

Research Article

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Towards a hybrid future in energy: A social media sentiment analysis on wind energy and energy storage systems

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Highlights

- Social media sentiment regarding wind energy integrated with energy storage systems was analyzed.
- A total of 7,800 social media posts and 2.3 million interactions were examined.
- The findings revealed a strong positive sentiment of 72% towards wind energy systems with storage.
- Negative sentiment was associated with political and legal obstacles rather than technological risks.

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ABSTRACT

This study examines the impact of Energy Storage Systems (ESS), presented as a solution to the intermittent nature of renewable energy sources, on perceptions of wind energy through social media data. The study analysed 7,800 posts and 2.3 million interactions from platforms such as X (Twitter), Bluesky, and LinkedIn, Reddit, Facebook and Instagram between December 4, 2025, and March 2, 2026. Combining quantitative sentiment analysis and qualitative content review, the methodology revealed a strong positive sentiment (72%) towards the concept of wind energy integrated with energy storage. The findings indicate that the concept of "Grid Stability" builds public trust and that storage technology reduces reliability concerns regarding wind energy. Negative perception (25%) stems more from bureaucratic processes such as Federal Judge decisions and political obstacles, rather than technological risks. The results demonstrate that energy storage systems are not only a technical necessity but also a strategic communication tool that increases the social acceptance of wind energy.

Keywords: Wind energy, Energy storage systems, Sentiment analysis, Grid stability

INTRODUCTION

The limited reserves of fossil fuels and the environmental damage they cause have forced a radical change in energy production paradigms worldwide. In the fight against global warming and climate change, countries aiming to reduce carbon emissions are rapidly increasing the share of renewable resources in their energy portfolios [1]. Wind energy, one of the most important actor in this transformation, has risen to a strategic position in the global energy supply due to its clean, sustainable, and abundant availability. However, wind energy, by its nature, has a variable and intermittent production profile; the cessation of energy production when the wind is not blowing poses a significant technical challenge in terms of grid stability and supply security [2].

At this point, Energy Storage Systems (ESS) come into play as the most effective solution to this problem of interruptions, which is seen as the "Achilles' heel" of renewable energy [3]. Advances in battery technologies (especially lithium-ion) and falling costs allow wind farms to transform into hybrid facilities that can provide energy not only when the wind is blowing, but also when the grid needs it, acting as more reliable and "base load" plants. The rapidly increasing number of wind power plant projects with storage worldwide demonstrates that this technology is no longer a niche application but a mainstream energy strategy [4].

In parallel with this global trend, Turkey has paved the way for wind and solar power plants with storage through recent regulations in its energy legislation. The increasing number of license applications and investor interest in our country prove that energy storage technologies will play a central role in the future of the Turkish energy market. While the use of wind energy as a domestic and national resource is encouraged, energy manageability is increased and national grid resilience is strengthened thanks to storage systems. In Türkiye, the regulatory framework for electricity storage was formalized through the Electricity Market Storage Activities Regulation and subsequent amendments to the electricity market secondary legislation. In particular, the amendments published in the Official Gazette on 19 November 2022 introduced provisions for storage-integrated electricity generation facilities and enabled investors committing electricity storage capacity to apply for wind or solar pre-licences under specific conditions [5].

However, beyond technological and economic feasibility, how these new energy infrastructures are perceived by the public is critical to the social acceptance of the projects. While wind energy is generally perceived as "clean" and "environmentally friendly" in literature, it can sometimes

face local resistance due to "visual pollution" and "noise". The inclusion of energy storage systems in the equation adds new dimensions to public perception. For example, does storage technology strengthen the positive perception by increasing the "reliability" of wind energy? Or do issues such as battery production, mining activities, and chemical waste management create new environmental concerns? This study aims to analyze public sentiment towards the integration of "Wind Energy and Energy Storage," a rising trend in Türkiye and worldwide, using the rich and unfiltered datasets offered by social media platforms. This study analyzed public reactions, concerns, and expectations regarding wind energy and battery technologies using sentiment analysis of 7800 posts from social media platforms such as X (Twitter), Bluesky, and LinkedIn, Reddit, Facebook and Instagram. The findings aim not only to measure current perceptions but also to provide important insights for policymakers and energy investors to understand public concerns and develop more effective communication strategies.

