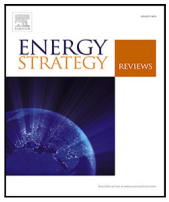
Energy Strategy Reviews 50 (2023) 101243

Contents lists available at ScienceDirect

Energy Strategy Reviews

journal homepage: www.elsevier.com/locate/esr



Public perspective on renewable and other energy resources: Evidence from social media big data and sentiment analysis☆

Dahye Jeong [a,b], Syjung Hwang [c], Jisu Kim [d], Hyerim Yu [e], Eunil Park [a,e,f,*]

[a] Department of Applied Artificial Intelligence, Sungkyunkwan University, Seoul, Republic of Korea
[b] Robotic Intelligence Laboratory, Universitat Jaume I, Castellón de la Plana, Spain
[c] Dreamus Company, Seoul, Republic of Korea
[d] AgileSoDA Company, Seoul, Republic of Korea
[e] Department of Interaction Science, Sungkyunkwan University, Seoul, Republic of Korea
[f] Teach Company, Seoul, Republic of Korea

ARTICLE INFO

Dataset link: https://github.com/dxlabskku/RenewableEnergy

Keywords:
Public perspectives
Renewable resources
social media big data

ABSTRACT

To address global climate change, many countries are reducing CO2 emissions and replacing conventional energy resources with alternative ones. When developing national energy plans, it is essential to investigate public perspectives on the relationship between renewable and other energy resources. This study employs sentiment and correlation analyses of social media data to assess public perspectives on the complex relationships between renewable and other energy resources. The results show that renewable energy and nuclear energy have a complementary relationship in terms of positive emotions, but a substitute relationship in terms of negative emotions. These findings can inform regional and national energy plans and policies for renewable and nuclear energy. Additionally, this study demonstrates that the proposed methodology can be used to assess public perspectives on various energy resources.

1. Introduction

The energy industry is an essential part of our society and is essentially related to both economic growth and quality of life worldwide [1]. Currently, the world is facing a global energy crisis mainly due to the COVID-19 pandemic and Russia's invasion of Ukraine [2]. Prices of natural gas and oil have reached unprecedented levels, and many countries are taking necessary measures to avoid energy shortages and high energy prices [2]. In addition, we face fossil energy depletion and environmental deterioration [3]. Therefore, the interest in the alternative energy is constantly increasing worldwide [4].

Considering the trajectory of global energy consumption, several organizations have begun to prepare and operate new policies for reducing environmental pollution and providing collaborative plans for the future [5]. Moreover, several nations have included alternative energy sources as focus areas in their national energy plans (e.g., China [5], EU [6], the United States [7], and South Korea [8]). For instance, the United States announced its national energy plans, which project the share of renewable energy sources to reach 38% by 2050, compared to 19% in 2019 [9]. The South Korean government announced its 2020 energy plans to invest in renewable energy facilities as an important national component of the "Green New Deal" policy [10].

In the short term, national and local governments should promptly respond to the rapid increase in energy demand by diversifying energy sources through energy-mix plans. In the long term, they should simultaneously address the stability and environmental concerns of energy facilities [11,12]. Here, the energy mix is defined as "*a group of different primary energy sources from which secondary energy for direct use–such as electricity–is produced.*" [13]. Hence, renewable energy sources should be considered as an essential component in national energy mix plans. Short-term energy plans tend to employ renewable sources as complementary energy sources, whereas long-term plans aim to substitute traditional energy sources with renewable energy sources [14,15]. This implies a huge transition, which can create profound changes in the energy industry structure. Thus, the use of conventional energy sources (e.g., oil and gas) will be reduced, while the utilization of renewable energy sources will be expanded [16].

☆ This research was supported by the MSIT (Ministry of Science and ICT), Korea, under the ICAN (ICT Challenge and Advanced Network of HRD) program (IITP-2020-0-01816 and IITP-2023-RS-2023-00259497) supervised by the IITP (Institute of Information & Communications Technology Planning & Evaluation). This work was also supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2023S1A5A8075518).

* Correspondence to: 310 International Hall, Sungkyunkwan University, 25- Sunkyunkwan-ro, Jongno-gu, Seoul, 03063, Republic of Korea.
E-mail address: eunilpark@skku.edu (E. Park).

https://doi.org/10.1016/j.esr.2023.101243
Received 4 May 2023; Received in revised form 25 September 2023; Accepted 19 October 2023
Available online 27 October 2023

Although adopting renewable energy sources as substitutes or complementary energy sources has been on the agenda of several countries for some time, the implementation process is relatively slow. This is mainly due to the difference in economic aspects between traditional and renewable energy sources [17], which lays a burden on both consumers and energy providers [18]. The role of renewable energy resources in the national economic market is a crucial issue for the government. By promoting renewable energy consumption, we can create a sustainable consumption and production pattern that is free from environmental problems in the long term [19]. CO_2 emissions show a negative correlation with nuclear energy and governmental consumption expenditures, but a positive relationship with economic growth [20]. Moreover, transitioning to sustainable energy sources not only enhances economic growth but also improves the long-term quality of the environment [21].

Understanding the relationships and roles of various energy resources is vital for informed government policy-making, and exploring the public perspective plays a significant role in achieving this goal. Since most governments intend to incorporate public opinions in drafting major policies, it is important to understand people's perspectives of the proposed policies being discussed. For example, in the case of an energy-related policy, both local and national governments would like to understand the public opinion on the substitute and complementary relationships between renewable and non-renewable energy sources or facilities. Especially, when energy facilities are established in specific areas (e.g., nuclear power plants), the national and local governments should reflect public opinions to reduce negative reactions to the facilities. In other words, understanding public perspectives can help governments to establish energy-related policies that can be better implemented and assessed [22]. However, understanding public perspective towards different types of energy sources is complex [23].

Several researchers have attempted to understand the complex relationships between renewable and non-renewable energy sources from both economic and social aspects. For example, [24] found that reducing the price of renewable energy sources led to the tendency of replacing the use of fossil fuels and accelerated the distribution of production facilities for renewable energy sources globally in 2017. Thus, utilizing renewable energy sources can lead to both diversification and transition in the global energy industry. Furthermore, [25] analyzed the relationship between carbon emission and renewable energy in terms of economy. They found out that renewable energy consumption and carbon emission have a negative relationship. Financial development and carbon emission also have a negative relationship. Hence, it is important to discuss how we manage, plan, and utilize energy resources to reduce potential social, environmental, and economic damages. [26] also explored the relationship between nuclear energy, economic growth, and carbon emissions. The analysis results showed that economic growth increased with increasing nuclear and renewable energy consumption. Additionally, carbon emissions increased with increasing oil and natural gas consumption.

To date, several articles have explored the price of specific energy sources using time series methods [27,28]. Some scholars investigated the impact of energy resources on economic growth and carbon emissions using panel datasets to apply time-varying analysis methods [29–33]. Few studies have investigated public perspectives on the complex relationships between renewable and non-renewable energy sources. In addition, most of the previous studies employed a survey-oriented approach [34,35]. However, these surveys are expensive and it is difficult to generalize the results of a small-scale survey as the overall public perspective. Additionally, conducting the surveys demands significant resources. Although the interview method has been employed for perception research [36], recruiting interviewees and collecting data through interview is not a straightforward task. Thus, a novel method is required for analyzing public perspective of energy using large-scale datasets. Currently, sentiment analysis is the predominant method used for perspective research. It is widely employed as the means to explore public perspectives and preferences [37].This study explored the public perspective toward renewable and multiple non-renewable energy sources using a social media dataset and examined their relationships. The following research questions were addressed in this study:

- Can we examine whether social media represents public perspectives towards renewable and non-renewable energy sources?
- Can we explore the potential substitutes or complementary relationships between energy sources using sentiment and correlation analysis?

Moreover, our main contributions are summarized as follows:

- We investigated the relationship between the renewable and multiple non-renewable energy resources concerning public perspective by analyzing the social media dataset.
- We conducted both sentiment and correlation analyses to explore public perspective and identify specific reasons for the relationships between renewable and the other energy resource.
- This research revealed a significant complementary relationship between renewable and the other energy resources from a long-term perspective.
- In this article, we presented an effective methodology for examining the public perspective towards multiple energy resources.

In this paper, the term 'public perspective' refers to the collective sentiment expressed through positive or negative opinions towards a specific target.

