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NAVIGATING EMOTIONS, COGNITION, AND PLACES: A SOCIAL MEDIA ANALYSIS FOR RENEWABLE ENERGY INFRASTRUCTURES

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Lists of Abbreviations

RETs: Renewable Energy Technologies

LIWC: Linguistic Inquire Word Count

SCA: Socio-Cognitive Approach

Abstract

The Sixth Assessment Report of the United Nations' Intergovernmental Panel on Climate Change reports that each of the last four decades has been warmer than any decade that preceded it since 1850. Energy plans have been proposed to reduce per capita energy consumption and increase the number of renewable sources to meet energy demand. While the global benefits of renewable energy are well known, some concerns about their impact on local environments still exist. Renewable energy technologies (RETs) increasingly affect people's daily lives, leading to emotions and cognitions influencing attitudes toward renewable energy. On the other hand, social media significantly impacts the creation of people's opinions. Thus, this thesis aims to investigate how renewable energy topics are shared and discussed on social media platforms to understand which emotions, cognitions, and places are mainly connected to the topics. In detail, this study delivers an understanding of the cumulative effects of people-place relations, emotions, and cognitions and the consequences of managing broader social acceptance relations. A better understanding of the drivers underlying public perception of RETs is essential for helping policymakers and project developers craft new strategies for managing processes.

S*tudy 1* thoroughly aims to describe linguistic connections by analyzing 1500 Instagram posts, assuming and interpreting emotional and/or cognitive words. Using a Socio-Cognitive Approach (SCA) and the appraisal theories of emotions, this research explores the salient words under a set of pre-specified RET hashtags (#solarenergy, #biomass, #windenergy, #geothermalenergy, #powerlines, #renewableenergy). The texts have been analyzed through frequency and sentiment analysis, revealing that each RET and powerline has different emotional and cognitive words in the posts. The results show the highest linguistic interconnection between solar and wind energy posts and no interconnection between RETs and powerlines. Solar, wind, and geothermal posts evoke more emotional and positive emotions than the other RETs and powerlines. Instead, biomass posts have a high frequency of cognitive processes and causal words. Powerline posts are linked to risk, body, health, and biological processes, showing a significant concern for health and perceived threat. These differences in the words used can be a guide to understanding peoples' reactions and building communication strategies for each of the energy sources.

Study 2 aims to increase the understanding of people-place relations by investigating the relationship between Instagram posts place-level (categorized from local to planet) and sentiments on different energy infrastructures. Using the same dataset as paper 1, paper 2 shows that place scales mentioned in Instagram posts are related to some differences in the emotions-cognition expressed by the words in the posts. Overall, city and planet words are significant predictors of affect; city, region, and planet are predictors of positive emotions, and city and region words are significant predictors of negative emotions, depending on the specific RET mentioned. In detail, in the #renewableenergy posts, the city, region, and planet words are significant predictors of affect. In the #biomass posts, the country's words significantly predict negative emotions. In the #powerline posts, the region words are significant predictors of cognitive processes, and the city words are significant predictors of affect and negative emotions. In the #geothermalenergy posts, the country words are significant predictors of cognitive processes, the city words are significant predictors of affect and positive emotions, and the region words are significant predictors of negative emotions. The risk and cognitive words are not significant for any place scales investigated, and the number of planet posts is insufficient to draw any conclusions. Thus, the construct "planet" may evoke fewer mental associations than other place levels. In conclusion, using an SCA, this study is the first to investigate Instagram posts in the context of the energy transition and people-place relationships. This research makes an essential contribution to understanding the public's reactions to RETs, their relationship to the places mentioned, and the role of their description on social media.

Study 3 intends to explore how renewable energy technologies (solar, wind, biomass, and geothermal) and the cumulative impact topics (environmental and human-centred) are expressed and linked on the news on the Internet. The links (URLs) with the highest total engagement used and shared on Facebook, Twitter, Pinterest, and Reddit platforms have been collected, and a content analysis was conducted. The results confirm significant differences among the topics used to describe RETs in social media platforms. Thus, each technology should be addressed differently in targeted communication strategies based on specific words, key topics, and infrastructure links. In detail, the results show that the topics shared about wind energy are more related to arguments connected to the environmental impact (e.g., eagles, offshore, and landscape) and emotional words (e.g., guilty and plead). Topics related to solar and geothermal energies are more linked to the economy and benefits *("help the world and help* *your bill"*). The biomass URLs focus on explaining its process to provide knowledge and awareness.

In summary, these results illustrate that emotions, cognitions, people-place bonds, and the cumulative impact of RETs are variables that have a relevant effect on the social perception of RETs. Furthermore, analyzing social media platforms allows us to examine the dynamics of public perception of energy issues (such as emerging technologies, environmental impacts, etc.).

Zusammenfassung

Der Sechste Sachstandsbericht des Zwischenstaatlichen Ausschusses für Klimaänderungen der Vereinten Nationen berichtet, dass jedes der letzten vier Jahrzehnte wärmer war als jedes Jahrzehnt davor seit 1850. Es wurden Energiepläne vorgeschlagen, um den Pro-Kopf-Energieverbrauch zu senken und die Zahl der erneuerbaren Energiequellen zur Deckung des Energiebedarfs zu erhöhen. Während die globalen Vorteile der erneuerbaren Energien bekannt sind, bestehen weiterhin Bedenken hinsichtlich ihrer Auswirkungen auf die lokale Umwelt. Die Technologien für erneuerbare Energien (RETs) beeinflussen zunehmend das tägliche Leben der Menschen, was zu Emotionen und Erkenntnissen führt, die die Einstellung zu erneuerbaren Energien beeinflussen. Andererseits haben die sozialen Medien einen erheblichen Einfluss auf die Meinungsbildung der Menschen. Ziel dieser Arbeit ist es daher, zu untersuchen, wie Themen zu erneuerbaren Energien auf Sozial-Media-Plattformen geteilt und diskutiert werden, um zu verstehen, welche Emotionen, Kognitionen und Orte hauptsächlich mit diesen Themen verbunden sind. Im Einzelnen liefert diese Studie ein Verständnis für die kumulativen Auswirkungen von Beziehungen zwischen Menschen und Orten, Emotionen und Kognitionen sowie für die Folgen des Managements breiterer sozialer Akzeptanzbeziehungen. Ein besseres Verständnis der Triebkräfte, die der öffentlichen Wahrnehmung von RETs zugrunde liegen, ist wichtig, um politischen Entscheidungsträgern und Projektentwicklern zu helfen, neue Strategien für das Prozessmanagement zu entwickeln.