2. LITERATURE REVIEW

2.1. Sentiment Analysis and Importance of Social Media Data

Sentiment analysis is a discipline that uses Natural Language Processing (NLP) and artificial intelligence techniques to identify and classify subjective expressions within text [6][7][8]. The information obtained does not only evaluate specific words. It also assesses the contextual cues surrounding these words and the basic textual language structure [9]. Its primary goal is to determine whether a text's author has a positive, negative, or neutral attitude towards a particular topic, product, or service. Advanced sentiment analysis methods can go beyond basic classification and detect the intensity of specific emotions such as anger, fear, or satisfaction in texts [10][11][12].

Social media platforms are a unique resource for sentiment analysis studies because they are massive data pools where users share their opinions unfiltered and in real-time. In areas directly relevant to public opinion and open to political debate, such as the energy sector, social media data functions as a "real-time" public opinion poll. Analyzing this data provides energy companies and policymakers with strategic insights into which energy types the public resists or embraces [13][14][15][16][17][18].

2.2. Studies on the Perception of Renewable Energy and Wind Energy

Numerous studies in literature examine public perception of renewable energy sources. Jain and Jain (2019), according to sentiment analysis based on Twitter posts, people are exhibiting a more positive attitude towards renewable energy sources, particularly solar and wind energy [19]. The vastness of social media has become a treasure trove for sentiment analysis, especially in sectors like finance and energy. Santos et al (2023) made sentiment analysis in the oil sector improves predictive models for oil prices [20]. Popoola et al. (2024) mentioned that social media provides very significant for providing large amount data for sentiment analysis in finance or relevant sectors [21].

Segreto et al. (2020) reviewed social acceptance in renewable energy across Europe with social media posts [22]. Şenyapar (2023) made social media sentiment analysis for reviewing concerns and impact of renewable energy resources [23]. These studies generally show that the "clean" and "sustainable" aspects of renewable energy are supported by the public, but local resistance can be encountered during the installation phase. Demski (2011) explained that public support for renewable energy is more complex than commonly believed, noting that it encompasses many different viewpoints, ranging from strong support to opposition [24]. Şenyapar (2024) conducted a comprehensive analysis aiming to measure public perception of hydroelectric, solar, wind, and nuclear energy types through social media data [16]. Larson and Krannich (2016) used data to illustrate that while renewable energy is supported by the American public, large-scale renewable energy projects face challenges in gaining acceptance from residents [25].

Studies, particularly those focusing on wind energy, reveal that public attitudes towards wind energy exhibit a complex (ambivalent) structure. While it receives strong support due to its carbon emission reduction, it also has a negative perception associated with the "NIMBY" (Not In My Backyard) syndrome [26] due to local environmental impacts such as noise, visual pollution, and bird deaths caused by turbines. The NIMBY syndrome and lack of civic engagement influence attitudes towards wind energy in rural areas, with socioeconomic conditions requiring tailored promotional strategies [27]. For example, Olson-Hazboun et al. (2016) emphasized that attitudes towards wind energy are shaped not only by environmental beliefs but also by local social values and economic expectations [28]. Public attitudes towards wind energy are complex, influenced by both global environmental issues and local factors such as noise and health concerns, with a lack of consensus on assessment methods and design for acceptability [29]. Similarly, social media

analyses show that the "intermittent" nature of wind energy, meaning that energy cannot be produced when the wind is not blowing, creates concerns about reliability, and this is reflected in negative sentiment scores.