2. Literature review

2.1. Public opinion toward specific issues related to energy

The growing interest in climate change and energy security has led to not only the examination of numerous renewable energy sources but also a diverse and deep exploration of people's attitudes toward various renewable energy sources. Governments often attempt to reflect people's perspectives when drafting new policies, such as those on renewable energy [38]. And some previous studies have sought to assess public perspectives of renewable energy sources.

[39] analyzed the conflicts toward renewable energy facilities such as the "not in my backyard (NIMBY)" phenomenon of the public. The NIMBY phenomenon refers to the public attitude in which people positively evaluate "something" as long as that "something" is not in their backyard. NIMBY phenomenon and anti-nuclear protests significantly increased after the Fukushima nuclear disaster, an accident such as three nuclear meltdowns, three hydrogen explosions, and radioactive contamination. With this background, the researchers conducted a face-to-face survey to examine the public perception of nuclear power plants in China. They attempted to measure people's willingness to pay for the construction of nuclear power plants in their neighborhoods through the contingent valuation method. Their results suggested that people had a strong NIMBY attitude toward nuclear power plants, as evident from the extremely low willingness to pay for the households (extra US$ 80.106–116.604). Through comparative group research, they highlighted that both the providing comprehensive information on nuclear power plants and creating transparency in energy-related policies are crucial for reducing negative public attitudes toward certain energy types.

[40] studied the influential effects of public opinions on the introduction of new policies related to renewable energy in several European countries. They analyzed data on public attitudes toward the environment and outcomes of renewable energy policies from 1974 to 2015. Their results indicated that public opinion alone could not change renewable energy policies, although it played a notable role and served as a catalyst in changing renewable energy policies.

Recently, social media has emerged as a valuable platform for gauging public perceptions of specific energy resources. For example, [41] examined public attitudes towards nuclear energy resources by analyzing approximately four million posts on four social networking services in South Korea using a sentiment analysis approach. Their results showed that public attitudes towards nuclear energy resources were significantly affected by energy-related issues and policies. Similarly, [42] used keyword and opinion analyses to investigate public perceptions of nuclear energy using social media data. They found that public attitudes towards nuclear energy could be easily swayed by certain negative nuclear events. Moreover, [43] proposed a social media-based analysis approach to mine public opinions on energy-related topics. [44] investigated public perceptions of blue hydrogen, as the financial costs of hydrogen appliances are the principal concern for most consumers.

Overall, public attitudes or opinions toward various energy resources have been extensively assessed across many nations. However, the majority of prior studies focused on how energy-related issues affect public attitudes and employed a survey-oriented approach to obtaining attitudes regarding a single energy resource. In addition, public perceptions of the complex or casual relationships among energy resources have not been investigated in detail. With this background, the present study considered a topic-oriented social network service and assessed not only public attitudes toward renewable and non-renewable energy resources but also the perceived relationships among these resources.

2.2. Relationships between energy sources

2.2.1. Fossil fuel and renewable energy

In 2018, approximately 27% and 23% of the global energy was produced using coal and natural gas, respectively [2]. Coal, which accounted for 26.9% of the global electricity production in 2018, has been considered a major energy resource [45]. However, both coal and natural gas produce greenhouse gases, which cause global warming and climate change [46]. A single unit of coal and natural gas generates 1.15 and 0.75 tons of carbon dioxide per MWh, respectively.

In the United States, fossil fuel combustion used for generating electricity was the second largest CO_2 emission source in 2018, accounting for about 32.3% of the total emissions. However, different types of fossil fuels have different CO_2 emissions per unit. For example, burning coal for electricity production produces more CO_2 than using natural gas or crude oil [47]. The global oil crisis has made most countries to understand the importance of reliable energy resources [48,49]. Consequently, they have started to explore and employ renewable energy resources to enhance their national energy security. For instance, the concept of "*transition to renewable energy*" has been used to reduce our dependence on oil and fossil fuel in both developed and developing countries [50,51]. In addition, most countries need to implement new environmental policies for reducing the use of fossil fuel to improve the environment quality [52,53]. Building reliable and sufficient energy supply systems is an important task for most countries [54].

Despite their efforts to reduce dependence on traditional energy resources, countries face many obstacles such as technical and economic aspects in successfully distributing facilities for alternative energy resources [55]. Social and economic burdens on users are seriously considered in several countries [56,57]. Therefore, these burdens and public perspectives of renewable energy resources should be studied to provide a better understanding of the resources and the national energy/electricity systems [58].

2.2.2. Nuclear and renewable energy

Originally, nuclear energy was considered a relatively clean and stable energy resource [59]. This led to an increased usage of nuclear and renewable energy resources, thus reducing CO_2 emissions [60,61]. This can be interpreted as a complementary relationship between nuclear and renewable energy resources.

However, after the Fukushima nuclear accident in 2011, there have been numerous debates on using nuclear energy resources and the relationships between nuclear and other energy resources [62]. Moreover, the utilization of nuclear energy resources significantly reduced during the COVID-19 pandemic (−3% in 2020), while the use of renewable energy resources expanded by approximately 3% in 2020 [45]. Hence, considering nuclear accidents and COVID-19, we assumed that there is a substitute relationship between nuclear and renewable energy resources.

2.2.3. Fossil fuel and social issues

Some scholars also investigated the relationship between energy sources and various other issues. For example, [27] examined the relationship between terrorist attacks and oil prices, finding that while they do impact each other, the effects differ. Terrorist incidents have mixed effects on oil prices, while brutality has consistently negative but weaker effects. [27] also observed that there is limited evidence that terrorist attacks respond significantly to oil prices. This research can help market participants analyze terrorism's impact on oil prices for investment and risk strategies in the oil markets. Additionally, [28] used a TVP-SV-VAR model to assess the impact of uncertainty risk on oil prices. They also observed a diminishing influence of supply and demand dynamics on oil prices, with notable oil price shifts attributed to major events like the global financial crisis and the 9/11 attacks.

2.3. Sentiment analysis method

2.3.1. Sentiment analysis and public perspective

Prior research has suggested various methods and applications of sentiment analysis [63]. Sentiment analysis has been utilized at different levels, including document-level, sentence-level, and aspect-level analysis. Several articles have employed sentiment analysis to explore customer perceptions or public opinions towards products or services. However, this paper focuses on using sentiment analysis to gain an approximate understanding of the general public's perceptions towards a specific subject.

Furthermore, the paper examines the public perception of COVID-19 using a Twitter dataset [64]. They utilized various methods, such as analyzing keyword frequencies, sentiment analysis, and topic modeling to analyze the discussions. The results revealed a negative perception of COVID-19 based on sentiment analysis. Additionally, the study found that valuable information about public trends and direct investigations could be obtained from the data.

Prior research has also aimed to explore potential disparities between social media and traditional media concerning discussions on specific issues, using sentiment analysis. Twitter was selected as the social media platform for the research and data related to the target of analysis were collected from Twitter. The research findings indicated an intensification of polarization and imbalance in sentiment within the social media discussions [65].

2.3.2. Sentiment analysis toward energy

Using a sentiment analysis is useful to capture public opinion and to implement the energy-related policies. Several researchers employed sentiment analysis on the datasets collected from social network services or academic articles to examine public perceptions of specific energy sources [66]. [67] examined the United States public perceptions toward solar energy based on the *Twitter* dataset. They analyzed the sentimental score of each tweet and showed that there are regional sentimental differences toward solar energy. In detail, the tweets in the northeast region were more positive than those in the south region. Further, sentiment analysis was utilized to examine public perceptions of nuclear energy in South Korea [68]. The result indicated that positive articles on nuclear energy are more frequently posted than negative

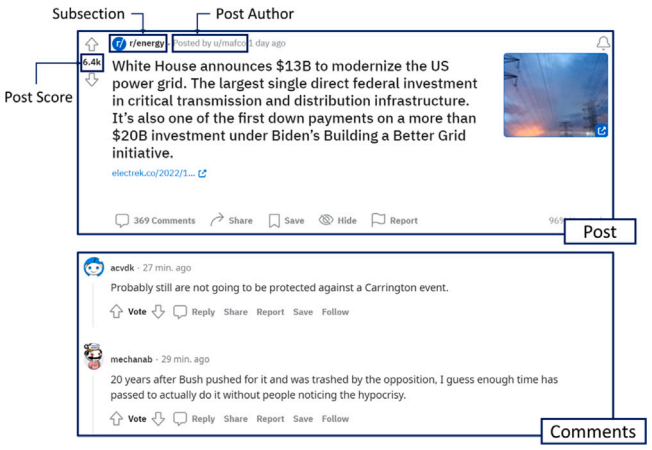


Fig. 1. The representative example of a post and comments on subreddits; A post consists of subsections representing the topic, a post score representing the post's views, the post author, and the content.

