active endorsement and engagement. This distinction highlights the need for proactive public involvement rather than mere acquiescence. Public skepticism toward energy transition often stems from economic concerns and perceived negative neighborhood factors ([Komendantova, 2021](#); [Buchmayr et al., 2021](#)). These authors note that the second factor can be addressed by changing technologies, as certain communities may have prejudices against specific technologies, while other technologies may have high support due to local experience and positive opinions formed in the media or discourse. Understanding public sentiment toward specific renewable energy technologies is essential for predicting societal responses and ensuring smoother project implementation. Studying public opinion on specific technologies is essential for anticipating societal responses to their implementation. This facilitates dialogue between policymakers and the public, enabling either the presentation of well-founded arguments in support of projects or the reconsideration of implementation strategies.

The Visegrad Group (Czech Republic, Hungary, Poland and Slovakia) countries have relied mainly on Russian fossil fuels ([Žuk et al., 2023](#); [Riepl & Zavarská, 2023](#)) and are therefore among the regions most affected by the energy crisis. Moreover, as [Mišík and Oravcová \(2024\)](#), [Brusenbauch Meislová \(2019\)](#) wrote, the Visegrad Group countries have different and uncoordinated strategies for achieving the energy transition to green energy and energy security. The skepticism within the EU regarding energy transition and decarbonization in Visegrad Group countries is driven by their historical reliance on fossil fuels, economic concerns, and political resistance, as reflected in their opposition to the EU's proposal to achieve climate neutrality by 2050. However, public perception in the Visegrad Group countries does not entirely align with governmental skepticism. Eurobarometer surveys indicate that societal attitudes toward sustainable energy solutions in these countries are close to the European average and continue to improve ([Surwillo & Popovic, 2021](#)). Nevertheless, a key challenge identified by [Surwillo and Popovic](#) is the low level of social mobilization, characterized by a weaker sense of personal responsibility for climate action. This lack of engagement could significantly influence public reactions to economically demanding energy policies, particularly those requiring higher financial contributions, lifestyle adjustments, or the adoption of new technologies.

Conducting social opinion research presents several challenges, particularly when using traditional data collection methods such as surveys, interviews, and focus groups. These approaches often require extensive preparatory work, significant financial resources, and long data collection periods, which can extend over several years. This poses additional difficulties when studying multiple countries simultaneously, as it increases the scope and complexity of the research ([Komendantova, 2021](#); [Dabbous et al., 2023](#)). To address these challenges, researchers are increasingly turning to digital data sources, particularly social media content and search engine queries. These methods provide access to both historical and real-time data, offering quantitative and qualitative insights that enhance research flexibility. Unlike traditional surveys, digital data collection allows for longitudinal analysis, enabling researchers to track public opinion trends over time. Furthermore, it facilitates cross-regional studies using consistent methodologies, making it possible to examine social attitudes in regions where traditional surveys may be unavailable ([Mellon, 2013](#)).

Among non-traditional data sources, search engine queries have gained particular prominence. Google Trends (GT) is one of the most widely used tools in empirical economic research, offering free access to keyword popularity data. This approach allows researchers to monitor emerging

trends and compare search term frequencies. However, GT's Search Volume Index (SVI) presents a notable limitation: it provides relative search interest rather than absolute search volumes, which can restrict the precision of quantitative analyses (Cebrián & Demenech, 2023). To overcome this limitation, researchers often supplement GT data with alternative keyword search volume tools, which estimate search activity based on data collected from third-party providers. The versatility of search query data enables researchers to explore a broad range of research questions. Successful studies on the dynamics of public interest include research on biodiversity conservation, as well as analyses exploring the relationship between rising internet searches and factors such as international climate events, political decisions, high-profile celebrity statements, and extreme weather events (Burivalova et al., 2018; Álvarez-García et al., 2023). Accordingly, examining the relationship between public interest and geopolitical events and crises is a logical approach, potentially providing valuable insights in a region among the most affected by the energy crisis.

3. METHODOLOGY AND DATA

This paper utilizes data from Semrush and Google Trends to analyze public interest in solar energy-related topics across Visegrad Group countries. Semrush (2024) gathers search engine results page (SERP) data from third-party providers, including both organic and paid search results from Google. This dataset captures top-ranking domains and search terms, updated monthly to reflect shifts in search trends. From Semrush, we extracted the following keyword-related metrics:

1. Keyword Search Volume: the average number of monthly searches for a keyword over the past 12 months.
2. Intent: categorizing user search behavior based on intent (e.g., informational, transactional). To account for differences in internet usage, Keyword Search Volume was adjusted based on Eurostat (n.d.) percentage of the population using the internet and converted into the number of search queries per 10,000 users. The data cover the period from January 2024 to December 2024 for one-year statistics and from January 2020 to December 2024 for five-year statistics.