2.3. Literature Gap

In recent years, the energy literature has focused on technical studies concentrating on the integration of Energy Storage Systems (ESS) to increase the reliability of wind energy. However, the "social acceptance" aspect of this technological transformation has not yet been sufficiently explored in the literature. Most existing studies focus either solely on wind energy or solely on the technical feasibility of battery technologies (especially in the context of electric vehicles). There are limited social media analyses on how large-scale storage systems integrated into wind farms change public perception of "reliability." Yet, energy storage technologies solve the "discontinuity" problem, which is the biggest disadvantage of wind energy, making it capable of operating like a base load power plant. This situation has a high potential to positively transform the public perception that "wind is unreliable."

On the other hand, there is also a growing debate in the literature regarding the environmental impacts of lithium-ion batteries (mining activities, waste management, and fire risks). Therefore, wind power plants with energy storage (hybrid plants) benefit from the "clean" image of wind energy on the one hand, while facing the concern of "chemical waste" from batteries on the other. This study aims to fill this gap in literature. It differs from existing studies by focusing not only on wind energy but also on its new "energy storage" form; analyzing whether energy storage technology strengthens the perception of wind energy in terms of "reliability" or creates new environmental concerns (waste, safety, etc.).

3. MATERIAL AND METHOD

3.1. Dataset and Study Workflow

This study conducted a comprehensive sentiment analysis to measure public perception of wind power plants integrated with wind energy and energy storage systems. The analysis utilized Brandmentions (<https://app.brandmentions.com>), a web-based sentiment analysis tool offering a specialized API infrastructure for such assessments. Despite limitations in the free version of the tool, a significant amount of data was collected from widely used social media platforms such as X (Twitter), Bluesky, and LinkedIn, Reddit, Facebook and Instagram.

Data collection was conducted on between December 4, 2025 and March 2, 2026, and the keywords "wind energy" and "wind energy with energy storage systems" were used for analysis. As a result of this search, a total of 7.800 randomly selected mentions related to the topic were included in the dataset (Table 1). Just English and Turkish languages were included in this study. No pre-screening was used. This is because Brand Mentions states that it uses bot filtering. The site uses machine learning and natural language processing methods. Users have no control over these methods. Accordingly, the results should be read as descriptive and associative. The analysis identifies sentiment distributions, platform differences, and thematic patterns in public discourse; it does not claim that ESS caused changes in public opinion or that particular political/legal themes directly caused negative sentiment.

Table 1. Distribution of contents

Platform	Number of Samples
X	3128
Bluesky	2999
Linkedin	784
Reddit	503
Facebook	152
Instagram	234

The choice of different social media platforms for analysis is a conscious strategy to broaden the scope of the study. Each platform has its own unique user demographics and interaction culture; this directly affects nature and tone of discussions about renewable energy. For example, while more professional, technical, and detailed discussions are common on platforms like Instagram, due to its visually focused structure, hosts more personal experiences and aesthetically pleasing content. Twitter and Facebook, on the other hand, play a critical role in news sharing and measuring community-focused instant reactions.

4. RESULTS AND DISCUSSION

During the analysis period, keywords focused on "Wind Energy and Energy Storage" received a total of 7,800 mentions. These mentions reached a massive 231 million people in the digital environment and generated a total of 2.3 million social media interactions. These high interaction

rates demonstrate that wind energy supported by energy storage has moved beyond being merely a technical niche and has become a topic of widespread interest.

When the sentiment analysis results are examined, it is seen that the perception of hybrid systems (Wind + Storage) is 72% Positive and 25% Negative and %3 Neutral (Figure 1). In this overall picture, excluding neutral content, the dominance of positivity proves that the existing concern about "intermittency" in wind energy in the literature has transformed into a perception of "reliability" with energy storage technologies.