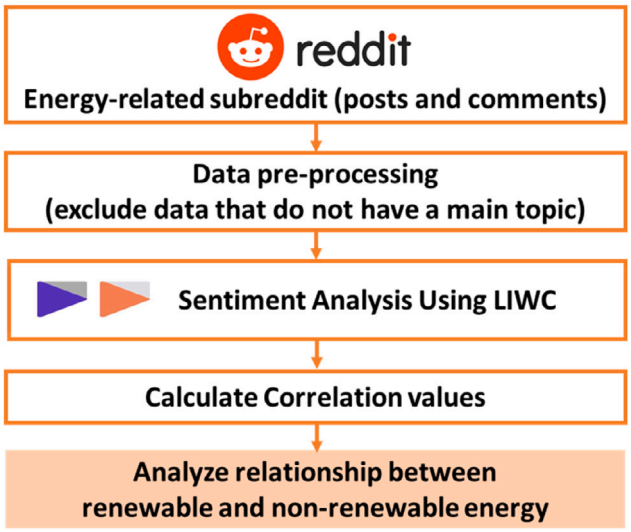


Fig. 2. The overall procedures; We collected energy-related posts and comments from Reddit and conducted data preprocessing, sentiment analysis, and correlation analysis.

articles. It was also found that the number of negative comments on nuclear energy issues was greater than that of positive comments. [43] analyzed the public perception of Alaskans through sentiment analysis and confirmed that their attitude toward renewable energy had gradually changed positively.

Previous studies have used sentiment analysis to analyze public perceptions of energy [66], but they have mainly focused on single energy resources. This study analyzes the complex relationship between renewable and non-renewable energy sources from the public perspective. We use both sentiment and correlation analyses to examine the public's understanding of these energy sources.

3. Methodology

3.1. Data collection

We collected a social media dataset from *Reddit* [69], an online discussion community with various sub-channels called "subreddits" that address and discuss particular topics. Each sub-channel is denoted by /r/, followed by the name of the subreddit, for example, $/r/gaming$.

Previous research collected Reddit posts and comments to explore public perceptions of energy [41,66,70,71]. Following these studies, we collected the posts and comments of users from energy-related subreddits (e.g., wind energy, nuclear power, and coal) between March 1, 2011 and August 31, 2020. Fig. 1 shows an example of the post and comment from the collected dataset. We used the pre-2020 dataset to analyze the relationship between energy sources prior to COVID-19.

3.2. Data pre-processing

For data pre-processing, we used the Natural Language Toolkit (NLTK), which is one of the Python packages for natural language processing and document analysis [72–75]. We selected subreddits, sections, and descriptions from the collected datasets (Table S.1 in Supplementary Information), excluding the posts and comments that did not address the main topics and issues discussed in each subreddit. Main topic contains five energy resources (energy, renewable energy, nuclear power, fossil fuel, and oil) and electricity. Then, we applied lemmatization and stemming to the raw text of the dataset and extracted nouns and verbs containing auxiliary verbs using the NLTK library.

3.3. Measurements

The overall procedures of our analysis are presented in Fig. 2.

3.3.1. Sentiment analysis

We conducted a sentiment analysis of the pre-processed posts and comments to explore people's perspectives toward various energy sources. To examine the sentiment analysis, we utilized the linguistic inquiry and word count, which is a text analysis library for computing sentiment scores of words in different categories (e.g., affective, cognitive, social, and positive/negative statements [76–78]). We also used the presented level of positive and negative emotions for each post or comment to analyze the correlation values among the energy resources [79].

3.3.2. Correlation between renewable and other energy resources

We analyzed the correlations among five different energy resources, in addition to "energy" as a whole. We then used Pearson's correlation coefficient (r) with the following equation in terms of two sentimental dimensions: positive and negative emotions [80].

$$\rho_{XY} = \frac{cov(X,Y)}{\sigma_X \sigma_Y} \tag{1}$$

In Eq. (1), X is the level of positive (or negative) emotions, and σ_X is the standard deviation of the corresponding positive (or negative) emotions shown for renewable energy. Y is the level of emotion for one of the other energy sources, and σ_Y is the standard deviation of the corresponding positive (or negative) emotions expressed for the other energy source.

4. Results

4.1. Correlation analysis: annual

Tables S3–S11 (see Supplementary Information) present the summary of the results. Fig. 3 shows a summary of the correlation analysis with positive emotions. In this study, Pearson's correlation coefficient (r) was used to analyze the correlation between positive emotions. A high positive value suggests a direct proportionality between the frequency of positive keywords associated with two energies. Conversely, a high negative value indicates an inverse relationship, implying that as the frequency of positive keywords increases for one energy, the frequency of positive keywords for the other energy decreases. There was a strong positive correlation between renewable and nuclear energies ($r = 0.93$, $p < 0.001$), whereas a negative correlation between renewable energy and fossil fuels was observed ($r = -0.8$, $p < 0.05$).

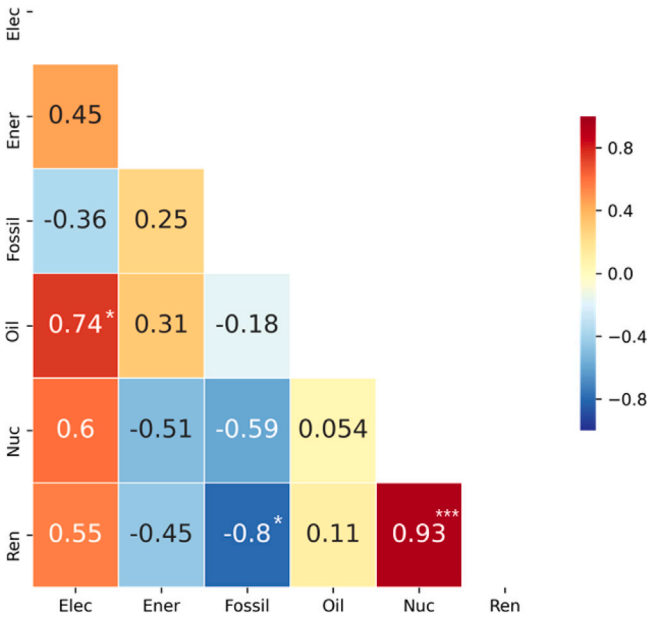


Fig. 3. Results of correlation analysis with positive emotions (annual); The darker the color and the larger the absolute value of the number, the stronger the correlation between the two energies. An asterisk (*) indicates a statistically significant correlation.

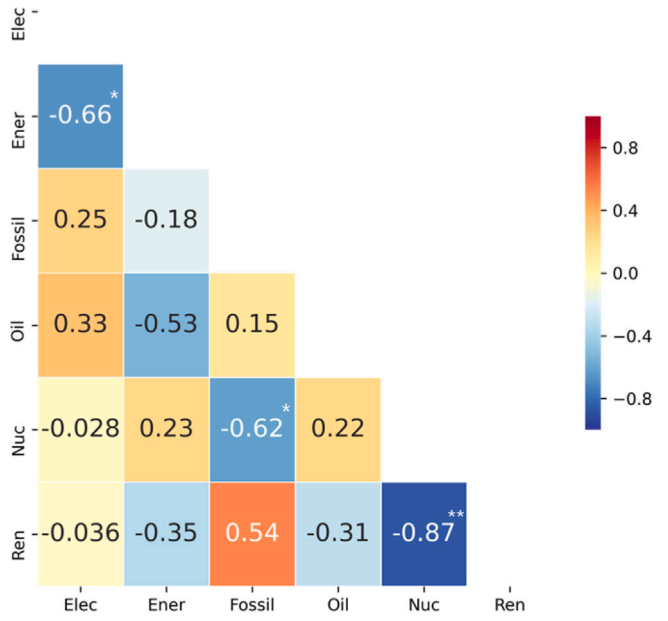


Fig. 4. Results of correlation analysis with negative emotions (annual); The darker the color and the larger the absolute value of the number, the stronger the correlation between the two energies. An asterisk (*) indicates a statistically significant correlation.