We examine whether the interest of Visegrad Group residents in searching for information about photovoltaics online is influenced by the type of information—whether it is provided by enterprises, government sources, location-based, or general informational content. With such purpose we grouped keywords into Regular (general terms), Locale (including geographic names), Brand (commercial names), and Government (keywords related to regulations or subsidies). To analyze this relationship, we will use association tables.

Keywords were identified using Semrush Keyword Magic Tool, selecting terms related to "solar energy," "solar panels/batteries/modules," and "photovoltaics" in each country's national language, restricted to the respective geographic region. This process yielded unbalanced keyword lists: Poland (3,690 keywords), Czech Republic (281), Slovakia (253), and Hungary (467). Given the high number of keywords, we applied a search volume cut-off threshold: 90 queries for Hungary and 110 for Poland, removing keywords contributing less than 0.001 to the total search volume. The cut-off principle is justified by authors, emphasizing that counting all queries is impossible and inherently part of the methodological approach (Lillo & Ruggieri, 2021; Álvarez-García et al., 2023). After applying these criteria, the final balanced keyword lists included Poland (269 keywords), the Czech Republic (281), Slovakia (252), and Hungary (275).

Google Trends data were used to analyze keyword popularity by region, with values ranging from 0 to 100, representing a keyword's proportion of total searches. Popularity values were derived from one-year (2024) and five-year (2020–2024) datasets.

To create statistical maps, the popularity value for each region was calculated as the weighted average of the top 10 keyword popularity scores, with weights assigned based on each keyword's search volume relative to the most popular keyword in the dataset.

4. RESULTS

To analyze keyword popularity across regions—both within individual countries and in a cross-regional context—we created analytical maps using Google Trends data (see Figure 1). Unlike the Search Volume Index, which measures a term's relative popularity over time, the index used in this study reflects keyword popularity in a given region relative to the total number of searches within the country.

To account for regional variations in keyword usage, we based the country-level popularity index on the top 10 keywords. Notably, none of these keywords are geo-referenced or tied to specific locations. The analysis covers both one-year (2024) and five-year (2020–2024) periods, allowing for an assessment of evolving trends across regions. The findings indicate a decline in interest across all regions in 2024 compared to previous years, though areas with consistently high keyword popularity remained unchanged. The most significant decline occurred in Hungary, where the regional average in 2024 was 13% lower than the five-year average. Slovakia and Poland experienced similar declines of approximately 10%, while the Czech Republic saw the smallest decrease at around 6%.

The popularity scores are distributed as follows, with the highest values observed in: Vysočina (98.26/96.24) in the Czech Republic, Žilina region (96.8/95.3) in Slovakia, Podkarpackie (96.94/98.32) in Poland, and Békés (85.13/86.8) and Bács-Kiskun (79.75/92.48) in Hungary. Interestingly, in all four countries, capital cities—including Prague, Bratislava, Warsaw, and Budapest—consistently show the lowest levels of interest. In the Czech Republic, Slovakia, and Poland, rankings remain relatively stable across regions in both the short and long term, with only minor fluctuations (1–3 position changes relative to the average). In contrast, Hungary exhibits greater variability, with position changes reaching up to 8 places.

