Research and Reviews: Journal of Social Sciences

Using Google Trends: To Assess Public Interest on Wind Energy

Alexandra Perju-Mitran[1], Raul-Augustin Mitran[2], Daniela Zirra[1]*, George Căruţaşu[1]

[1]Department of Research Economic, Romanian-American University, Bucharest, Romania
[2]Department of Applied Chemistry, Institute of Physical Chemistry, Bucharest, Romania

Research Article

Received: 04-Jan-2023, Manuscript No. JSS-23-85383; **Editor assigned:** 06-Jan-2023, Pre QC No. JSS-23-85383 (PQ); **Reviewed:** 20-Jan-2023, QC No. JSS-23-85383; **Revised:** 30-Jan-2023, Manuscript No. JSS-23-85383 (A); **Published:** 06-Feb-2023, DOI: 10.4172/JSocSci.9.1.001

***For Correspondence:** Daniela Zirra, Department of Research Economic, Romanian-American University, Bucharest, Romani

E-mail: daniela.zirra@gmail.com

Citation: Zirra D, et al. Using Google Trends: To Assess Public Interest on Wind Energy. RRJ Soc Sci. 2023;9:001.

ABSTRACT

There are several methods that can be used to analyze public interest on a variety of topics. One of them is based on the use of consumer search frequency data, which can be obtained free of charge thanks to the Google Trends service. This method can be used to assess the attitude of the public towards a wide range of topics, including wind energy. The overall conclusion of the study we have developed is somewhat disappointing. The public interest for most of the researched subjects decreased between 2004 and 2021, with one exception, namely offshore wind.

Keywords: Google trends; Wind energy; Modeling; Public interest: Consumer

INTRODUCTION

The changes of public opinion regarding the renewable energy adoption, is largely debated in opinion [1]. Public opinion has changed over time in relation to pollution and climate change, considering fossil fuel as an important

factor which affects the quality of live. The COVID pandemic influence over the industry did not stop the greenhouse effect, the CO_2 emissions increased by 6% in 2020, with a 36.3 GT in total [2].

However, the CO_2 emissions from fossil fuels are largely given by coal, with 40%, followed by natural gas, and oil, with a recovery after the pandemic period. However, as field counter, the main consumption sector was Electricity and heat, with almost 1400 TWh largely produced from coal (36%). Furthermore, the next in line as emissions percentage is transportation, followed by other industries, with buildings in last place. Replacing the fossil fuel energy with renewable sources also reveals the major downside regarding production costs and predictions [3].

The public interest on different topics, is presented as a benchmark for new inquiries using Google Insights for Search as support for decision-making processes. Even though some correlations were identified between Google searches, traded volume, and stocks, a validated model could not be determined. In the case of energy prices, the model is based on searches, using Multivariate Singular Spectrum Analysis (MSSA) model [4-6].

Using Google Insights for Search and Google Trends, public interest on conservation topics evolves in the decade 2004-2013 [7]. Further research presents an early warning system using Google Flu Trends. Another possible dependence was investigated for precious metals and Google searches (Palladium, Gold, Silver, and Platinum). The limitations of Google search models in healthcare require further investigation of keywords used for searches and their validity on certain search topic [8-10].

The general limitation of a Google search model is given by search engine popularity, total number of searches, market share and the number of internet users. All models indicate an increase of annual searches. Previous research for the period 2004-2017, studied a two-stage behaviour, with a rise in interest for solar energy sources revealed by the number of searches [11]. In case of consumer interest towards renewable energy, the “renewable” Google keyword is negatively correlated with household energy consumption. Furthermore, another keyword evolution, “Green energy”, in the renewable energy structure used in Google searches shows a decrease in frequency starting with 2010 [12,13].

In the present article, we investigate the possible public interest towards wind energy using the Google Trends service for the period 2004-2021 using search keywords, and the energy production depicted on geographical sites. So far, public interest towards wind energy has not been studied by use of Google search data.

MATERIALS AND METHODS

Monthly data series were analyzed, for the period 2004 January 2022, regarding the popularity of topics in the mentioned interval. In the present research we refer to the interest of the general public towards the use of wind energy.