This means that a higher frequency of positive words on renewable energy was associated with a higher frequency of positive words on nuclear energy and a lower number of positive words on fossil fuels. Hence, we inferred that there was a partial substitute relationship between renewable energy and fossil fuels, whereas a complementary association existed between renewable and nuclear energies. However, no significant relationship between renewable energy and oil was evident ($r = 0.11$, $p > 0.05$).

Fig. 4 presents the results of correlation analysis with negative emotions. In correlation analysis involving negative emotions, a high positive value indicates direct proportionality between the frequency of negative keywords associated with two energies. In other words, as the frequency of negative keywords increases for one energy, the frequency of negative keywords also increases for the other energy. Conversely, a high negative value indicates an inverse relationship implying that as the frequency of negative keywords increases for one energy, the frequency of negative keywords for the other energy decreases. There is a negative correlation between renewable and nuclear energy, with a correlation coefficient of −0.87 ($p < 0.01$). This indicates that as the number of negative words on nuclear energy increased, the number of negative words on renewable energy decreased. Accordingly, we can interpret that nuclear and renewable energies show a substitute relationship.

Our research results, like those of previous research, justified the methodology of analyzing public perception through social media data. Furthermore, our results are consistent with earlier research, which suggested that when negative thoughts or issues related to nuclear energy arise, the public tends to harbor negative sentiments [41]. These findings support the notion of a potential complementary or substitute relationship between renewable and nuclear energy.

4.2. Correlation and keyword analyses: monthly

We analyzed the monthly frequency of keywords for six sections (five energy resources and electricity) to present unique keywords for each section. Figures S1–S4 (see Supplementary Information) display the results of word clouds using frequently occurring keywords from posts and comments related to each energy resource. These word cloud images provide insights into the keywords associated with each energy resource, helping us understand how the public perceives and associates certain concepts with them. Additionally, we calculated the correlation coefficient between negative and positive emotions associated with renewable and non-renewable energy on a monthly basis. We have listed the results for correlation coefficients that are 0.7 or higher while summarizing the remaining results in the supplementary information (see Table 1).

4.2.1. Negative emotion

In November 2011, renewable energy and oil showed a strong positive correlation with a coefficient of 0.91 ($p < 0.05$). The most frequent keywords related to renewable energy were “solar”, “power”, “energy”, “job”, and “get”, whereas those related to oil were “have”, “acres”, “oil”, “mineral”, and “amount”.

In November 2012, renewable energy and oil showed a strong positive correlation with a coefficient of 0.90 ($p < 0.05$). The most frequent keywords for renewable energy were “solar”, “have”, “power”, “energy”, and “costs”, whereas those for oil were “oil”, “Saudi”, “car”, “use”, and “overtake”.

In February 2014, renewable energy and fossil fuel showed a strong positive correlation with a coefficient of 0.86 ($p < 0.05$). The most frequent keywords for renewable energy were “solar”, “have”, “panels”, “system”, and “do”, whereas those for fossil fuel were “coal”, “burning”, “underground”, “experiment”, and “lacked”.

In October 2015, renewable energy and electricity showed a positive correlation with a coefficient of 0.74 ($p < 0.05$). The most frequent keywords for renewable energy were “solar”, “have”, “energy”, “power”, and “get”, whereas those for electricity were “electricity”, “tennessee”, “tva”, “power”, and “distribution”.

In July 2016, renewable energy and fossil fuel showed a strong positive correlation with a coefficient of 0.95 ($p < 0.05$). The most frequent keywords for renewable energy were “solar”, “have”, “power”, “panels”, and “do”, whereas those for fossil fuel were “coal”, “LNG”, “workers”, “vote”, and “years”.

In December 2018, renewable energy and fossil fuel showed a strong negative correlation with a coefficient of −0.75 ($p < 0.05$). The most frequent keywords for renewable energy were “solar”, “have”,

Table 1
Results of keyword counts in each energy section; The top five keywords that appear most frequently in posts and comments for each energy resource.

Rank	Energy	Renewable energy	Nuclear power	Fossil fuel	Oil	Electricity
1	energy	solar	nuclear	coal	oil	electricity
2	solar	have	have	gas	gas	power
3	power	energy	power	energy	prices	energy
4	oil	power	energy	solar	production	voltage
5	nuclear	do	fuel	power	energy	current

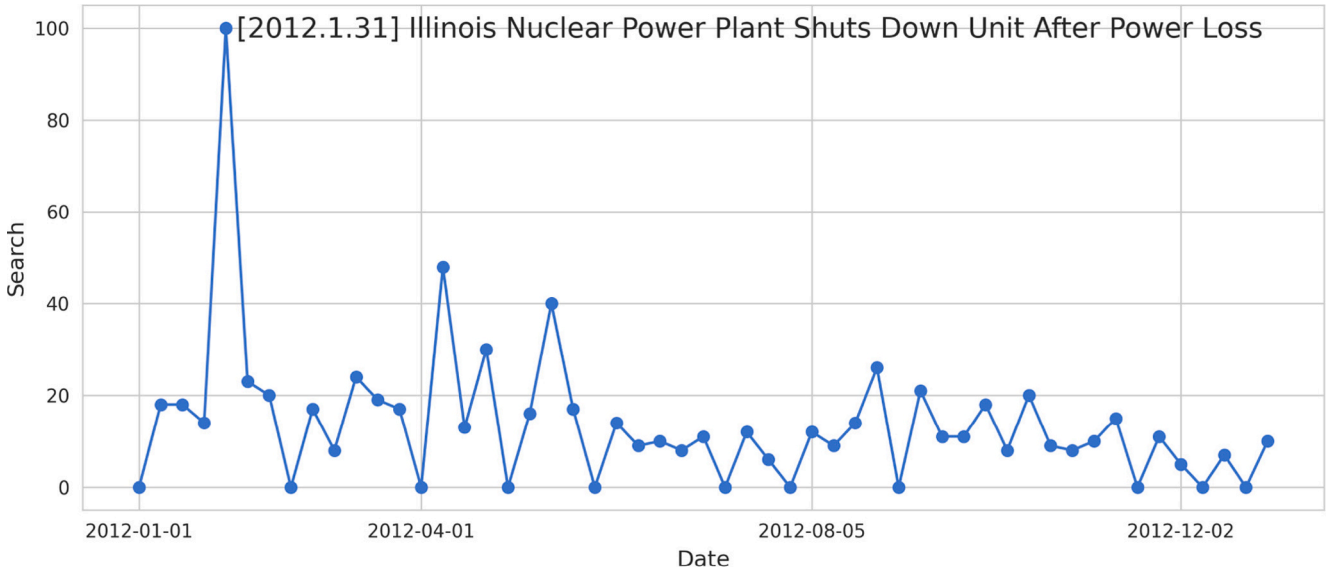


Fig. 5. Search engine results of *Google Trends* and news title about 'Illinois nuclear'.

"subreddit", "new", and "post", whereas those for fossil fuel were "gas", "coal", "app", "get", and "global".

In September 2019, renewable energy and fossil fuel showed a strong negative correlation with a coefficient of −0.99 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "have", "do", "subreddit", and "panels", whereas those for fossil fuel were "coal", "history", "premature", "declare", and "dead–domestic".

4.2.2. Positive emotion

In January 2012, renewable energy and nuclear energy showed a positive correlation with a correlation coefficient of 0.84 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "energy", "solutions", "power", and "volume", whereas those for nuclear energy were "nuclear", "plant", "illinois", "power", and "french". We confirmed that there were several search engine results on '*Illinois nuclear*' in January 2012 [81]. This is because there was a nuclear power plant shutdown accident in Illinois at that time [82]. The search engine results are presented in Fig. 5. It indicates that the number of positive words for both nuclear and renewable energy resources decreased. Accordingly, we can infer that both energy resources have a complementary relationship, in terms of positive emotions.

In March 2012, renewable energy and oil showed a positive correlation with a coefficient of 0.84 ($p < 0.05$). The most frequent keywords for renewable energy in March 2013 were "solar", "have", "power", "need", and "battery", whereas those for oil were "oil", "happy", "birthday", "big", and "tax".