Studie 1 zielt grundlegend darauf ab, sprachliche Zusammenhänge zu beschreiben, indem 1500 Instagram-Posts analysiert werden, wobei emotionale und/oder kognitive Wörter angenommen und interpretiert werden. Unter Verwendung eines sozio-kognitiven Ansatzes (SCA) und der Bewertungstheorien von Emotionen untersucht diese Studie die hervorstechenden Wörter unter einer Reihe vorgegebener RET-Hashtags (#solarenergy, #biomass, #windenergy, #geothermalenergy, #powerlines, #renewableenergy). Die Texte wurden mit Hilfe von Häufigkeits- und Stimmungsanalysen analysiert, die zeigen, dass jeder RET und jede Powerline unterschiedliche emotionale und kognitive Wörter in den Beiträgen enthält. Die Ergebnisse zeigen die größte sprachliche Verbindung zwischen Solar- und Windenergie-Beiträgen und keine Verbindung zwischen RETs und Stromleitungen. Solar-, Wind- und Geothermie-Beiträge rufen mehr emotionale und positive Gefühle hervor als die anderen RETs und Stromleitungen. Im Gegensatz dazu weisen die Beiträge über Biomasse eine hohe Häufigkeit von kognitiven Prozessen und kausalen Begriffen auf. Beiträge zu Stromleitungen werden mit Risiko, Körper,

Gesundheit und biologischen Prozessen in Verbindung gebracht, was auf eine erhebliche Sorge um die Gesundheit und eine wahrgenommene Bedrohung hinweist. Diese Unterschiede in den verwendeten Wörtern können ein Anhaltspunkt sein, um die Reaktionen der Menschen zu verstehen und Kommunikationsstrategien für jede der Energiequellen zu entwickeln.

Studie 2 zielt darauf ab, das Verständnis der Beziehungen zwischen Menschen und Orten zu verbessern, indem die Beziehung zwischen Instagram-Posts auf Ortsebene (kategorisiert von lokal bis planetarisch) und Stimmungen zu verschiedenen Energieinfrastrukturen untersucht wird. Unter Verwendung desselben Datensatzes wie in Studie 1 zeigt Studie 2, dass die in Instagram-Posts erwähnten Ortsskalen mit einigen Unterschieden in den durch die Wörter in den Posts ausgedrückten Emotionen und Kognitionen zusammenhängen. Insgesamt sind die Wörter „Stadt“ und „Planet“ signifikante Prädiktoren für den Affekt; „Stadt“, „Region“ und „Planet“ sind signifikante Prädiktoren für positive Emotionen, und „Stadt“ und „Region“ sind signifikante Prädiktoren für negative Emotionen, je nachdem, welcher RET gerade erwähnt wird. Im Einzelnen sind in den Posts zu #renewableenergy die Wörter Stadt, Region und Planet signifikante Prädiktoren für den Affekt. In den #biomass-Posts sagen die Wörter des Landes signifikant negative Emotionen voraus. In den #powerline-Posts sind die Wörter der Region signifikante Prädiktoren für kognitive Prozesse, und die Wörter der Stadt sind signifikante Prädiktoren für Affekte und negative Emotionen. In den #geothermalenergy-Posts sind die Wörter des Landes signifikante Prädiktoren für kognitive Prozesse, die Wörter der Stadt sind signifikante Prädiktoren für Affekte und positive Emotionen und die Wörter der Region sind signifikante Prädiktoren für negative Emotionen. Die Wörter „Risiko“ und „kognitiv“ sind für keine der untersuchten Ortsskalen signifikant, und die Anzahl der Beiträge zum Thema „Planet“ reicht nicht aus, um irgendwelche Schlussfolgerungen zu ziehen. Das Konstrukt „Planet“ ruft also möglicherweise weniger mentale Assoziationen hervor als andere Ortsebenen. Zusammenfassend lässt sich sagen, dass diese Studie die erste ist, die Instagram-Posts im Zusammenhang mit der Energiewende und den Beziehungen zwischen Menschen und Orten untersucht. Diese Untersuchung leistet einen wesentlichen Beitrag zum Verständnis der Reaktionen der Öffentlichkeit auf RETs, ihrer Beziehung zu den genannten Orten und der Rolle ihrer Beschreibung in den sozialen Medien.

In *Studie 3* soll untersucht werden, wie Technologien für erneuerbare Energien (Solar-, Wind-, Biomasse- und geothermische Energien) und die Themen der kumulativen Auswirkungen (Umwelt und Mensch) in den Nachrichten im Internet ausgedrückt und verlinkt werden. Es wurden die Links (URLs) mit dem höchsten Gesamtengagement gesammelt, die auf den

Plattformen Facebook, Twitter, Pinterest und Reddit verwendet und geteilt wurden, und es wurde eine Inhaltsanalyse durchgeführt. Die Ergebnisse bestätigen signifikante Unterschiede zwischen den Themen, die zur Beschreibung von RETs auf Sozial-Media-Plattformen verwendet werden. Daher sollte jede Technologie in gezielten Kommunikationsstrategien auf der Grundlage spezifischer Wörter, Schlüsselthemen und Infrastrukturverbindungen unterschiedlich angesprochen werden. Im Einzelnen zeigen die Ergebnisse, dass die Themen, die über Windenergie geteilt werden, eher mit Argumenten im Zusammenhang mit den Umweltauswirkungen (z. B. Adler, Offshore und Landschaft) und emotionalen Begriffen (z. B. schuldig und plädieren) verbunden sind. Themen im Zusammenhang mit Solar- und geothermischen Energien sind eher mit der Wirtschaft und den Vorteilen verbunden (*„helfen Sie der Welt und helfen Sie Ihrer Rechnung“*). Die Biomasse-URLs konzentrieren sich auf die Erläuterung des Verfahrens, um Wissen und Bewusstsein zu vermitteln.

Zusammenfassend zeigen diese Ergebnisse, dass Emotionen, Kognitionen, Bindungen zwischen Menschen und Orten und die kumulativen Auswirkungen von RETs Variablen sind, die einen relevanten Einfluss auf die soziale Wahrnehmung von RETs haben. Darüber hinaus ermöglicht die Analyse von Sozial-Media-Plattformen die Untersuchung der Dynamik der sozialen Wahrnehmung von Energiefragen (z. B. neue Technologien, Umweltauswirkungen usw.).

Chapter 1: Introduction

This introduction chapter provides an overview of the main topics presented in the thesis, as well as their interconnections and relevance in exploring the empirical case of RETs. It starts by describing the role of emotions and cognitions related to RETs, the people-place bonds, the cumulative impact of RETs (environmental and human-centred impact), and the analysis of social media platforms. Then, it explains the overall research questions and the design of three empirical studies, as well as the research methodology and data used.