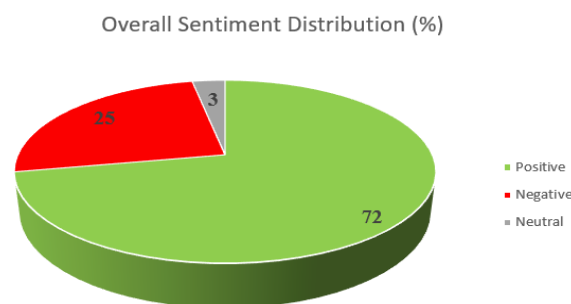


Figure 1. Overall sentiment distribution

The distribution of social media platforms provides important clues about the nature of discussions. During the period analyzed, the platforms with the most intense discussions were, in order, X (Twitter), Bluesky, and LinkedIn (Figure 2).

- *X (Twitter) and Bluesky:* On platform X, 1,341 positive posts were identified compared to 608 negative posts. Similarly, on Bluesky, a growing platform, 1,187 positive and 674 negative mentions were observed. The relatively high negative rate on these platforms compared to others is attributed to the fact that the discussions were not only technological but also open to political.
- *LinkedIn:* On LinkedIn, a professional network, only 25 negative posts were made compared to 340 positive posts. This situation shows that energy sector professionals and investors find wind power plants with storage to be highly successful from a commercial and technical standpoint, and that their risk perception is very low, unlike the public.
- *Reddit:* On Reddit, where more technical discussions take place, neutral/technical discussions predominate with 218 neutral posts, but positive opinions (154) outnumber negative opinions (104).

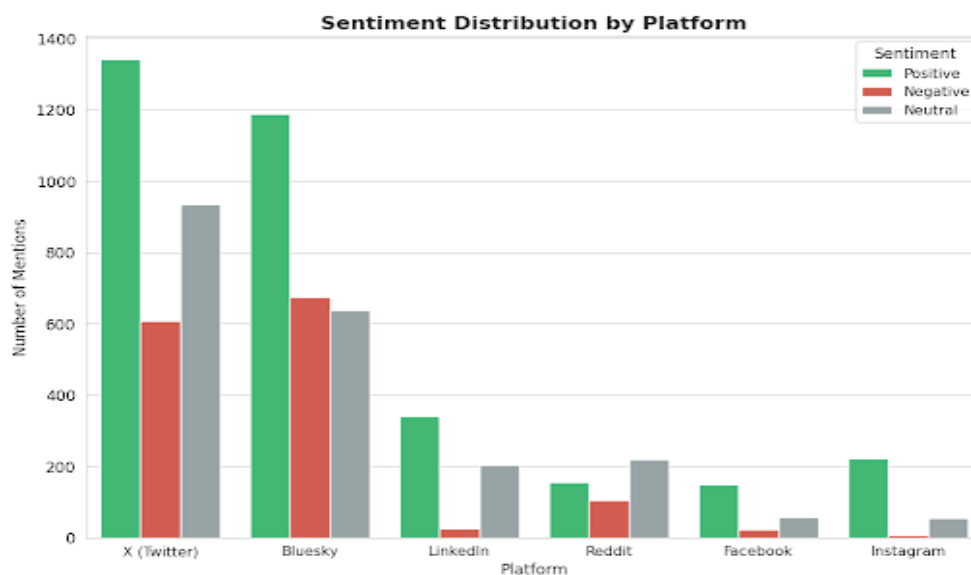


Figure 2. Sentiment distribution by platform

Table 2. Statistical comparison of positive and negative sentiment across platforms

Platform	Positive (n)	Negative (n)	Total (n)	Positive (%)	Negative (%)	Adjusted residual Positive	Adjusted residual Negative	Interpretation
X	1,341	608	1,949	68.8	31.2	0.80	-0.80	close to the expected distribution.
Bluesky	1,187	674	1,861	63.8	36.2	-5.33	5.33	Negative sentiment significantly overrepresented.
LinkedIn	340	25	365	93.2	6.8	10.70	-10.70	Positive sentiment significantly overrepresented.