In April 2012, renewable energy and oil showed a positive correlation with a coefficient of 0.99 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "energy", "system", "panels", "costs", whereas those for oil were "flash", "lube", "oil", "service", and "check".

In April 2013, renewable energy and oil showed a positive correlation with a coefficient of 0.77 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "have", "energy", "system", and "panels", whereas those for oil were "oil", "spill", "Arkansas", "EXXON", and "couple". We observed that there was an oil spill accident at ExxonMobil pipeline in Mayflower in this period [83], and the search engine results are shown in Fig. 6. In addition, the keywords for oil are crucially related to the oil spill accident. This means that the low frequency of positive words on oil was associated with a low frequency of positive words on renewable energy. Hence, we can interpret that oil and renewable energy had a complementary relationship in terms of positive emotions.

In August 2013, renewable energy and oil showed a negative correlation with a coefficient of −1.00 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "have", "system", "get", and "panels", whereas those for oil were "Carduchi", "Kurdistan", "region", "energy", and "briefings".

In January 2014, renewable energy and oil showed a positive correlation with a coefficient of 0.78 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "have", "energy", "panels", and "like", whereas those for oil were "oil", "years", "high", "quality", and "Australia".

In January 2014, renewable energy and fossil fuel showed a positive correlation with a coefficient of 0.86 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "have", "power", "energy", and "get", whereas those for fossil fuel were "coal", "mining", "global", "towns", and "hazardous".

In August 2014, renewable energy and fossil fuel showed a positive correlation with a coefficient of 0.96 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "have", "energy", "panels", and "system", whereas those for fossil fuel were "coal", "suppliers", "china", "build", and "gasification".

In January 2015, renewable energy and electricity showed a negative correlation with a coefficient of −0.97 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "have", "power", "energy", and "get", whereas those for electricity were "electricity", "bid", "energy", "business", and "natural".

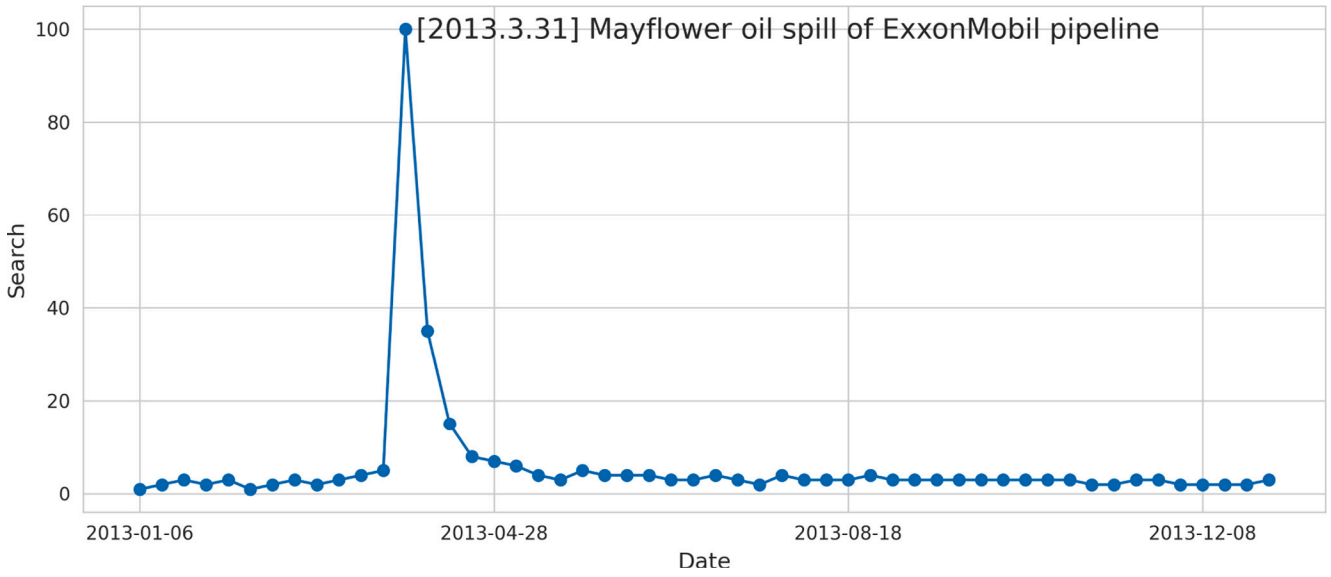


Fig. 6. Search engine results of *Google Trends* and news title about 'Arkansas oil'.

In April 2015, renewable energy and fossil fuel showed a positive correlation with a coefficient of 0.88 ($p < 0.05$). The main keywords for renewable energy were "solar", "have", "panels", "energy", and "power", whereas those for fossil fuel were "coal", "global", "shifts", "electricity", and "generation".

In August 2015, renewable energy and electricity showed a positive correlation with a coefficient of 0.89 ($p < 0.05$). The main keywords for renewable energy were "solar", "have", "power", "energy", and "panels", whereas those for electricity were "ground", "path", "electricity", "wire", and "resistance".

In March 2016, renewable energy and electricity showed a positive correlation with a coefficient of 0.83 ($p < 0.05$). The most frequent keywords for renewable energy were "solar", "have", "power", "energy", and "panels", whereas those for electricity were "electricity", "bill", "get", "cashback", and "payments".

In March 2016, renewable energy and fossil fuel showed a positive correlation with a coefficient of 0.89 ($p < 0.05$). The main keywords for renewable energy were "solar", "have", "power", "energy", and "panels", whereas those for fossil fuel were "coal", "renewables", "electricity", "protests", and "rise".

In September 2019, renewable energy and fossil fuel showed a positive correlation with a coefficient of 1.00 ($p < 0.05$). The main keywords for renewable energy were "solar", "have", "do", "subreddit", and "panels", whereas those for fossil fuel were "coal", "history", "premature", "declare", and "dead–domestic".

In November 2019, renewable energy and fossil fuel showed a positive correlation with a coefficient of 0.87 ($p < 0.05$). The main keywords for renewable energy were "solar", "have", "karma", "low", and "post", whereas those for fossil fuel were "coal", "plants", "waste", "gas", and "research".

5. Discussion and conclusion

This study investigated whether there were complex relationships between renewable and other energy resources concerning public perspectives. To address this issue, we gathered the posts and comments of *Reddit* users on multiple subreddits discussing specific topics. The collected dataset comprised 77,416 posts and 115,715 comments from March 2011 to August 2020, and we used the dataset prior to 2020.

We conducted sentiment analysis and calculated correlation for examining relationships between renewable and other energy resources in terms of public perspectives. We also conducted a monthly keyword analysis, which is a useful method for exploring public perspectives and identifying specific reasons for the relationships between renewable and other energy resources. A series of monthly keyword analyses are useful for a detailed exploration and understanding of public perspectives toward the relationships between renewable and other energy resources.

As a result, we found that there was a remarkable complementary relationship between renewable and nuclear energy resources in terms of positive emotions, an important contribution of this study. Because both nuclear and renewable energy resources are considered to generate relatively low CO_2 emissions [59], social media people tend to regard them as environment-friendly resources. However, there is a substitute relationship between the resources in terms of negative emotions. Considering several traumatic nuclear accidents (e.g., the Fukushima disaster), it is apparent that people consider renewable energy to be relatively safer than nuclear energy.

We further shortly analyzed the dataset after 2020, although the experiment analyzed the data before COVID-19. As a result, when the data after 2020 is included, fossil energy and renewable energy have a positive correlation coefficient in the negative emotions. This value is higher than the value without the inclusion of the 2020 data. Therefore, we have confirmed that fossil energy and renewable energy have become complementary after the pandemic.

Previous research on public perspectives of renewable energy resources had notable limitations (e.g., regional constraints; [62]). Therefore, it is difficult to generalize their findings. This study employed a large-scale dataset to assess the complex relationships between renewable and other energy resources. Therefore, the relationships presented in this study can be effectively and efficiently generalized to understand public perspectives on the energy industry.

Moreover, the methodology adopted in this study can be useful for analyzing public perspectives using social media data, which means that this study can be adapted to capture public opinions on other social and industrial topics. In addition, our collected dataset includes a vast amount of samples and information on various energy resources examined on *Reddit*, one of the topic-oriented social media channels. Thus, we share our collected datasets for future research (see Data availability) .