1. Defining the Core Elements of the Thesis: Focus and Purpose

As we see it today, modern society would have been impossible without energy. Energy plays a crucial role in the development and well-being of a nation and of every person. While energy consumption is necessary, fossil fuel-based energy consumption is primarily responsible for carbon dioxide emissions that accumulate in the atmosphere, contributing to climate change and environmental issues. In detail, energy can be obtained in a *non-renewable way* from static stores of energy that remain bound unless released by human interaction (e.g., fossil fuels of coal, oil, and natural gas) and in a *renewable way* from regenerative inexhaustible sources of energy occurring in the natural environment (e.g., solar, wind energy, etc.) (Panda, 2024).

Globally, policies have grown significantly to support renewable energy transitions. In many countries, renewable energy technologies (RETs) currently supply a sizeable fraction of the energy demand, given the increasing need to decarbonize economies and the decrease in the cost of RETs over the years. In fact, in 2021, the European Union made the goal of climate neutrality, achieving net zero emissions by 2050 with a target of 55% emission reduction by 2030. A 2023 report by the European Environment Agency (Targa et al., 2024) claimed that European countries expect to achieve a combined net emissions reduction of 43% by 2030 with current policies and measures in place. Renewable energy transitions are influential in decarbonizing the world economy and mitigating global climate change to achieve these goals.

On the other hand, the RETs taking place in the energy transition mean a substantial transformation process at the system level and a significant intervention in the living environment at the local level. The changes associated with energy infrastructure projects are various, and the interpretation given to the place changes is one of the most important aspects (Devine-Wright & Peacock, 2024). Social science literature has identified several factors influencing the acceptance of energy projects and technologies, most prominently the perceived impacts on the landscape, property values, and health issues (Hoen et al., 2019), social and personal norms (Karakislak et al., 2023), risk (Wüstenhagen et al., 2007), trust in actors as well as distributional and procedural justice (Firestone et al., 2018). Thus, some different theories and models cover several aspects and variables involved in the path of public perception of RETs like people (Petrova, 2016), place (Devine-Wright & Wiersma, 2020), and process (Hübner et al., 2023).

Therefore, social acceptance is considered a multifaceted, dynamic process, and controversies can highlight important shortcomings that need to be addressed at an institutional and local level (Wolsink, 2018). Huijts et al. (2012) define technology acceptance as *"behavior towards the technology"* and have distinguished this from evaluations of the technology by referring to that specifically as acceptability. A distinction may be made between a *"general social acceptance,"* which is social acceptance on the broadest level, and a *"local social acceptance,"* which is active at a community level and is involved in siting and the actuation of renewable energy projects (Wüstenhagen et al., 2007). The *Sensemaking Theory* (Weick et al., 2009; Turner et al., 2023) contributes to understanding how actors make sense of infrastructure by enacting cues and creating plausible stories. The authors proposed a list of questions that citizens ask themselves as the starting point of sensemaking: *"What is going on here? How does it concern me? How do others react? And now what should I do?".* All these processes are formed by previous experiences, identities, and information received.

Scholars (McLeod et al., 2017; Dai et al., 2020; McCombs & Valenzuela, 2020) have investigated how much information from the media impacts the perception of a particular object and/or situation. For example, the Agenda-Setting Theory (McCombs & Shaw, 2023) proposes that media play a critical role in influencing people's perceptions and directing their thoughts toward a specific agenda or topic. As well as it has been demonstrated that media can directly influence consumers' environmental attitudes and behavior related to various issues like energy, pollution levels, and consequences of ecological degradation (Cheung et al., 2016). Indeed, through social media, people exchange opinions, ideas, feelings, personal information, pictures, and videos. On the other hand, they also constantly receive a significant amount of information, which is processed consciously and/or unconsciously and can change people's viewpoints (Happer & Philo, 2013).

Nowadays, several online tools and analytical techniques (co-occurrence, sentiment, content analyses, etc.) can be used to analyze data from the web, trace interpretative schemes, and reconstruct the meaning of the information (Kumar et al., 2025; Al-Tameemi et al., 2024). Generally, text analysis is used to classify words or phrases according to linguistic or semantic criteria until reconstructing, even according to a quantitative dimension, the summary features of the content. These techniques and tools derive from combining several disciplines: cognitive psychology, computer science, and linguistics (Paley, 2002).

This thesis examines information circulating on the web concerning RETs. In particular, the first study (Paper 1) aims to describe linguistic connections combining different RETs and assuming and interpreting emotional and/or cognitive words on Instagram posts. The second study (Paper 2), focusing on the role of different place scales (local to global), aims to describe the relation between the scale of places, RETs, emotions, and cognitions. Papers 1 and 2 use the same dataset: 1500 Instagram posts scraped following the hashtags #windenergy, #solarebergy, #biomass, #geothermalenergy, #powerlines, #renewableenergy. The third study (Paper 3) intends to create awareness of how renewable energy technologies (solar, wind, biomass, and geothermal) and cumulative impact topics (environmental and human-centred) are expressed in the news on Facebook, Twitter, Pinterest, and Reddit platforms through content analysis.

Overall, the findings and recommendations of this cumulative research aim to contribute to understanding the words, emotions, cognitions, places, and environmental and human impacts posted and shared on the web about RETs. The outcome has implications for the stakeholders, who can develop a series of communication strategies focused on each energy technology. This allows a deeper understanding of the population's needs and the support and information required.

2. Theoretical Background

The following paragraphs provide a summary of the theoretical background of the study. First, the role of emotions and cognitions, as well as the mental association in the formation of attitudes and behaviors is presented. Second, the variable "place" is introduced as one of the important factors in the public perception of RETs. Third, the cumulative impact of renewables, divided into environmental (landscape and visual impact, ecological, and noise) and human-centred impacts (personal, social cultural, and economic) is explained to understand the current and potential arguments associated with each renewable energy source and their public perception. Lastly, the role of communication in shaping attitudes and opinions, along with its effects on cognitive and emotional dimensions, and an analysis of social media are presented.

2.1. The Role of Emotions and Cognitions

Emotions and cognitions influence attitudes toward renewable energy (Vrieling et al., 2021), and they have an explanatory power about energy-related decisions and how people look for information (Cousse et al., 2020). If people experience certain emotions toward energy projects may influence their cognitive evaluations of these projects and relative knowledge (Slovic et al., 2007). Thus, negative perceptions of renewable energy development can lead to protests, resulting in project delay or failure. On the other hand, good communication and sensitivity to community feelings are pathways to success (Lundheim et al., 2022). The assessment of emotional and cognitive perceptions is crucial for adequately understanding consumptive or productive aspects of energy and the entire ecosystem.