The source of the data is the Google Trends site, which allows for freely obtained data in a worldwide setting. It was considered necessary to select the World wide setting to access all the search data that the Google search engine can provide to users who have used English as their search language. The criteria used for scaling to all searches that were performed in a certain location in the analysis interval (2004 January 2022) [14,15].

The normalization interval of the data points, part of the selected time series, is between the values 0 and 100, taking as reference the highest point (value) in the series. One data point obtained through the Google Trends service represents the data that corresponds to one week of searches. In addition, note that Google Trends reports data for a period of time only if the number of monthly searches exceeds the minimum value, such as 50 searches.

According to various opinions, in order for research regarding public interest on one topic or another to be considered relevant to the field, several types of keywords need to be used. This refers to a series of related words that can provide enough data to assess the public's interest in a topic [16].

The justification for using multiple related keywords is twofold. On the one hand, keywords can lose or gain popularity over time. On the other hand, a keyword can be used to perform searches on different topics.

In view of the above considerations, to assess the public interest in the use of wind energy, it was decided to use three groups of terms (words), which are described in Table 1.

Finally, the third group of keywords was introduced since those who use English have different preferences or habits of expression (even if they are scaled, the data provided by Google Trends does not consider this aspect), and to create a relevant reference base.

RESULTS AND DISCUSSION

The data provided by Google Trends is directly proportional to the number of searches on a topic (keyword) over a period of time, also called search frequency. With Google Trends, there is the option to compare multiple keywords using the same scale, even if the data normalization is between 0 and 100, as described in the methodology. This means that all data series are normalized to the highest value in the series.

Therefore, please note that the data provided by Google Trends takes into account changes that occur over time in the search volume. In terms of English language preferences or habits, a common line or group of common words was used as a baseline, as shown in Table 1.

Table 1. Terms used to assess the public interest in wind energy.

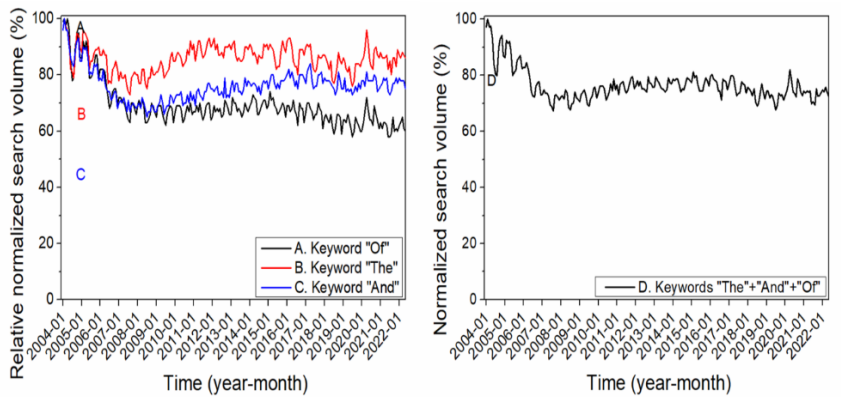
No	Group name	Terms/Key words
1	Key words to assess the public interest on wind energy	Wind Power (WP)
		Wind Energy (WE)
		Offshore Wind (OW)
		Wind Farm (WF)
		Wind Turbine (WT)
		Wind Generator (WG)
2	Key words to assess the public interest on small equipment/devices/installations that are producing wind energy	Small
		Home
		For home
		Kit/Diy
3	Key words for different preferences in using English language	The
		Of
		And

Also, we specify that the baseline was constructed or calculated as the sum of the values obtained for the keywords the, of, and, being renormalized also between the values 0 and 100 (Figure 1).

The result of the data shown in Figure 1 is that both the values for each of the three keywords and their sum indicate similar behavior. Maximum values are recorded in the beginning of the analyzed period (2004 January 2022), with a decrease until 2008. In the rest of the range, the values recorded that can be considered relatively constant. The interpretation of these results is that between 2004 and 2008 the number of users in the non-English category increased, then remained relatively constant until the end of the analyzed period. Monthly changes in baseline data followed the same trends.