5.1. Policy implications

In addition, this study has a number of implications in the light of determining energy plan/policy. Exploring public perspectives of substitute or complementary relationships between renewable and other

energy sources is an important determinant that controls the regional and national energy plans/policies regarding the utilization of renewable energy resources. Considering the recent transitions in major energy resources, which aim to generate electricity in an environment-friendly manner, appropriate energy transition policies should be introduced after considering public opinion. Moreover, the proposed method in this paper can be employed to investigate both instant and immediate responses of public perspectives toward specific policies. Especially, in the case of such a problem, which is required to address public perspectives, multiple examinations of the perspectives including the proposed approaches can be considered for policy decision-makers. In other words, our research method could suggest multiple guidelines for energy-related policy and law by applying basic analysis methods. Such property would be helpful for policy-makers when they have to tune into public opinion or orient policies. Also, they can get what topics require in-depth analysis and research. The findings of this study can be valuable for policymakers. By understanding public perspectives on the relationship between nuclear and renewable energy, policymakers can make informed decisions. For instance, they can use the research to improve nuclear safety policies while also implementing measures to reduce carbon dioxide emissions. This approach enables policymakers to align their actions with public opinion while actively working towards achieving carbon reduction goals. By considering the insights gained from this study, policymakers can develop more effective and well-received policies that address both energy security and environmental concerns.

5.2. Limitations and future recommendations

Although this study has several implications as mentioned above, it still has some notable limitations. First, the analysis did not consider demographic information. Because we used data from a topic-oriented social media channel, *Reddit*, it may be skewed toward the age group that frequently uses social media [84].

Second, this study did not consider socio-demographic and regional information. Because it was not possible to identify the socio-demographic profiles and regions of the users on the selected social media, we could not incorporate this information into the analysis. Given that previous research has shown regional differences as an important factor determining public perspectives toward specific energy resources [85], future research should include socio-demographic data. Certainly, incorporating socio-demographic data and users' regional characteristics can be a valuable direction for future researchers. Extracting users' demographic information from social media platforms using relevant hashtags such as region and age can provide deeper insights into how different groups perceive and discuss renewable energy. Moreover, gathering opinions from multiple platforms would enhance the external validity of the findings, as it would capture a more diverse range of perspectives. By including data from various social media platforms, researchers can better understand the broader public sentiment toward renewable energy. The collected socio-demographic information can be utilized in future research for age, gender, nationality analysis, and more. This approach enables the examination of how individuals' perspectives on renewable energy differ based on their socio-demographics. Understanding these variations can help policymakers and stakeholders develop more targeted and inclusive strategies to promote renewable energy adoption and address potential barriers specific to certain demographics.

Third, the results of our study may be insufficient to provide solid interpretations for public perspectives because we employed one of the basic analyzing methods (e.g. sentimental analysis, correlation analysis). Moreover, it can be required to conduct additional research for policy decision-makers. However, the proposed method can be suitable for exploring both immediate and instant trends of public perspectives through social media channels. The findings of the current study also show that examining semantic interpretations can be presented with social media datasets. We found that specific keywords are likely to be frequently presented during energy-source-related accidents. Based on these results, future research should be examined with more complex and multiplicative analyses to present a better understanding of public perspectives toward specific energy resources [71,86].

Ethical approval

No ethical approval is required because no novel data were collected or analyzed.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

CRediT authorship contribution statement

Dahye Jeong: Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Syjung Hwang:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Data curation, Writing – original draft. **Jisu Kim:** Software. **Hyerim Yu:** Investigation, Writing – review & editing, Visualization. **Eunil Park:** Conceptualization, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

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

Data availability

All datasets are available at https://github.com/dxlabskku/RenewableEnergy.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.esr.2023.101243.

References

[1] T. Ahmad, D. Zhang, A critical review of comparative global historical energy consumption and future demand: The story told so far, Energy Rep. 6 (2020) 1973–1991, http://dx.doi.org/10.1016/j.egyr.2020.07.020.

[2] International Energy Agency, World energy outlook 2022, 2022, https://www.iea.org/reports/world-energy-outlook-2022. (Accessed 7 September 2022).

[3] L. Cai, J. Luo, S. Li, J. Li, L. Liu, M. Wang, Renewable energy resources potentials in G8 and BRICS, Energy Res. Soc. Sci. 835 (2021) 012013, http://dx.doi.org/10.1088/1755-1315/835/1/012013.

[4] V. Samarina, T. Skufina, A. Samarin, D. Ushakov, Alternative energy sources: Opportunities, experience and prospects of the Russian regions in the context of global trends, Int. J. Energy Econ. Policy 8 (2018) 140–147.

[5] J. Liu, China's renewable energy law and policy: a critical review, Renew. Sustain. Energy Rev. 99 (2019) 212–219, http://dx.doi.org/10.1016/j.rser.2018.10.007.

[6] D. Bogdanov, A. Gulagi, M. Fasihi, C. Breyer, Full energy sector transition towards 100% renewable energy supply: Integrating power, heat, transport and industry sectors including desalination, Appl. Energy 283 (2021) 116273, http://dx.doi.org/10.1007/s10640-020-00437-w.

[7] D. Coral, F. Lisa, Biden plans to move fast with a 'climate administration.' Here's how, 2020, https://www.nytimes.com/2020/11/17/climate/biden-climate-change.html. (Accessed 15 September 2022).

[8] E.B. Barbier, Greening the post-pandemic recovery in the G20, Environ. Resour. Econ. 76 (2020) 685–703, http://dx.doi.org/10.1007/s10640-020-00437-w.