Social perception is an established consideration in energy planning and renewable energy policy. Authors often conceptualize *"the dance of affect and reason"* under dual-process models, whereby measures of cognition and affect are coordinated to explain overall intuition (Finucane et al., 2003; Slovic et al., 2005; Trujillo, 2018). Cognitive and affective dualism refers to the processing of the object as perception, and each has a role in deciding judgment or behavior. Slovic et al. (2013) describe the affective way as *"intuitive, fast, mostly automatic, and not very accessible to conscious awareness"* and the cognitive way as the use of *"algorithms and normative rules, such as probability calculus, formal logic, and risk assessment."* Their interactive nature, with one often proceeding with the other in guiding behavior, is a key concept in interpreting the psychological aspects of renewable energy infrastructures.

In literature, there are several approaches to analyzing affect both independent of and in combination with cognition regarding renewables (Truelove, 2012). Some studies have relied on appraisal theory in the study of emotional evaluation of energy projects and specific RET to explain why and when certain emotions arise (Huijts, 2018). In particular, the theory pointed out that different appraisals can elicit several emotions. Continuing on this path, scholars claim a strong relationship exists between mental life structures and the production of written and/or verbal discourse (Schacter & Addis, 2007). Several techniques have been used to study the mental association between topics in written texts. For example, working on the frequency of topics (co-occurrence analysis) helps find similarities within word patterns to discover latent structures of mental associations. Instead, sentiment analysis allows scholars to analyze, for example, whether the words used have a cognitive or emotional valence (Balahur et al., 2018). One of the popular text analysis tools used is the Linguistic Inquiry and Word Count software (LIWC) (Pennebaker et al., 2015). The dictionaries of the tool analyze text by counting words, numbers, punctuation, and even short phrases, giving an emotional and cognitive identification of human coders. Additionally, content analysis helps to interpret meaning in communication forms by isolating pieces of data that represent salient concepts. Using a systematic data interpretation process, the analyzed texts are organized to describe or explain a phenomenon (Vankrunkelsven et al., 2018).

A relevant contribution to the study of the interrelations between emotions, cognitions, and language is made by the Socio-Cognitive Approach (SCA). SCA claims that a schema can be reconstructed through close attention to language that systematically shows the relationships between concepts and experiences represented in written messages. SCA is based on the role of salience in language production, and this means that when a person is faced with having to choose a word, a ranking of the available choices is obtained, and the word is selected for utterance based on maximum salience (Kecskes, 2010).

Research on RETs and relative social/environmental psychology aspects has pointed out that there are several aspects to be considered in the evaluation of the RETs, and it is relevant to include the roles of emotions in this process, as well as the rational aspects (Leiserowitz, 2006). Thus, studies have shown that affects and the specific quality of something, being good or bad, experienced as a feeling, play an important role in decision-making, evaluation, and preferences for energy sources. As a result, a gap between public acceptance of RETs, as documented in national opinion polls, and local acceptance of RETs remains (Upham & Johansen, 2020). In particular, while many studies have focused on the public perception of wind and solar energies in recent years (e.g., Dwyer & Bidwell, 2019), the social perception of other RETs and their relationship (especially in social media) has received less attention. Consequently, the goal of this study is to understand, through the analysis of words used on social media platforms, what emotions are aroused from which energy technologies and if there are RETs that elicit more emotional aspects than cognitive ones (and vice versa).

2.2. People-Place Relations

People-place bond has become an increasingly popular concept for understanding local responses to large-scale RETs (Dang & Weiss, 2021). Research has found that place and related concepts of attachment and identity play an important role in forming opinions about energy development (Bell et al., 2013). Thus, the people-place bond is an important motivator for developing RET projects, but different degrees of place attachment also form a key source of disagreement (Van Veelen & Haggett, 2017). There are numerous strands of research concerning people-place relations, including those focused on sense of place (Convery et al., 2012), place identity (Hernández et al., 2020), and place attachment (Lewicka, 2011), described as a distinct form of sense of place (Puren et al., 2018) and a precursor to place identity (Hernández et al., 2007).

The emotional responses to places are multivalent, and people can be firmly attached to places at larger scales that extend to the neighborhood, the city/region, and the planet (Devine-Wright, 2013) or to multiple places (Di Masso et al., 2017). Graumann (1983) claims that multiple identities are the normality rather than the exception, and different settings make different types of identities salient. Attachments may also reflect distinct aspects of the place to which a person feels attached: physical and social (Hidalgo & Hernandez, 2001) or natural and civic aspects (Scannell & Gifford, 2010). Studies emphasize how disruption to place attachments arises when physical changes negatively affect place-related symbolic meanings, giving rise to negative emotions (anxiety, grief, and loss) (Fried, 2000), disruption to social networks (Speller &

Twigger-Ross, 2009), and leading to diverse coping responses, including place-protective behaviors (Stedman, 2002).

The relevance of place attachment for understanding public perception of renewable energy was first investigated empirically by Vorkinn and Riese (2001) in a case study of a proposed hydropower project in Norway. Whilst the project was expected to bring socio-economic benefits to the locality, it was also expected to negatively affect recreation and tourism activities in the affected areas. The analyses indicated that the place attachment variables explained 20% of the variance in attitudes towards the project, exceeding the total variance explained by socioeconomic variables (e.g., age, gender, and household income). Furthermore, in that study, each attachment variable's importance differed in direction and size. Thus, attachment to the natural areas is negatively correlated with acceptance. In contrast, attachment to the municipality was positively correlated. Moreover, attachment to the affected areas was a more important predictor in the analyses, explaining more variance. The authors concluded that place attachment predicts attitudes towards specific proposed environmental changes and that the importance of place attachment differs significantly in terms of direction and size of effect, depending on the context.

Scholars have also studied the power of social media, employing datasets gathered from media platforms to understand people-place bonds by conducting real-time analytics (e.g., Gregory & Chambers, 2021). Thus, social media enables people-place connections to be preserved in cyberspace. Furthermore, the emotional responses documented on social media enable interactions between stakeholders to share their memories and attachments to heritage places. That is why, when used with data collection methods, digital technologies can broaden the understanding of the sense of place (Dai & Liu, 2024). The potential of social media data for characterizing the urban landscape, visualizing the perceived environment, and measuring the relations with RETs has become an additional resource for place-RETs conservation and planning (Stefanidis et al., 2013).

In conclusion, this study proposes a combined approach in which place, RETs, powerlines, and their ties are the significant factors of the analysis, considering a systemic picture of the coexistence of the technologies. Focusing on four place categories: city, region, state, and planet, this investigation explores different place scales in the context of social media.