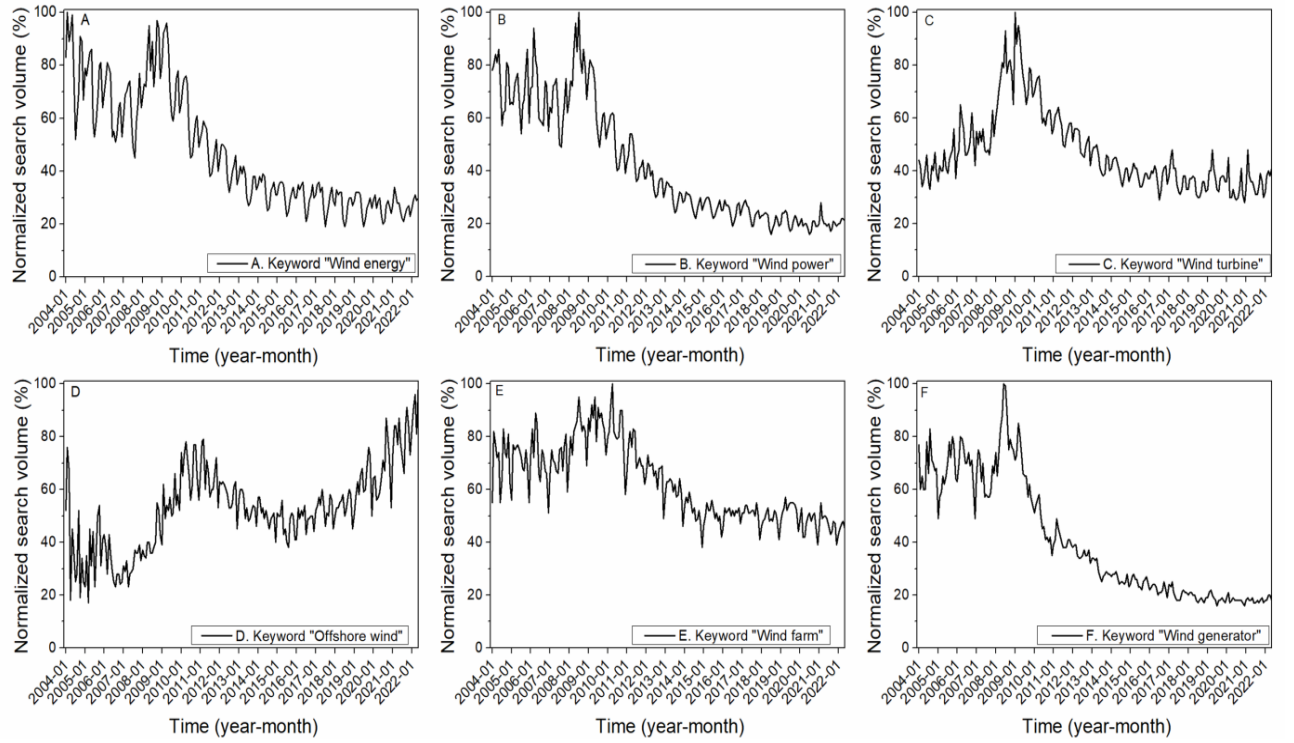
Minimum local search volumes were recorded in the months that may be associated with winter and summer vacations in the northern hemisphere, namely June, July, August, and December.

Figure 1. Normalized Google search data of common English words: (A) Of; (B) The; (C) And (D) The+And+Of. The baseline is constructed by renormalization of their sum (D=A+B+C). **Note**: (—)A. Keyword "Of"; (—)B. Keyword "The"; (—) C. Keyword "And";(—)D. Keyword "The"+ "Of"+ "And".



Figures 2A-2F shows the data corresponding to the time series for another group of keywords, respectively those that are directly associated with wind energy: WP, WE, OW, WF, WT, and WG. This time, time series are normalized to their maximum values, but not normalized to changes in Google search engine usage. We note that there has been a similar evolution for most of the keywords, respectively the highest values were recorded between 2008 and 2010. With reference to the keyword OW, we find the registration of a local maximum value for the years 2010 and 2011, a local minimum in 2015-2017, followed by a steady rise in frequency. OW has reached the maximum search values in January 2022.

Figure 2. Google search data for the six keywords related to wind energy: (A) "Wind energy, (B) "Wind power, (C)"Wind turbine", (D)"Offshore wind", (E) "Wind farm", (F) "Wind generator. **Note:** We must say that the data does not consider changes in language use.