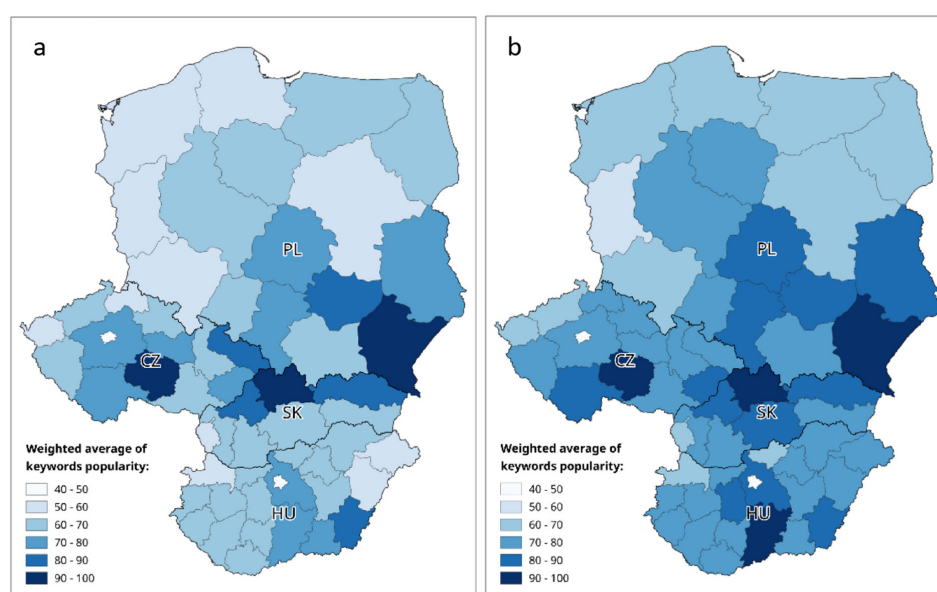


Figure 1. Regional Keyword Popularity (a: One-Year Data, b: Five-Year Data)

Source: Own processing based on Google Trends data

Keyword intent reflects the purpose behind a user's search query, with Semrush categorizing it into four types: Informational (I), Commercial (C), Navigational (N), and Transactional (T), representing a gradual progression from initial interest to action. Informational intent corresponds to the learning phase, where users seek general knowledge, asking questions such as “What is it?” or “How does it work?”. Commercial intent represents the consideration phase, during which users compare options, research brands, and read reviews. Navigational intent indicates brand awareness, as users search for specific websites or brands. Transactional intent marks the final stage, where users are ready to make a purchase or sign up for a service.

Table 1. Descriptive statistics by Intent and Country

| Intent | CZ | | | HU | | | PL | | | SK | | |
|--------|-----|------|------|-----|------|------|-----|------|------|-----|------|------|
| | N | Avg | SD | N | Avg | SD | N | Avg | SD | N | Avg | SD |
| C | 60 | 0.10 | 0.20 | 24 | 0.23 | 0.23 | 68 | 0.08 | 0.06 | 73 | 0.07 | 0.12 |
| I | 156 | 0.12 | 0.24 | 202 | 0.28 | 0.42 | 147 | 0.12 | 0.17 | 128 | 0.13 | 0.27 |
| I, C | 9 | 0.19 | 0.28 | 25 | 0.14 | 0.06 | 3 | 0.04 | 0.02 | 3 | 0.06 | 0.03 |
| I, T | 41 | 0.10 | 0.28 | 8 | 0.23 | 0.10 | 29 | 0.22 | 0.34 | 24 | 0.09 | 0.16 |
| N | 5 | 0.15 | 0.17 | 10 | 0.33 | 0.31 | 17 | 0.10 | 0.08 | 8 | 0.18 | 0.31 |
| N, T | 2 | 0.17 | 0.12 | 4 | 0.20 | 0.16 | 3 | 0.05 | 0.02 | 5 | 0.03 | 0.01 |
| T | 4 | 0.01 | 0.00 | 0 | 0.00 | 0.00 | 0 | 0.00 | 0.00 | 7 | 0.02 | 0.00 |

Source: Own calculations based on [Semrush \(2024\)](#)

Analyzing the distribution of keyword intent provides insights into user behavior at different stages of this journey. Table 1 presents the intent distribution across the Visegrad Group, including keyword count (N), mean adjusted search volume (Avg), standard deviation (SD), and median adjusted search volume (M). The results show that informational intent dominates across all four countries, with Hungary having the highest share (74%), indicating a strong focus on learning rather than purchasing. In Slovakia, Poland, and the Czech Republic, informational intent ranges from 52% to 56%. Commercial intent follows a similar pattern, accounting for 29% in Slovakia, 26% in Poland, and 22% in the Czech Republic, while Hungary has a notably lower share at 9%. Navigational intent is most common in Poland (6%), reflecting a higher volume of searches for specific brands or websites. Transactional intent remains minimal, with Slovakia (3%) having the highest share, followed by the Czech Republic (1.5%), while Hungary and Poland show no purely transactional searches. Additionally, there is a significant share of searches classified as both informational and transactional, ranging from 10% to 15% in all countries except Hungary, where it stands at just 3%. This suggests that in most cases, users transition from research to purchase-related searches, though this pattern is less pronounced in Hungary.

We found that the response rate of residents is low, highlighting the need for more effective strategies to target potential individuals interested in photovoltaics. Across Visegrad Group countries, residents primarily searched for general Informational content related to photovoltaics. Information provided by state authorities, such as details on government subsidies for photovoltaic equipment, was the second most frequently searched category. The Chi-square test confirms a significant relationship between search intent and the type of information sought, with a significance level approximately equal to zero. This indicates that targeted searches for photovoltaic-related information are statistically significant.