2.3. Cumulative Impact of RETs

Experts (e.g., Wüstenhagen et al., 2007) have examined several moderators based on socio-political, community, and market moderators and their effects on the local population's opinion towards RETs. Moderators like expectations (Walker, 2014), familiarity (Mantonakis et al., 2011), inclusion and financial participation (Lienhoop, 2018), perception of justice (Wolsink, 2007), risks and uncertainty (Upham et al., 2015), and identity of place (Pasqualetti, 2011) are included in a large cluster of cumulative impact of the RETs, which can be divided into two big categories: the environmental (Akella et al., 2009) and human-centred impacts (Khan et al., 2020).

Regarding environmental impacts, there are three main aspects in determining the applications of RET development (Sayed et al., 2021): 1) landscape and visual impact; 2) ecological (habitat structure); and 3) noise (Haac et al., 2022). The exact type and intensity of environmental impacts vary, for example, on the specific technology and the geographic location. The environmental impacts of renewable energy resources like solar, wind, geothermal, and biomass energy systems have received relevant attention to understand the population's needs and adequate land protection. Thus, comprehending the current and potential environmental issues associated with each renewable energy source and their public perception can effectively avoid or minimize the negative impacts (Levenda et al., 2021).

The human-centred impacts of RETs, instead, can be divided into three clusters (Kumar, 2023): 1) personal (human health and wellbeing); 2) social and cultural (tourism, recreation sites, etc.); and 3) economic (tax credits, benefits, regional value-added, etc.). How the environmental and human-centred moderators influence public opinions depends on the moderators themselves, how they are discussed in the media, and their association with some content rather than others. Media analyses show a clear trend in publication as a direct output for geothermal, biomass, wind, and solar energy research work and activities in the title of journal articles over the period 1996-2020 (Ghenai et al., 2020). It emerged that the publications related to wind and solar energy are about 21.5–73.3% over the same period, with an overall average of about 60%. Followed by biomass energy of 17–68%, with an overall average of 23%. Geothermal energy was the third type of renewable energy in this ranking, with about 5.3–17.3% over the study period, with an overall average of 10% (Sayed et al., 2021). However, there is still a lack of knowledge to describe exactly which topics are associated with which RETs and how to exploit this knowledge. Therefore, this study contributes to understanding what people share most on the web about energy technologies, helping to understand which key environmental and human impact topics are used to describe different technologies.

2.4. Social Media Analysis

In general, social media refers to the wide range of internet-based mobile services that allow users to participate and engage in online exchanges, contribute to user content, or join online communities. In the late 2000s, social media gained widespread acceptance from the global community, even though the first social network site, Sixdegrees.com, had already appeared in 1997 (Balas et al., 2013).

There has been increasing interest in studying how opinions are formed and evaluated over time and how they change following different social interactions. The development of public opinion is a complex process that includes both interpersonal communication among individuals and mass communication through various media platforms like television, radio, and print media (Owolabi, 2022). Research demonstrates that communication plays a pivotal role in shaping attitude change, leading to significant shifts in our perceptions across cognitive, emotional, and behavioral dimensions (Bhattacherjee & Premkumar, 2004). For example, counter-narratives are stories that challenge widespread beliefs and discourses, and through these discussions, people construct alternative representations. This aspect is linked explicitly to the strategic communication intended to persuade an audience to support specific goals (De Graaf et al., 2015).

Media communication is a *"two-way"* process in which people have an active role, especially on social media platforms, using them as a space where they express emotions, experiences, and opinions (Quan-Haase & Young, 2010). The uses and gratifications theory is one of the theories used to understand why people engage with social media (Alajmi et al., 2016; Katz et al., 1973). In detail, the theory is a psychological communication perspective and theorizes that individuals actively seek out media that they believe will satisfy specific needs. Reassuming, the needs are: i) originating (sharing emotions and thoughts by posts); ii) interacting (converting knowledge through the reactions and comments); iii) collaborating (by fostering virtual interaction among the followers); and iv) implementing (by facilitating the creation of new emotional and cognitive knowledge) (Leon & Marcu, 2016). The way topics appear in various forms of media tends to shape public opinion, which is also true for renewable energy technologies (Nuortimo et al., 2017).

Existing research has shown that the media coverage on renewable energies is dominated by economic (e.g., benefits and losses for the community), technological (e.g., impact in terms of noise, colors, etc.), and environmental aspects (e.g., landscape, space, etc.) (Stauffacher et al., 2015). Furthermore, social aspects, such as conflicts in energy infrastructure implementation projects, have recently gained more attention in the news. Previous research has shown that two main factors might play a role in how renewable energy is covered in the media (Strömbäck et al., 2016): 1) the natural structural conditions, which are any relevant factor related to the deployment of RET within a specific territory (local, regional, or national); and 2) the main influencing factors which are focusing on specific events. For example, the Fukushima nuclear catastrophe affected the public perception of energy sources, and it is assumed that the portrayal of renewable energies in the media might have benefitted from this focusing event as well since they may appear to be less dangerous than nuclear energy (Biddinika et al., 2014). Furthermore, scholars have shown that unconscious stimuli (to which people do not consciously pay attention) can also influence the emotions felt, and this leads to the conclusion that media stimuli influence not only people's actions but also their emotional states (Bargh, 2022).

Accordingly, the words used on the web extensively impact the formation of opinions. Thus, the ongoing discourse between societal actors has helped citizens recognize their responsibility to behave environmentally friendly (Prothero et al., 2011). Methods for promoting good communication and understanding among developers, governments, and communities are pathways to success. However, there is still a lack of knowledge about what kind of information is shared on the web about RETs and if there are differences in the words used to describe energy technologies.

2.5. Research Gap

As outlined above, a broad range of research investigates the societal implications and public perception of RETs. Different factors like people-place bonds, personal attitudes, cognitions, and emotions influence energy project responses, requiring an in-depth understanding. However, despite social media's importance for modern discourse, no study has investigated people-place relations, cognitions, emotions, and the cumulative impact of RETs via online content. Furthermore, research on energy transition often focuses on studying the impact of one renewable energy source (e.g., Benighaus & Bleicher, 2019) or on the relationship between two energy technologies (such as wind and solar) and their support/opposition (e.g., Sposato & Hampl, 2018). Instead, the following research proposes a combined approach in which RETs, powerlines, and their interconnections are the significant factors of the study. In detail, through three research papers, this work addresses the lack of knowledge in the following way: the first paper, taking both emotions and cognitions into account, explains different types of considerations regarding energy projects. The second study increases the understanding of people-place bonds by investigating the relationship between the place scales mentioned (categorized from local to the planet) and the sentiments expressed in Instagram posts, depending on different energy infrastructures (solar, wind, biomass, geothermal, and powerlines). The last research paper, focusing on the cumulative impacts of RETs (environmental and human-centred impacts), invests what is on the Internet in the key topics used to describe different technologies. The information given by this work can offer insights helpful to practitioners who struggle to adequately deal with people's responses (Cass & Walker, 2009). Plus, this research elaborates on the differences in the words used, which can be a guide to understanding peoples' reactions and communication needed for each of the energy sources.