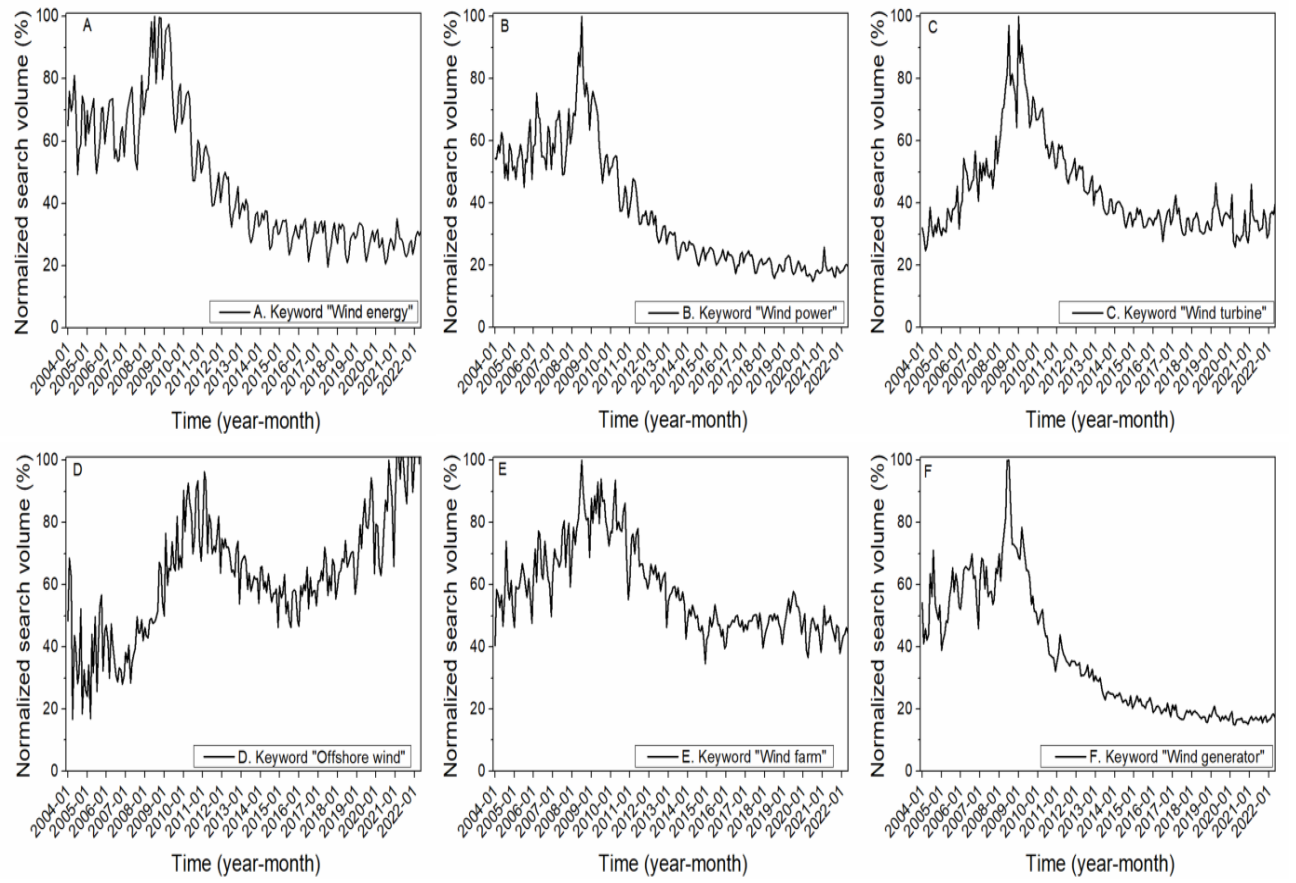
For WP, WE, WF, WT, and WG the evolution of the frequency of occurrence is on a downward slope, after the highest values recorded in the period between 2008 and 2011. The sixth keyword (OW) shows a different evolution, with a growing public interest recorded between 2007 and 2011. After the peak in 2011, we see a decrease in the search frequency for this keyword by 2017.

After this year, the frequency has increased relatively steadily, until January 2022. It is also notable that the maximum value in January 2022 is much higher than the local maximum recorded in 2011. Figures 3A-3F shows the effects of changes in users' searches frequencies for the six keywords. The same methodology is applied for English language preferences (The, Of, and And).