To provide additional statistical support for the platform-based sentiment differences (Table 2), a chi-square test of independence was conducted using the positive and negative sentiment counts reported for X/Twitter, Bluesky, LinkedIn, and Reddit. The results showed a statistically significant association between platform type and sentiment polarity, $\chi^2(3, N = 4,433) = 130.39$ $p < .001$. The effect size, measured by Cramer's V, was 0.172, indicating a small-to-moderate

association. Adjusted standardized residuals showed that positive sentiment was significantly overrepresented on LinkedIn, whereas negative sentiment was significantly overrepresented on Bluesky and Reddit. Although X contained the largest absolute number of negative posts, its positive–negative distribution was close to the expected pattern after controlling for platform-level totals. X/Twitter generated the largest absolute number of negative posts due to its high discussion volume, whereas Bluesky and Reddit showed a proportionally higher negative sentiment pattern.

An examination of the word cloud (Figure 3) and top conversation topics (Figure 4) in the obtained data reveals more clearly how wind and storage integration is coded in the public mind.

- *Technological Security and Stability:* The frequent use of terms such as "Grid Stability" (113 mentions) and "Grid Reliability" confirms the main hypothesis of our study. The public and experts discuss energy storage as a factor that balances the irregularity of wind. Furthermore, the high frequency of "Clean Energy" (266 mentions) and "Renewable Energy" (584 mentions) indicates continued environmental sensitivity.
- *Wind-Focused Themes:* The terms "Wind Energy" (154), "Wind Turbines" (126), and "Offshore Wind" (114) are intertwined with the concept of energy storage (Energy Storage - 1093 mentions). This shows that the two technologies are no longer considered independently.
- *Political and Legal Obstacles:* The top-topic analysis identified "Federal Judge" (227 mentions) and "Trump blocking" (113 mentions) among the most visible discussion topics. Together with the platform-level residuals showing that negative sentiment was overrepresented on Bluesky and Reddit, these terms provide analytical evidence that political and legal controversies were salient within negative or contentious discussions. However, these terms should not be interpreted as direct causes of negative sentiment. Rather, they indicate that legal decisions, project-blocking narratives, and political polarization were frequently present in discussions associated with negative sentiment. The qualitative content review of posts containing these terms also suggested that users often framed project delays, court decisions, and administrative blocking as sources of uncertainty or frustration rather than as purely technical concerns about ESS.