Table 2 presents directional measures for intent by type of web search. These measures quantify the reduction in the error of predicting type of web search by intent or vice versa. The highest Goodman & Kruskal’s tau value is 0.373 in Poland when intent is the dependent variable, meaning

a 37.3% reduction in misclassification. When type is dependent, it is expected a 39.2% reduction in misclassification. The lowest value was observed in the Czech Republic. Notably, in Slovakia, the Goodman & Kruskal's tau values differ significantly, with only a 6.4% reduction in misclassification when intent is the dependent variable. All directional measures are statistically significant, with p -values smaller than 0.01.

Table 2. Directional measures for intent by type of web search

| Measure | Stat | Visegrad Group | CZ | HU | PL | SK |
|-------------------------|------------------|----------------|-------|-------|-------|-------|
| Lambda | Symmetric | 0.117 | 0.033 | 0.064 | 0,457 | 0.107 |
| | Intent Dependent | 0.148 | 0.000 | 0.085 | 0,433 | 0.058 |
| | Type Dependent | 0.073 | 0.100 | 0.043 | 0,482 | 0.207 |
| Goodman & Kruskal tau | Intent Dependent | 0.114 | 0.028 | 0.096 | 0,373 | 0.064 |
| | Type Dependent | 0.143 | 0.111 | 0.109 | 0,392 | 0.217 |
| Uncertainty Coefficient | Symmetric | 0.149 | 0.106 | 0.146 | 0,359 | 0.173 |
| | Intent Dependent | 0.130 | 0.086 | 0.136 | 0,347 | 0.141 |
| | Type Dependent | 0.174 | 0.139 | 0.158 | 0,372 | 0.226 |

Source: Own calculations based on Semrush (2024)

Table 3. Symmetric measures for intent and type

| Statistics | Visegrad Group | CZ | HU | PL | SK |
|-------------------|----------------|-------|-------|-------|-------|
| Phi | 0.655 | 0.623 | 0.657 | 0.967 | 0.742 |
| Cramer's V | 0.378 | 0.360 | 0.379 | 0.558 | 0.429 |
| Contingency coef. | 0.548 | 0.529 | 0.549 | 0.695 | 0.596 |

Source: Own calculations based on Semrush (2024)

Table 3 presents symmetric measures such as Phi, Cramer's V, and the Contingency Coefficient. All values are statistically significant, with p -values approximately equal to zero (not reported here). These results confirm that citizens of Visegrad Group countries actively seek information about photovoltaics. In Poland, the Phi coefficient is 0.967, indicating a strong dependency. Followed by Slovakia in second place, Hungary and the Czech Republic ranking third and fourth, respectively.

5. CONCLUSION

This study examined search intent for photovoltaic energy in the Visegrad Group countries. Analysis of interest distribution maps over two periods revealed a clear trend: rural and less urbanized areas showed significantly higher interest, while capital cities and industrial regions displayed lower engagement. This pattern likely reflects factors such as available space, favorable weather, energy independence goals, and economic conditions. Notably, high interest in eastern Poland, eastern Slovakia, and southern Hungary suggests that government policies, incentives, and climate influence adoption. In contrast, large cities may face barriers like infrastructure constraints and centralized energy reliance. These findings highlight the need for further research into regional disparities in solar adoption.

Our findings show that informational searches are the most common, reflecting the early stage of the user journey toward adopting photovoltaic energy. In Slovakia, the Czech Republic, and Poland, search terms with both informational and transactional intent rank third with a relatively high share, suggesting a positive shift from research to purchase-related queries. Commercial intent is the second most frequent, indicating interest in products and services but not necessarily an immediate intent to buy.

Chi-square test confirms a significant relationship between search intent and the type of information sought, with a near-zero significance level. This validates the relevance of targeted searches for photovoltaic-related information. The highest Goodman & Kruskal's tau value (0.373) was observed in Poland, indicating a substantial reduction in misclassification, while the lowest was in the Czech Republic. Slovakia showed notable differences in tau values depending on the dependent variable. Symmetric measures such as Phi, Cramer's V, and the Contingency Coefficient further support the strong link between search intent and information type. Poland exhibits the highest Phi coefficient (0.967), followed by Slovakia, Hungary, and the Czech Republic. These findings confirm active public interest in photovoltaics across the Visegrad Group countries.

Our research highlights the need for targeted strategies to better reach interested audiences, given the relatively low response rate observed. Future studies could explore how policy changes, technological advancements, or seasonal variations further influence public engagement with photovoltaics. These insights can support more effective promotion and adoption of renewable energy in the Visegrad Group.

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