Time series of data were constructed for each of the six keywords. The methodology applied for the construction of the series consisted in the fact that each data point was divided by the value considered as reference for the same month. Then, renormalization was performed. The time series obtained by renormalization has a behavior like the series obtained before normalization. From a qualitative point of view, changes that occur over time in searches used with the Google search engine do not affect the results obtained.

According to the values shown in Figures 3A-3F, searches for five of the six keywords provide maximum frequencies between 2008 and 2011, after which the values indicate a steady decline.

Figure 3. Google search data for six wind energy keywords (A) “Wind energy, (B) “Wind power, (C) “Wind turbine”, (D) “Offshore wind”, (E) “Wind farm”, (F) “Wind generator), renormalized with respect to changes to Google search engine use.



For the keyword OW, the search frequency starts to increase from 2016, reaching a maximum value in January 2022. The value of the parameter in the last month of the analysis was higher than the local maximum in 2011. According to Snyder and Kaiser, the explanation for this evolution is the relatively high degree of novelty of

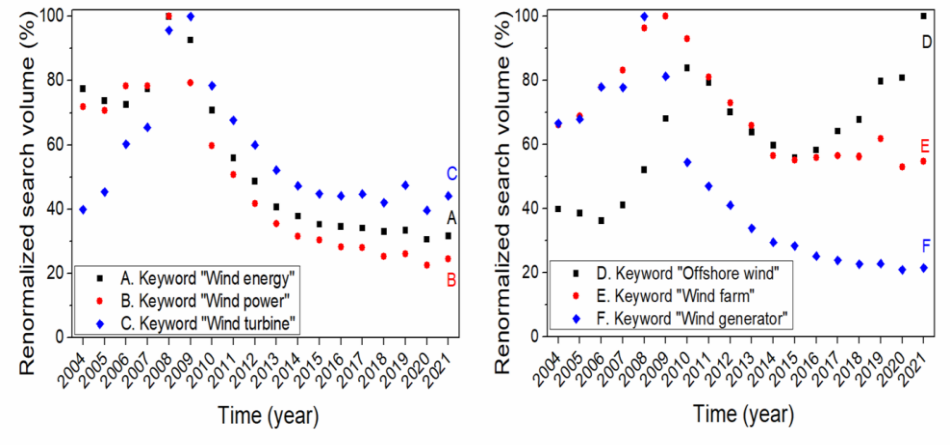
technology, if we consider the fact that the first production capacity for wind energy was built and put into operation in 1991 [17].

Thus far, the data that shows the Google search for the six keywords shows significant variations, both from one month to the next and depending on the season. Moreover, for these variations there were similarities at the level of one year. The same phenomenon has been observed for the common English keywords (The, Of, and And) that we have considered.

The values calculated for each year followed the same evolution as the data considered for each month. Maximum values were usually recorded in 2008 or 2009 for five of the six keywords used. For OW the maximum was in 2010 as we see in Figure 4. Please note that corrected benchmarks were used to calculate the annual values of each of the six keywords.

The search frequency values that were recorded between 2009 and 2014 show a decrease. In the case of four keywords, WP, WE, WF, and WT, search frequencies remain relatively constant or stable between 2015 and 2021, with a significant upward trend between 2018 and 2021. For WG, after a maximum in 2008, we observe a predominantly decreasing evolution, until the end of 2021. The values recorded for OW show a different evolution, because they only increase between 2016 and 2021, with a significant evolution in 2019 compared to 2018 and in 2021 compared to 2020.