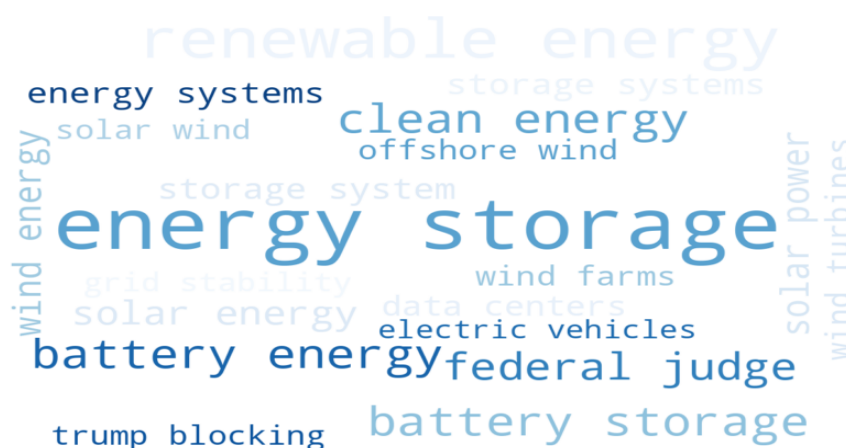


Figure 3. Wordcloud

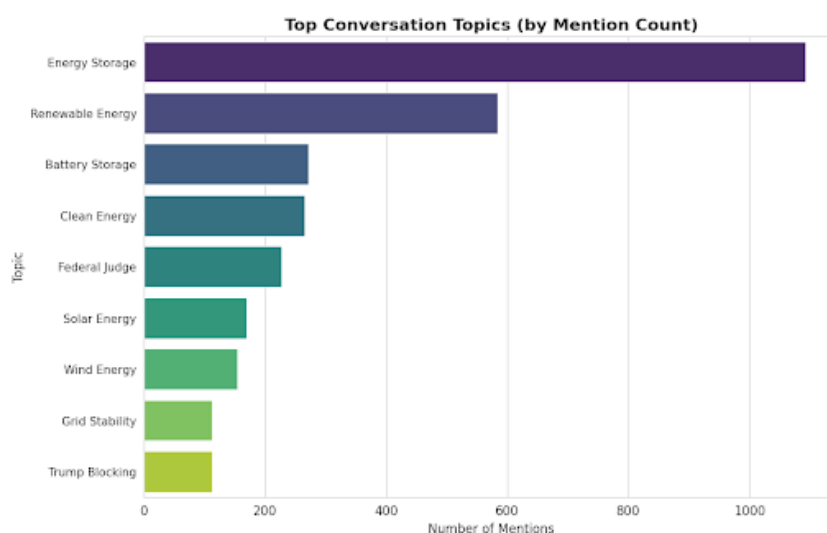


Figure 4. Top conversation topics

The findings of this study reveal that energy storage systems (ESS) may contribute to a more positive reliability-oriented framing of wind energy in social media discussions. As stated in [14], wind energy, when considered alone, has a negative perception rate of 21% (noise, visual pollution); however, this study shows that when integrated with storage, the negativity rate drops below 7% on professional platforms such as LinkedIn. However, the data flow on publicly available platforms such as X and Bluesky indicates that the issue has shifted to a "techno-political" ground. The frequency of terms such as "Federal Judge" and "Blocking projects" suggests that the biggest social barrier to energy investments is no longer "technology fear," but "bureaucratic and political uncertainties."

In conclusion, energy storage systems have successfully erased the "unreliable" label associated with wind energy. The emphasis on "Grid Stability" seen in the data indicates that the public accepts these hybrid systems as the energy security of the future, but discomfort due to political obstacles is dragging down the overall sentiment.

5. CONCLUSION AND SUGGESTIONS

This study analyzed public perception of the integration of wind energy and energy storage systems using the time periods and social media posts mentioned in previous sections. The findings indicate that hybrid systems (wind + storage) have surpassed a critical social acceptance threshold in the future of renewable energy.

The results show that public perception of wind energy is significantly strengthened when supported by "storage" technology. The 72% positive sentiment identified in the study proves that energy storage systems minimize concerns about "intermittency," the biggest disadvantage of wind energy. The frequent occurrence of "Grid Stability" and "Grid Reliability" in the word cloud confirms that the public and experts view battery technologies as a guarantee of grid security.

While previous literature studies generally focused on negative perceptions of wind energy related to "noise" or "visual pollution," this study suggests that a substantial portion of negative discourse in the present dataset is associated with "political and legal" themes. The prominence of terms like "Federal Judge" and "Trump blocking" [30][31] in the dataset indicates that bureaucratic obstacles and political polarization surrounding energy projects are highly visible in the analyzed discussions. Nevertheless, these findings should be interpreted as thematic associations rather than causal evidence that such issues directly produced negative sentiment.

The fact that almost all discussions (93%) on professional networks like LinkedIn are positive or neutral suggest that industry professionals give this technology a high rating for its commercial and technical success. In contrast, the concentration of negative content on platforms like Twitter and Bluesky indicates that public relations crises need to be managed on these platforms.