3. Research Questions and Design

This study aims to explore the research gaps and investigate the dimensions of emotions and cognitions, place, and cumulative impact regarding RETs through three empirical studies. Figure 2 outlines the framework pillars and components investigated in these studies.

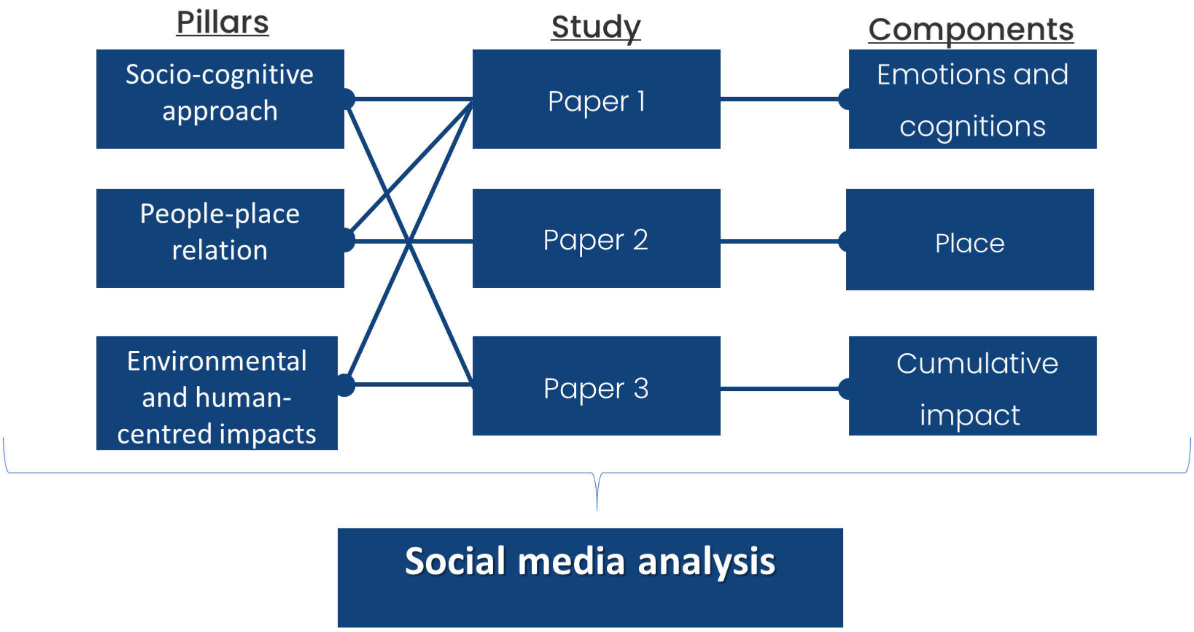

Figure 1. The overarching framework of the research papers

Paper 1 (Vespa et al., 2022) proposes a conceptual framework for the relationship between emotions and cognitions regarding wind, solar, biomass, geothermal energies, and powerlines. Using a SCA, the paper explores the salient words under a set of pre-specified RET hashtags. Building on the appraisal theories of emotions, this research investigates the coexistence of several energy technologies (solar, wind, biomass, and geothermal) and powerlines. In detail, paper 1 aims to study two main points: 1) the co-occurrence of words referring to RETs (to create a schema of the mental association between the energy technologies); 2) to what extent people express emotions and cognitions in writing about RETs. Starting from the idea that there is complementary thinking of RETs and powerlines, mentally organized as a single block connected, the study analyzes the language association and the emotional and cognitive words used to describe them.

Paper 2 (Vespa et al., 2022) analyses the relationship between people-place bonds regarding wind, solar, biomass, geothermal energies, and powerlines. The paper increases the understanding of people-place relations by investigating the link between the place scales mentioned in Instagram posts (categorized from local to the planet) and the sentiments expressed, depending on different RETs. The study uses a SCA to explore the mental association between places and RETs.

Paper 3 (Vespa, 2025; submitted) investigates the interconnection between the cumulative impact topics (environmental and human-centred) regarding wind, solar, biomass, and geothermal energies. The links with the highest total engagement used and shared on Facebook, Twitter, Pinterest, and Reddit platforms were collected, and a content analysis was conducted. It emerges that the themes shared on the web follow a pattern in describing different renewable energies. By understanding and studying these patterns, it is possible to have a clearer idea of how to approach each renewable energy source, what kinds of information people want in the future, what people's needs are, and how they are determined.

This cumulative research aims to answer the following questions:

1. How are RETs described and discussed on social media platforms?
2. What are the most frequent themes and topics shared on the web about RETs?
3. What are the mental associations (emotional, cognitive, place-level) about RETs on the media platforms?

Table 1 gives an overview of the three research papers in the study, providing information about the title, authors, aims, research method, and publication status.

Table 1: Overview of the research papers in the study

N.	Title	Authors	Aim and objective	Research method and analysis	Publication status
1	Getting emotional or cognitive on social media? Analyzing renewable energy technologies in Instagram posts	Mariangela Vespa, Petra Schweizer-Ries, Jan Hildebrand, Timo Kortsch	To explore the mental association between RETs and to what extent people express emotions and cognitions writing about RETs.	Social media analysis of energy-related Instagram posts. Keyword analysis (co-occurrence of words) with the frequency analysis observation. Sentiment analyses with LIWC.	Published in Energy Research & Social Science (2022)

2	Not All Places Are Equal: Using Instagram to Understand Cognitions and Affect towards Renewable Energy Infrastructures	Mariangela Vespa, Timo Kortsch, Jan Hildebrand, Petra Schweizer-Ries, Sara Alida Volkmer	To question and further explain the public consideration of RETs, places (divided into four place categories: city, region, country, and planet), and their ties.	Social media analysis of energy-related Instagram posts. Mapping the Instagram Post with the "rworldma" R package. Sentiment analyses with LIWC.	Published in Sustainability (2022)
3	A world of words: investigating topics on the web of renewable energy technologies through content analysis	Mariangela Vespa	To conceptualize how the RETs and the cumulative impact topics (environmental and human-centred) are expressed and linked to each other on the news on the Internet.	Social media analysis of energy-related URLs with the most engagement on Facebook, Twitter, Pinterest, and Reddit. Content analysis.	Submitted in Energy and Climate Change (2025)

4. Methodology and Data

Paper 1, Paper 2, and Paper 3 report on studies that employed quantitative and qualitative research methods with a social media analysis.