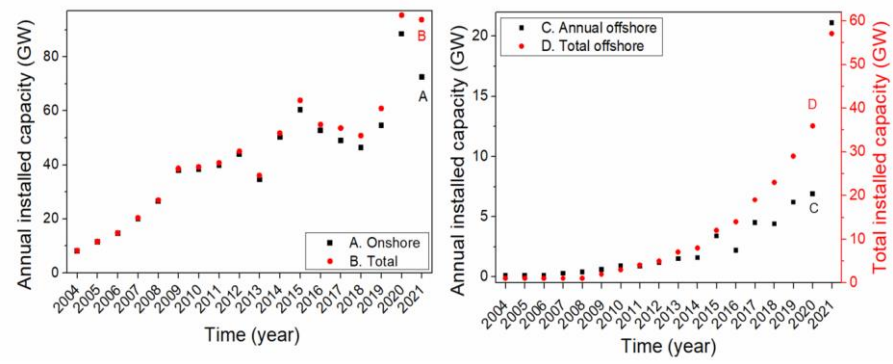
Figure 4. Annual search volume of the wind energy keywords: **Note**: (A and D) ■ Wind energy and Offshore wind (B and E) ● Wind power and Wind farm (C and F) ◆ Wind turbine and Wind generator



For a better substantiation of the results and conclusions, we considered that the simple analysis of the searches by the six keywords is not enough. In order to better understand the reasons behind changes in the volume of data, the installed capacity for the use of wind energy requires consideration. To this end, we examine the annual capacity that has been installed for both onshore and offshore wind turbines, and also take into account the total annual installed capacity. The installed capacity data shown in Figure 5 were taken from the Global Wind Energy Council (2022) reports [18].

As can be seen in Figure 5, the total annual installed capacity, and the onshore wind capacity (A and B) show a similar evolution. The explanation for this trend is that the share of onshore wind generators in the total installed wind capacity is 90%.

Figure 5. Annual installed capacity of onshore (A) and total wind capacity (B), annual installed offshore wind capacity (C) and total installed offshore wind capacity (D). **Note:** (•) A: onshore, C: Annual offshore; (▪) B: Total, D: Total offshore.



The graph in Figure 5 (showing the rate of increase in newly installed wind capacity) can be segmented into three sections:

Section 1

2004 - 2009: the evolution shows an increase, and the average growth rate is 36%, with changes of+6% from one year to another, both in terms of onshore wind capacity (A) and total wind capacity (B).

Section 2

2010 - 2018: the evolution shows a slower development, with large variations from one year to another, the average rate standing at 4%, and the variations are+19%.

Section 3

2019 - 2021: after 2018, we notice a significant increase, on average by 18% per year, and the registered variations are at+2% from one year to another.

What ultimately resulted was that the three sections we identified in Figure 5 (onshore and total) correlated with the search volume for the 6 keywords we chose (WP, WE, OW, WF, WT, and WG). It should be noted that in terms of OW (which is a slightly newer technology than onshore, because the total installed capacity reached 2 GW only in 2009) Figure 5, graph C shows two periods of growth:

Period 1

2006 - 2014: a period of slow growth, with an average value of 0.7+0.5 GW per year.

Period 2

2015 - 2021: it can be considered a period of accentuated growth, with an average value of 4.1+1.8 GW per year.

Again, the rapid growth period after 2014 corresponds to the increasing evolution of the search frequency for the keywords OW (Figure 4). Most importantly, the installed annual offshore capacity in 2021 has increased to 21.1 GW, representing a very large increase with respect to previous years. The Google Trends interest for the OW search keyword shows a strong correlation with the newly installed capacity.

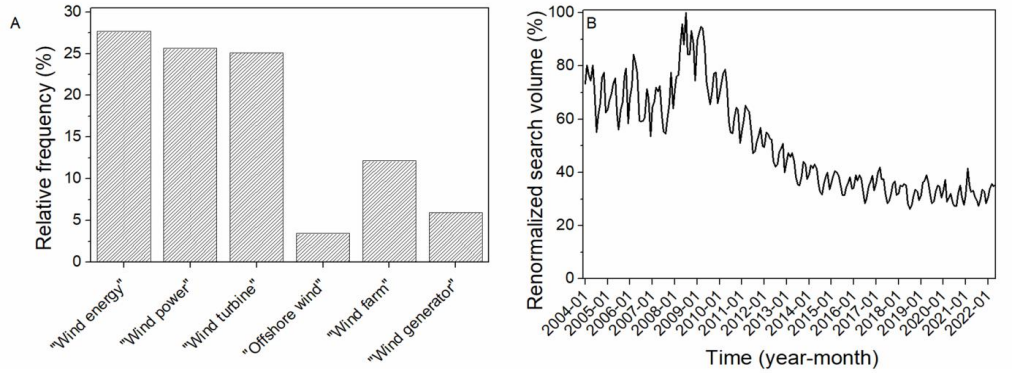
Regarding the calculation of the relative frequency of the maximum values for each of the six keywords, this was done for the time interval between 2004 and 2021, as can be seen in Figure 6A. We note that most searches for the field or subject of wind energy (out of the total volume of searches) were made for the words WE (28%), WP (26%), and WT (25.2%).