Turkey has taken a significant step towards increasing its wind energy capacity and ensuring grid flexibility with the recently enacted "Electricity Generation Facilities with Storage" regulation. The findings of this study, based on global data, offer the following strategic recommendations for policymakers and investors in Türkiye:

- *"Reliability"-Themed Communication:* In public presentations of energy projects in Türkiye, the ability of storage facilities to provide "uninterrupted energy" should be emphasized alongside the environmental benefits of wind turbines. The emphasis on "Grid Stability" in our analysis suggests that the Turkish public may prioritize the guarantee of "no power outages" over "green energy."
- *Bureaucratic Transparency:* The risk of negative perception stemming from "legal obstruction," as seen in this study, is also relevant for Turkey. Transparency on the part of investors and government institutions in the environmental impact analysis processes and licensing phases is critical to prevent the perception that projects are "hindered by legal obstacles." To avoid the "project obstruction" anger seen in global data, legal processes need to be explained accurately to the public.
- *Business to Business (B2B) and Investors:* The high positive perception on LinkedIn indicates that energy companies in Türkiye should use this platform as their primary communication channel in seeking corporate collaborations and financing.
- *Public Opinion and Crisis Management:* Platforms like Twitter are breeding grounds for misinformation and political reactions. Instead of technical jargon, content emphasizing "energy independence" and "domestic technology" should be shared in language understandable to the public.

In conclusion, wind energy and energy storage integration is the strongest candidate for the "Hybrid Future" vision. The biggest obstacle to these technologically mature systems is no longer technical inadequacy, but rather the social and political acceptance processes. If Turkey manages this transformation not just as an infrastructure investment, but as a societal communication campaign, it will achieve its energy independence goals much faster.

6. LIMITATIONS

This study provides a current overview of the literature by examining social media sentiment regarding the integration of wind energy and energy storage systems. However, there are some limitations to consider when interpreting the findings.

First, the study is based on observational social media data. Therefore, while the findings reveal trends in public opinion, sentiment patterns, and relationships between specific concepts, they are not sufficient to establish a direct cause-and-effect relationship.

Second, the dataset is limited to a specific time period. The social media posts analyzed in the study only reflect online discussions within the relevant period. External events such as energy policies, investment decisions, legal processes, or political developments can change social media sentiment in a short time. Therefore, the results should be considered as the digital discussion climate during the analyzed period, rather than long-term and lasting public attitudes. Also, since the study is based on the posts of social media users, the sample may not fully represent the general public.

Another limitations is sentiment classification relies on the machine learning and natural language processing infrastructure provided by the Brandmentions tool. The bot filtering, sentiment classification, and content processing processes of this tool cannot be fully controlled by the researcher. Therefore, irony, sarcasm, out-of-context statements, political references, or technical terms may be misclassified in some cases. For this reason, the results should be evaluated not as absolute measures of sentiment, but as analytical indicators showing general trends.

Additionally, the study only includes content collected through the specified keywords. While posts related to concepts such as “wind energy,” “energy storage,” and “battery storage” were analyzed, some discussions using different word choices or local terminology may have been excluded from the dataset. On the other hand, Sixth, caution should be exercised in interpreting political and legal themes. The appearance of phrases like “Federal Judge” and “Trump blocking” in the dataset indicates that these topics hold a significant place in social media discussions; however, it is not possible to conclude that these phrases directly generate negative sentiment. Such concepts are more likely to appear alongside sentiment patterns related to politics, permit processes, court decisions, and legal discussions concerning energy investments.

Finally, while social media interaction numbers are valuable in demonstrating public interest, they are not directly equivalent to the level of societal acceptance. Numbers of likes, shares, comments, or views can be influenced by numerous factors, including platform algorithms, news coverage, user behavior, and political polarization. Therefore, future studies are recommended to support social media sentiment analysis with surveys, interviews, focus groups, or regional case studies. This would allow for a more comprehensive and reliable assessment of societal acceptance of wind energy integrated with energy storage systems.

DECLARATION OF ETHICAL STANDARDS

The author of the paper submitted declare that nothing which is necessary for achieving the paper requires ethical committee and legal-special permissions.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

CONTRIBUTION OF AUTHORS

This manuscript prepared by single author.

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