[9] Energy Information Administration, Annual energy outlook 2020, 2020, https://www.eia.gov/outlooks/archive/aeo20/pdf/AEO2020%20Full%20Report.pdf. (Accessed 15 September 2022).
[10] Korean government, Korea new deal policy, 2020, https://www.korea.kr/special/policyCurationView.do?newsId=148874860. (Accessed 15 September 2022).
[11] Z. Said, A.A. Alshehhi, A. Mehmood, Predictions of UAE's renewable energy mix in 2030, Renew. Energy 118 (2018) 779–789, http://dx.doi.org/10.1016/j.renene.2017.11.075.
[12] M. Wierzbowski, I. Filipiak, W. Lyzwa, Polish energy policy 2050–an instrument to develop a diversified and sustainable electricity generation mix in coal-based energy system, Energy Policy 74 (2017) 51–70, http://dx.doi.org/10.1016/j.rser.2017.02.046.
[13] M.R. Kolhe, P.G. Khot, Optimal energy mix: A tool for judicious use of energy sources to mitigate the related problems, IMPACT Int. J. Res. Humanit. Arts Lit. 6 (2018) 41–60.
[14] K. Muhammad, Current status and future success of renewable energy in Pakistan, Renew. Sustain. Energy Rev. 82 (2018) 609–617, http://dx.doi.org/10.1016/j.rser.2017.09.049.
[15] S.D. Cîrstea, C. Moldovan-Teselios, A. Cîrstea, A.C. Turcu, C.P. Darab, Evaluating renewable energy sustainability by composite index, Sustainability 10 (2018) 811, http://dx.doi.org/10.3390/su10030811.
[16] W. Matar, F. Murphy, A. Pierru, B. Rioux, D. Wogan, Efficient industrial energy use: The first step in transitioning Saudi Arabia's energy mix, Energy Policy 105 (2017) 80–92, http://dx.doi.org/10.1016/j.enpol.2017.02.029.
[17] G. Trencher, J. van der Heijden, Contradictory but also complementary: National and local imaginaries in Japan and Fukushima around transitions to hydrogen and renewables, Energy Res. Soc. Sci. 49 (2019) 209–218, http://dx.doi.org/10.1016/j.erss.2018.10.019.
[18] S. Erdogan, I. Okumus, A.E. Guzel, Revisiting the Environmental Kuznets Curve hypothesis in OECD countries: the role of renewable, non-renewable energy, and oil prices, Environ. Sci. Pollut. Res. 27 (2020) 23655–23663, http://dx.doi.org/10.1007/s11356-020-08520-x.
[19] A. Zakari, V. Tawiah, I. Khan, R. Alvarado, G. Li, Ensuring sustainable consumption and production pattern in Africa: Evidence from green energy perspectives, Energy Policy 169 (2022) 113183, http://dx.doi.org/10.1016/j.enpol.2022.113183.
[20] W. Azam, I. Khan, S.A. Ali, Alternative energy and natural resources in determining environmental sustainability: a look at the role of government final consumption expenditures in France, Environ. Sci. Pollut. Res. 30 (2023) 1949–1965, http://dx.doi.org/10.1007/s11356-022-22334-z.
[21] H. Liu, I. Khan, A. Zakari, M. Alharthi, Roles of trilemma in the world energy sector and transition towards sustainable energy: A study of economic growth and the environment, Energy Policy 170 (2022) 113238, http://dx.doi.org/10.1016/j.enpol.2022.113238.
[22] F. Wang, J. Gu, J. Wu, Perspective taking, energy policy involvement, and public acceptance of nuclear energy: Evidence from China, Energy Policy 145 (2020) 111716, http://dx.doi.org/10.1016/j.enpol.2020.111716.
[23] F. Ribeiro, P. Ferreira, M. Araújo, A.C. Braga, Modelling perception and attitudes towards renewable energy technologies, Renew. Energy 122 (2018) 688–697, http://dx.doi.org/10.1016/j.renene.2018.01.104.
[24] K. Tomas, Progress of renewable electricity replacing fossil fuels, Glob. Energy Interconnection 1 (2018) 48–52, http://dx.doi.org/10.14171/j.2096-5117.gei.2018.01.006.
[25] H. Khan, I. Khan, T.T. Binh, The heterogeneity of renewable energy consumption, carbon emission and financial development in the globe: a panel quantile regression approach, Energy Rep. 6 (2020) 859–867, http://dx.doi.org/10.1016/j.egyr.2020.04.002.
[26] Q. Wang, J. Guo, R. Li, X.T. Jiang, Exploring the role of nuclear energy in the energy transition: A comparative perspective of the effects of coal, oil, natural gas, renewable energy, and nuclear power on economic growth and carbon emissions, Environ. Res. 221 (2023) 115290, http://dx.doi.org/10.1016/j.envres.2023.115290.
[27] Y. Song, B. Chen, Y. Hou N. Yang, Terrorist attacks and oil prices: A time-varying causal relationship analysis, Energy 246 (2022) 123340, http://dx.doi.org/10.1016/j.energy.2022.123340.
[28] Y. Song, B. Chen, X. Wang, P. Wang, Defending global oil price security: Based on the perspective of uncertainty risk, Energy Strategy Rev. 41 (2022) 100858, http://dx.doi.org/10.1016/j.esr.2022.100858.
[29] G. Li, X. Wang, Q. Wang, Does renewable energy reduce ecological footprint at the expense of economic growth? An empirical analysis of 120 countries, J. Clean. Prod. 346 (2019) 131207, http://dx.doi.org/10.1016/j.jclepro.2022.131207.
[30] Q. Wang, F. Zhang, R. Li, Revisiting the environmental kuznets curve hypothesis in 208 counties: The roles of trade openness, human capital, renewable energy and natural resource rent, Environ. Res. 216 (2023) 114637, http://dx.doi.org/10.1016/j.envres.2022.114637.
[31] Q. Wang, L. Wang, Renewable energy consumption and economic growth in OECD countries: A nonlinear panel data analysis, Energy 207 (2020) 118200, http://dx.doi.org/10.1016/j.energy.2020.118200.
[32] Q. Wang, Z. Dong, R. Li, L. Wang, Renewable energy and economic growth: New insight from country risks, Energy 238 (2022) 122018, http://dx.doi.org/10.1016/j.energy.2021.122018.
[33] Q. Wang, X. Yang, Investigating the sustainability of renewable energy–An empirical analysis of European union countries using a hybrid of projection pursuit fuzzy clustering model and accelerated genetic algorithm based on real coding, J. Clean. Prod. 268 (2020) 121940, http://dx.doi.org/10.1016/j.jclepro.2020.121940.
[34] Z. Abdmouleh, A. Gastli, L. Ben-Brahim, Survey about public perception regarding smart grid, energy efficiency & renewable energies applications in Qatar, Renew. Sustain. Energy Rev. 82 (2018) 168–175, http://dx.doi.org/10.1016/j.rser.2017.09.023.
[35] Y. Jang, E. Park, Social acceptance of nuclear power plants in Korea: The role of public perceptions following the Fukushima accident, Renew. Sustain. Energy Rev. 128 (2020) 109894, http://dx.doi.org/10.1016/j.rser.2020.109894.
[36] L. Aghlimoghadam, Solar business in an oil-rich country? A socio-technical investigation of solar PV businesses in Iran, Sustainability 15 (2023) 8973, http://dx.doi.org/10.3390/su15118973.
[37] V.D. Puavualoaia, E.M. Teodor, D. Fotache, M. Danilet, Opinion mining on social media data: sentiment analysis of user preferences, Sustainability 11 (2019) 4459, http://dx.doi.org/10.3390/su11164459.
[38] S. Dasgupta, C.E. De, The influence of institutions, governance, and public opinion on the environment: Synthesized findings from applied econometrics studies, Energy Res. Soc. Sci. 43 (2018) 77–95, http://dx.doi.org/10.1016/j.erss.2018.05.023.
[39] S. Jarvis, The economic costs of NIMBYism: evidence from renewable energy projects, 2021, http://eprints.lse.ac.uk/113653/. (Accessed 15 September 2022).
[40] B. Anderson, T. Böhmelt, H. Ward, Public opinion and environmental policy output: a cross-national analysis of energy policies in Europe, Environ. Res. Lett. 12 (2017) 114011, http://dx.doi.org/10.1088/1748-9326/aa8f80.
[41] E. Park, Positive or negative? Public perceptions of nuclear energy in South Korea: Evidence from Big Data, Nucl. Eng. Technol. 51 (2019) 626–630, http://dx.doi.org/10.1016/j.net.2018.10.025.
[42] S. Roh, Big data analysis of public acceptance of nuclear power in Korea, Nucl. Eng. Technol. 49 (2017) 850–854, http://dx.doi.org/10.1016/j.net.2016.12.015.
[43] M. Abdar, M.E. Basiri, J. Yin, M. Habibnezhad, G. Chi, S. Nemati, S. Asadi, Energy choices in Alaska: Mining people's perception and attitudes from geotagged tweets, Renew. Sustain. Energy Rev. 124 (2020) 109781, http://dx.doi.org/10.1016/j.rser.2020.109781.
[44] J.A. Gordon, N. Balta-Ozkan, S.A. Nabavi, Homes of the future: Unpacking public perceptions to power the domestic hydrogen transition, Renew. Sustain. Energy Rev. 164 (2022) 112481, http://dx.doi.org/10.1016/j.rser.2022.112481.
[45] International Atomic Energy Agency, Nuclear power reactors in the world 2020, 2020, https://www.iaea.org/publications/14756/nuclear-power-reactors-in-the-world. (Accessed 15 September 2022).
[46] K.O. Yoro, M.O. Daramola, Co2 emission sources, greenhouse gases, and the global warming effect, Adv. Carbon Capture 1 (2020) 3–28, http://dx.doi.org/10.1016/b978-0-12-819657-1.00001-3.
[47] Environmental Protection Agency, Overview of greenhouse gases, 2018, https://www.epa.gov/ghgemissions/overview-greenhouse-gases. (Accessed 15 September 2022).
[48] W. Zhou, A. Kou, J. Chen, A retrospective analysis with bibliometric of energy security in 2000–2017, Energy Rep. 4 (2018) 724–732, http://dx.doi.org/10.1016/j.egyr.2018.10.012.
[49] M. Murshed, M.M. Tanha, Oil price shocks and renewable energy transition: Empirical evidence from net oil-importing South Asian economies, Energy Ecol. Environ. 6 (2021) 183–203, http://dx.doi.org/10.1007/s40974-020-00168-0.
[50] A. Azzuni, A. Aghahosseini, M. Ram, D. Bogdanov, U. Caldera, C. Breyer, Energy security analysis for a 100% renewable energy transition in Jordan by 2050, Sustainability 12 (2020) 4921, http://dx.doi.org/10.3390/su12124921.
[51] I. Udalov, The transition to renewable energy sources as a threat to resource economies, Int. J. Energy Econ. Policy 11 (2021) 460–467, http://dx.doi.org/10.32479/ijeep.10902.
[52] I. Khan, L. Han, H. Khan, L.T. Kim Oanh, Analyzing renewable and nonrenewable energy sources for environmental quality: dynamic investigation in developing countries, Mathematical Problems in Engineering 2021 (2021) 1–12, http://dx.doi.org/10.1155/2021/3399049.
[53] H. Khan, I. Khan, R. BiBi, The role of innovations and renewable energy consumption in reducing environmental degradation in OECD countries: an investigation for innovation claudia curve, Environ. Sci. Pollut. Res. 29 (2022) 1–14, http://dx.doi.org/10.1007/s11356-022-18912-w.
[54] J.C. Reboredo, M.A. Rivera-Castro, A. Ugolini, Wavelet-based test of co-movement and causality between oil and renewable energy stock prices, Energy Econ. 61 (2017) 241–252, http://dx.doi.org/10.1016/j.eneco.2016.10.015.
[55] M.D. Leonard, E.E. Michaelides, D.N. Muchaelides, Energy storage needs for the substitution of fossil fuel power plants with renewables, Renew. Energy 145 (2020) 951–962, http://dx.doi.org/10.1016/j.renene.2019.06.066.
[56] M.J. Burke, J.C. Stephens, Political power and renewable energy futures: A critical review, Energy Res. Soc. Sci. 35 (2018) 78–93, http://dx.doi.org/10.1016/j.erss.2017.10.018.