For the other keywords, the searches had a very low frequency, respectively 3.2% for OW (correlated with only 4.9% installed capacity of the total), around 15.5% for WF, and about 6% for WG.

Figure 6B shows the evolution of the aggregate number of searches by the six keywords, which decreased steadily after 2009 and until the end of the investigated timeframe. The maximum value was reached in 2008, then the decrease was relatively sharp until 2016. Therefore, both the aggregate amount and the individual values for the keywords (except OW, for which interest has increased since 2015) show a decrease after the maximum recorded value in 2008. The result is a decrease in public interest in the subject of wind energy.

However, the OW keyword still represents a small fraction of the total Google search data on the topic of wind energy, even if the offshore installed capacity in 2021 represented 22.5% of the total installed wind capacity for this year.

Figure 6. (A) Relative frequency of the six keywords; (B) The normalized sum of the six wind energy keywords.



Next, we found it relevant to take a look on geographic search frequency distribution, as Google Trends provides data for this approach as well, as shown in Table 2.

According to Al-Eroud, the public in English-speaking countries (United Kingdom, New Zealand, Ireland, Australia, Canada, United States, etc.) stand at an advantage, but even so, the interest in wind energy is high in all regions the world [19].

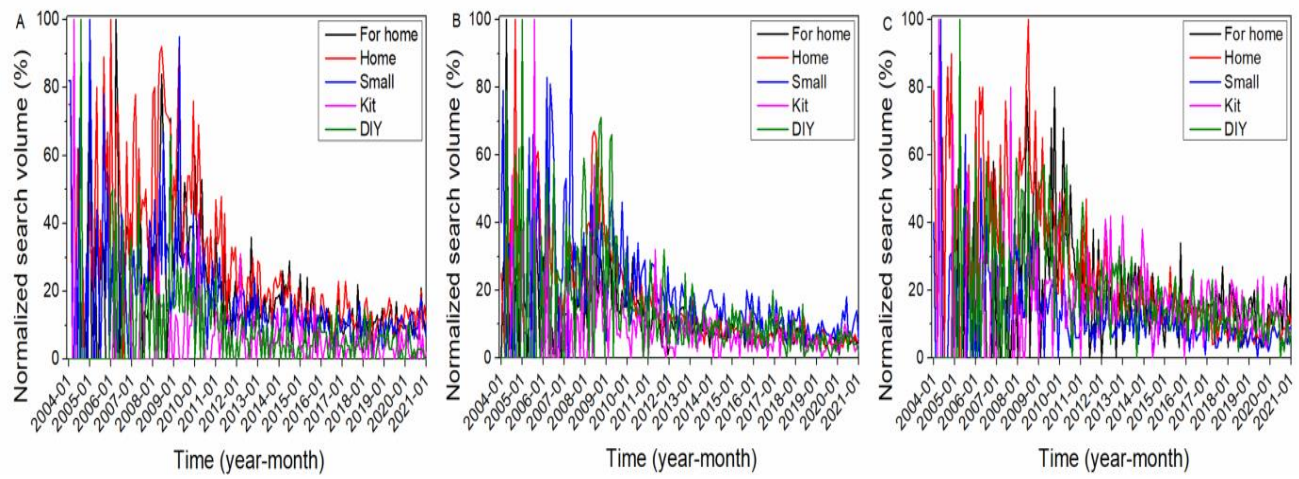
Table 2. Ranking of the top 10 countries in terms of geographic distribution of searches for each keyword.