In detail, Paper 1 and Paper 2 reported analysis focusing on the same dataset: 1500 posts (250 for each hashtag) scraped from Instagram. Instagram provides metadata, such as usernames, the time and date of creation, captions, comments (and the user and time information for comments), tags, likes, and location information when users have geotagged their posts. These metadata fields of public posts are available to anyone accessing Instagram via the app or third-party tools (Highfield, 2017).

First, 250 posts for each selected hashtag were scraped using R, Version 4.0.0, and the Jsonlite package (Version 1.6.1). The hashtags selected were #windenergy, #solarenergy, #biomass, #geothermalenergy, #powerlines, and #renewableenergy. The reasons behind the decision to use these specific RET hashtags were different. In detail, wind, biomass, and geothermal have an intense local penetration, becoming subjects of high consideration and discussion by the communities (Ochoa et al., 2019). Solar was added due to its broad distribution. Instead, powerlines are central to energy infrastructure and often contested. To gain an overall overview, the hashtag #renewableenergy has been added. On Instagram, the data can be scraped for free, only selecting a specific number of posts, not following a day-frame. For the same number of posts, the dataset was filtered on "recent" and not on "most popular" posts at the moment of scraping. The "following the hashtag" method has been used for scraping data instead of the "following people" method in which one or more public accounts are attained. This way, all published posts containing the selected hashtags in the caption are obtained.

The advantages of using Instagram for this research are: (i) the number of words that are used in the caption is unlimited, which is contrary to other platforms (e.g., Twitter), and this is an important advantage for this research, which is based on the analysis of text; (ii) Instagram is known for its strong use of hashtags, both as descriptions of pictures/videos and as search terms for particular topics (Handayani, 2015). The extensive use of hashtags allows the study of the sets of words associated with the RET descriptions; (iii) Instagram, as a web source, has never been used to study RETs. Although Instagram is also a social media platform for sharing videos and pictures, the analyses of this study are focused on the analytical procedure of the text, not the images. Since these papers focus on linguistic and mental word associations regarding RETs, analyzing the images would not have provided helpful insight.

The analytical procedures used for Paper 1 are keyword analysis with frequency analysis observation and sentiment analysis with LIWC software. The keywords were selected by analyzing Instagram posts and papers referring to the RETs. The authors discussed and chose the keywords following a specific schema:

1) selecting the keywords named in the text with the highest frequency of occurrence;

2) having for each hashtag the same number of keywords;

3) trying to use similar words (when possible) for each hashtag (for example, using the word power for each keyword).

The central idea of Paper 2 was to analyze the words, the places, and their connections to understand how place scales are linked to the respective RETs named. The analysis element can be broken down into text analysis and the geo-localization of the posts through the mapped places. After scraping the post, a second step was to code the posts about four place categories (city, region, country, and planet) based on the available information in the hashtags, the place geotags, and the captions. One author categorized all of the posts (1500) into categories. A second author coded 20% of the posts independently from the first author for 300 posts. The inter-rater reliability achieved satisfactory significance (85.7%) between the two coders. In the end, 821 posts mentioned a place. Finally, the quantitative analysis maps the posts based on the places named in the hashtags, captions, and/or geotags. The information that is considered here is the location that was provided by the user's geotag (if provided), the caption (if provided), and the hashtag (if provided). The posts are mapped using the "rworldmap" R package. The maps show how often a hashtag (e.g., #windenergy) was used in the different regions, countries, etc. Then, a sentiment analysis with LIWC was applied.

The dataset of Paper 3 includes 1.077 URLs (272 links were of wind energy, 270 links of solar energy, 254 links of biomass, and 281 links of geothermal energy) of the most shared URLs on Facebook, Twitter, LinkedIn, and Pinterest, then a content analysis is applied. Content analysis is a research method mainly used in social science, and it acknowledges the analysis of social words like talks, texts, etc. Content analysis inquiries into social phenomena by treating data as communications created and disseminated to be seen, read, interpreted, etc. (Krippendorff, 2018). The Buzzsumo tool's content analyzer (Drisko & Maschi, 2016) was used to research the top-performing articles, infographics, lists, interviews, newsletters, posts, reviews, and blogs shared on the web. Searching for keywords (wind energy, solar energy, biomass energy, and geothermal energy), the tool brought up a list of all the top pieces of content related to those keywords, alongside insights about them, such as their total number of backlinks, social engagements, and evergreen score. The textual contents of the Web sites to which the URLs linked were entered into Voyant (https://voyant-tools.org/) for a semantic overview and a more contextualized visualization on WordTree (https://www.jasondavies.com/wordtree/). Analysis software MAXQDA was used for the systematic URL review, transcribing the URL contents, coding the data, and identifying the frequencies. This analysis was done for both the full texts of the URLs (full-length articles) and the titles of each article. In this study, qualitative thematic analysis is done by following six main steps: getting familiar with the data, generating initial codes, searching for themes, reviewing potential themes, defining and naming themes, and finally, producing the report (Clarke & Braun, 2017).

4.1. Ethical Considerations

The ethical principles of scientific practice were upheld in all three research works. To respect user privacy, only public content from Instagram (without any privacy restrictions) was examined. Similarly, data was collected exclusively from publicly accessible URLs on other platforms. During the analysis and in the final publications, the names and usernames of the writers of the posts are not traceable, except by the authors of the papers themselves. Additionally, the data has been secured by the required scientific protocols.

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Chapter 2: Empirical Studies

This chapter includes three research papers conducted and published in peer-reviewed journals. As explained in the following paragraphs, Paper 1, Paper 2, and Paper 3 contribute significantly to the research on social perception, description, and evaluation of RETs. Specifically, they offer new insights into the themes related to RETs expressed across various media platforms.

Paper 1, titled "Getting Emotional or Cognitive on Social Media? Analyzing Renewable Energy Technologies in Instagram Posts" (Vespa et al., 2022), examines the mental associations between RETs and the emotional and cognitive words used in Instagram posts.

Paper 2, titled "Not All Places Are Equal: Using Instagram to Understand Cognitions and Affect Towards Renewable Energy Infrastructures" (Vespa et al., 2022), explores the concept of place levels (from local to global) and how it is expressed in Instagram posts.

Paper 3, titled "A World of Words: Investigating Topics on the Web of Renewable Energy Technologies Through Content Analysis" (Vespa, 2025 - submitted), provides insights into the themes shared online regarding each RET. In detail, it presents an overview of which topics are associated with specific RETs.