[57] K. Moorthy, N. Patwa, Y. Gupta, Breaking barriers in deployment of renewable energy, Heliyon 5 (2019) e01166, http://dx.doi.org/10.1016/j.heliyon.2019.e01166.
[58] International Atomic Energy Agency, International status and prospects for nuclear power 2017, 2017, https://www.iaea.org/sites/default/files/gc/gc61inf-8_en.pdf (Accessed 15 September 2022).
[59] L.S. Lau, C.K. Choong, C.F. Ng, F.M. Liew, S.L. Ching, Is nuclear energy clean? Revisit of Environmental Kuznets Curve hypothesis in OECD countries, Econ. Model. 77 (2019) 12–20, http://dx.doi.org/10.1016/j.econmod.2018.09.015.
[60] T. Jin, J. Kim, What is better for mitigating carbon emissions–renewable energy or nuclear energy? A panel data analysis, Renew. Sustain. Energy Rev. 91 (2018) 464–471, http://dx.doi.org/10.1016/j.rser.2018.04.022.
[61] K. Saidi, A. Omri, Reducing CO2 emissions in OECD countries: Do renewable and nuclear energy matter? Prog. Nucl. Energy 126 (2020) 103425, http://dx.doi.org/10.1016/j.pnucene.2020.103425.
[62] E. Park, J.Y. Ohm, Factors influencing the public intention to use renewable energy technologies in South Korea: Effects of the Fukushima nuclear accident, Energy Policy 65 (2014) 198–211, http://dx.doi.org/10.1016/j.enpol.2013.10.037.
[63] B. Marouane, K. Mohameed, B. Abderrahim, A comprehensive survey on sentiment analysis: Approaches, challenges and trends, Knowl.-Based Syst. 226 (2021) 107134, http://dx.doi.org/10.1016/j.knosys.2021.107134.
[64] S. Boon-Itt, S. Yukolpat, Public perception of the COVID-19 pandemic on Twitter: sentiment analysis and topic modeling study, JMIR Public Health Surveillance 6 (2020) e21978, http://dx.doi.org/10.2196/21978.
[65] N. Von, B. Karin, K. Lars, Reuniting a divided public? Tracing the TTIP debate on Twitter and in traditional media, Int. J. Commun. 12 (2018) 22.
[66] J. Kim, D. Jeong, D. Choi, E. Park, Exploring public perceptions of renewable energy: Evidence from a word network model in social network services, Energy Strategy Rev. 32 (2020) 100552, http://dx.doi.org/10.1016/j.esr.2020.100552.
[67] S.Y. Kim, K. Ganesan, P. Dickens, S. Panda, Public sentiment toward solar energy—opinion mining of Twitter using a transformer-based language model, Sustainability 13 (2021) 2673, http://dx.doi.org/10.3390/su13052673.
[68] S. Jeong, J. Kim, Y. Kim, H.Y. Joo, J.H. Moon, Sentiment analysis of nuclear energy-related articles and their comments on a portal site in Rep. of Korea in 2010–2019, Nucl. Eng. Technol. 53 (2021) 1013–1019, http://dx.doi.org/10.1016/j.net.2020.07.031.
[69] Reddit, Social media, 2023, https://www.reddit.com. (Accessed 16 January 2023).
[70] T. Ruan, Q. Lv, Public perception of electric vehicles on reddit over the past decade, Commun. Transp. Res. 2 (2022) 100070, http://dx.doi.org/10.1016/j.commtr.2022.100070.
[71] D. Jeong, J. Kim, D. Choi, E. Park, Social networking services as new venue for public perceptions of energy issues: The case of Paris agreement, Energy Strategy Rev. 39 (2022) 100758, http://dx.doi.org/10.1016/j.esr.2021.100758.
[72] J. Im, E. Park, Effects of political orientation on sentiment features: the case of online news outlets in South Korea, Telemat. Inform. 74 (2022) 101882, http://dx.doi.org/10.1016/j.tele.2022.101882.
[73] S. Lee, H. Ji, J. Kim, E. Park, What books will be your bestseller? A machine learning approach with Amazon Kindle, Electron. Libr. 39 (2021) 137–151, http://dx.doi.org/10.1108/EL-08-2020-0234.
[74] NLTKTeam, NLTK 3.7, 2022, https://www.nltk.org. (Accessed 4 September 2022).
[75] S. Oh, H. Ji, J. Kim, E. Park, A.P. del Pobil, Deep learning model based on expectation-confirmation theory to predict customer satisfaction in hospitality service, Inf. Technol. Tourism 24 (2022) 109–126, http://dx.doi.org/10.1007/s40558-022-00222-z.
[76] E. Park, Y. Jang, J. Kim, N.J. Jeong, K. Bae, Determinants of customer satisfaction with airline services: An analysis of customer feedback big data, J. Retail. Consumer Serv. 51 (2019) 186–190, http://dx.doi.org/10.1016/j.jretconser.2019.06.009.
[77] E. Park, J. Kang, D. Choi, J. Han, Understanding customers' hotel revisiting behaviour: a sentiment analysis of online feedback reviews, Curr. Issues Tour. 23 (2020) 605–611.
[78] J.W. Pennebaker, M.E. Francis, R.J. Booth, Linguistic Inquiry and Word Count: LIWC 2001, Vol. 71, Lawrence Erlbaum Associates, Mahway, 2001, p. 1.
[79] S. Hwang, J. Kim, E. Park, S.J. Kwon, Who will be your next customer: A machine learning approach to customer return visits in airline services, J. Bus. Res. 121 (2020) 121–126, http://dx.doi.org/10.1016/j.jbusres.2020.08.025.
[80] P. Sedgwick, Pearson's correlation coefficient, Br. Med. J. 345 (2012) e4483, http://dx.doi.org/10.1007/978-1-4020-5614-7_2569.
[81] Google, Google trend, 2022, https://trends.google.co.kr/trends/?geo=US. (Accessed 28 September 2022).
[82] National Public Media, Illinois nuclear power plant shuts down unit after power loss, 2012, https://www.npr.org/sections/thetwo-way/2012/01/31/146137547/illinois-nuclear-power-plant-shuts-down-unit-after-power-loss. (Accessed 28 September 2022).
[83] The New York Times, Oil pipeline ruptures in Arkansas, 2013, https://www.nytimes.com/2013/03/31/us/oil-pipeline-ruptures-in-arkansas.html. (Accessed 29 September 2022).
[84] R. Thackeray, B.T. Crookston, J.H. West, Correlates of health-related social media use among adults, J. Med. Internet Res. 15 (2013) e21, http://dx.doi.org/10.2196/jmir.2297.
[85] M. Suškevičs, S. Eiter, S. Martinat, D. Stober, E. Vollmer, C.L. de Boer, M. Buchecker, Regional variation in public acceptance of wind energy development in Europe: What are the roles of planning procedures and participation? Land Use Policy 81 (2019) 311–323, http://dx.doi.org/10.1016/j.landusepol.2018.10.032.
[86] H.S. Boudet, Public perceptions of and responses to new energy technologiesm nature energy 4, 2019, pp. 446–455, http://dx.doi.org/10.1038/s41560-019-0399-x.