Wind Energy (WE)	Wind Power (WP)	Wind Turbine (WT)	Offshore Wind (OW)	Wind Farm (WF)	Wind Generator (WG)
Ethiopia (100%)	Denmark-100%	Ireland (100%)	Denmark (100%)	Ireland (100%)	Estonia (100%)
Jamaica (98%)	Ethiopia (67%)	United Kingdom (79%)	Norway (89%)	Australia -65%	New Zealand (86%)
Trinidad and Tobago (94%)	Australia (52%)	New Zealand (59%)	St. Helena (88%)	United Kingdom (65%)	Australia (83%)
Ireland (92%)	Canada (51%)	Australia-58%	United Kingdom (69%)	Jamaica (48%)	South Africa (73%)
India (70%)	Kenya (47%)	Denmark-55%	Ireland (45%)	New Zealand (42%)	Canada (61%)
Australia (67%)	United Kingdom (45%)	Canada (54%)	Netherlands-39%	St. Helena-41%	United States (61%)
South Africa (67%)	Sri Lanka (41%)	South Africa (51%)	Singapore (34%)	Denmark-27%	Lebanon (52%)
United States (61%)	United States (40%)	United States (50%)	South Korea-33%	South Africa (27%)	Ireland (52%)
Canada (61%)	New Zealand (40%)	Lebanon (37%)	Belgium (25%)	Canada (24%)	United Kingdom (48%)
Philippines-58%	India (39%)	Pakistan (32%)	Germany (24%)	United States (20%)	Philippines-45%

Moreover, interest is high regardless of the level of development of countries (developing or developed). A ranking of the top 10 countries for the six keywords associated with wind energy is presented in Table 2. We note that the countries with a geographically advantageous position for wind energy (usually island countries) occupy the highest ranks [20,21].

In previous studies, the same methodology was used to assess the public interest in the field of solar energy. It has been found that interest in extended solar installations has decreased, and interest in smaller or even smaller solar installations has increased [22]. In this regard, to test whether wind energy follows the same trend, several compound keywords were chosen, which also contain words that express small size, such as small, home, for home, kit or diy (Figures 7A-7C).

Figure 7. Google search data for selected keywords containing terms related to small-scale wind power use for (A) Wind Energy (B) Wind Power (C) Wind generator. **Note:** (—) For home; (—) Home; (—) Small; (—) Kit; (—) DIY



Unlike research on solar energy, words associated with interest in small-scale wind energy have the same evolution as parent keywords, as shown in Figure 7A. That is, the frequency of searches decreases after the highest value was recorded in 2008, 2009 or 2010.

However, of all the keyword searches that were associated with a word associated to small size, the highest recorded interest was in the WG keyword.

CONCLUSION

Public interest towards wind energy was assessed using Google search data, freely provided by the Google Trends service, in the January 2004 January 2022-time range. The present study brings novelty first by use of a novel method towards the assessment of public interest towards the wind energy topic, which has shown rapidly evolving public and private attempts in penetration expansion, as well as global aspirations, and regional policies in its support.

Six English wind energy- related search engine keywords were investigated. Onshore WP related keywords all follow the same pattern, with periods of increasing frequency that reach maximum values in 2008-2011, and a subsequent decline until the year 2017. The only increase in search frequency is registered by the OW keyword from 2015 onwards, with a maximum registered value in 2018. Results remain valid upon correction for changes in search engine language preferences. Due to the fact that the investigated keywords are in English, the geographical distribution of the proposed search frequencies remains biased towards English speaking

countries which feature high internet connectivity. Despite this fact, the results show a global interest towards wind energy topics across developed and developing countries.

Reported public interest towards a given topic exerts influence on both consumer behavior and public policy priorities. Although the global installed WP registers an increase in the 2004-2020 timeframe, our results show that public interest towards wind energy has decreased, registering lower overall values in 2020 than in 2004. The single exception from this analysis was registered for the OW keyword, which reaches a maximum value in 2018. This exception is not surprising, and the search volume for OW in 2018 is only 2% higher than in 2010. Is increase in interest towards offshore WP can also be understood because offshore wind technology is newer than the others and installed offshore capacity started to increase in the 2010-2020 decade. The annual installed offshore capacity reaches 22.5% of total annual installed wind capacity in 2021, increasing from 7.2% for the previous year. This marked increase is correlated with the increase in Google searches. However, the interest for offshore wind energy has only increased by 18.6% in the same time interval. These results suggest that more action should be undertaken towards raising support and public awareness towards forms of renewable energy such as wind in the immediate future.

Future research of this type that may bring added value to our research topic may reveal new results when directed towards a comparison between wind and other renewable energy topics.

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