The findings of these papers suggest that studying emotions and cognitions on social media platforms can significantly enhance knowledge and improve communication among stakeholders. Furthermore, these papers demonstrate that each type of RET evokes specific emotions and cognitions and is linked to particular topics.

Empirical Studies: Paper 1

Getting Emotional or Cognitive on Social Media? Analyzing Renewable Energy Technologies in Instagram Posts[1]

Mariangela Vespa [2,3]; Petra Schweizer-Ries [4]; Jan Hildebrand [2]; Timo Kortsch [5]

Abstract

Renewable energy development is a widely and intensively discussed topic, though it is still unclear which exact variables may influence people's evaluation of the phenomenon. There is a need to study the general public's knowledge, emotions, and cognitions linked to energy technologies, especially in the context of advanced inventions. Social media is a powerful communication tool that has a huge impact on studying public opinions. This study aims to describe linguistic connections through an analysis of 1500 Instagram posts, assuming and interpreting emotional and/or cognitive words. Using a socio-cognitive approach, this research explores the salient words under a set of pre-specified renewable energy technology (RET) hashtags. Building on the appraisal theories of emotions, this research investigates the coexistence of several energy technologies (solar, wind, biomass, and geothermal) and powerlines. The results showed the highest linguistic interconnection between solar and wind energy posts. Furthermore, powerlines were not linguistically connected to the RETs, as they are not included in the schema or not salient when people write posts about renewable energy. Solar, wind and geothermal posts evoked more emotional and positive emotions than the other RETs and powerlines. Instead, biomass posts had a high frequency of cognitive processes and

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causal words. Powerline posts were linked to the words of risk, body, health, and biological process showing a great concern for health and perceived threat. These differences in the words used can be a guide to understanding peoples' reactions and communication for each of the energy sources. This study, taking both emotions and cognitions into account, explains different types of considerations towards energy projects.

Keywords: renewable energy infrastructures, emotions, cognitions, social media analysis, Instagram

1. Introduction

Renewable energy technologies (RETs) increasingly penetrate people's daily lives and lead to emotions and cognitions that may eventually influence attitudes toward renewable energy (Vrieling et al., 2021). Sustainable energy transition is not a purely technological endeavor, but it has a prominent social dimension and requires public support to be successfully achieved (Clayton et al., 2016). In light of research on dual-process models of information processing (Epstein, 1994), recent models have proposed that behavior stems from emotional reactions or affective feelings about cognitive beliefs of a topic (Slovic et al., 2007). Affective and cognitive evaluations are interactive, so affective evaluations can precede cognitive assessments and vice versa (Loewenstein, 2001). Emotions and cognition have played an important role in the study of energy transition analyzing the predictors to accept energy technologies (Johansson & Laike, 2007) or the emotional and cognitive response to energy systems (Schweizer-Ries, 2010). Other studies have assessed the cognitive aspects of acceptance of RETs in terms of political attitudes (e.g., Karlstrøm & Ryghaug, 2014), process-related effects (e.g., Walker et al., 2010), and perceived side effects (e.g., Langer et al., 2016). Furthermore, if people experience certain emotions toward energy projects this may influence their cognitive evaluations of these projects, a phenomenon known since 2007 as the *affect heuristic* (Slovic et al., 2007). These results emphasize the importance of including both affective and cognitive factors when studying the social consideration of energy technologies and energy-related behaviors (e.g., Cousse et al., 2020).

Social media are an arena for public emotions and cognitions and for this reason, we have used a media platform as a source of information. Many existing studies rely on surveys and interviews to understand public perception of renewable energy (Kim et al., 2020). Although surveys and interviews can provide targeted individual-level data, they can be susceptible to selection and response biases (Li et al., 2019). Furthermore, social media platforms can offer several types of interactions and, consequently, different levels of analysis. For example, distinct communication channels permit users to build various explicit or implicit social relationships (Urena et al., 2019), as well as real or implicit information (Tang et al., 2015). By posting on Instagram, people can share the complexity of their emotional words and concepts to a wider audience in an intuitive way (Sonne & Erickson, 2018).

One of the techniques used in social media to study emotions is sentiment analysis, a process that detects and classifies sentiments in texts into different classes of emotions and cognitions (Truelove & Parks, 2012). Building on the appraisal theories of emotions (Scherer, 2001) and with the help of the Linguistic Word Count (LIWC) software (Pennebaker et al., 2015), This research evaluates the text of Instagram posts. The appraisal theories of emotion assume that emotions are elicited by a person's appraisal of events concerning his or her concerns. Appraisal criteria involved in eliciting emotion include the novelty and pleasantness of events, their controllability, and evaluation. Furthermore, this paper presents a Socio-Cognitive Approach (SCA) to the language on Instagram posts. The SCA is issue-oriented and able to investigate relevant social problems focusing on the relations between discourse and society in a critical approach to studying text and talk conversations (Amoussou & Allagbe, 2018).

The remainder of this article is structured as follows: in *Section 2, Theoretical Background,* we address some prevailing theories on the word associations with a socio-cognitive approach to the language used in Instagram posts. Furthermore, the appraisal theory of emotions was discussed to emphasize the relevance of emotional and cognitive connotations in the context of renewable transition. Then, studies on communication and social media platforms provided insight into the opportunities that social media platforms offer to examine the dynamics of social perceptions of energy issues. *Section 3, Method and procedures,* explains the methodology used from the data scraping of the Instagram posts to the analytical procedure of text analysis by keyword analysis (with the frequency observation) and sentiment analysis (with LIWC). *Section 4, Results,* shows the findings of the analyses on the dataset, explaining them by referring to the research hypotheses. *Section 5, Finding Overview and Discussion,* presents an overview of the results and their discussion also referring to scientific literature, as well as the limitations of the study and future research ideas.

2. Theoretical Background

2.1. Appraisal Theory

All forms of RETs have environmental impacts, and their potential impacts on wildlife as well as on the evaluation and reaction to RETs have been the subject of multiple studies (e.g., Lovich and Ennen, 2013). Scholars have analyzed the affective and cognitive side of decision-making regarding energy projects (e.g., Jobin & Siegrist, 2018), especially when the context is complex and uncertain (Slovic et al., 2013). According to appraisal theory, *"emotional components are caused and differentiated by an appraisal of the stimulus as mis/matching with goals and expectations, as easy/difficult to control, and as caused by others, themselves or impersonal* *circumstances"* (Moors, 2020). However, the question remains which emotions are aroused from which energy technologies and if there are RETs that elicit more emotional aspects than cognitive ones (and vice versa). We propose that taking both emotions and cognitions into account can help explain different types of considerations towards energy projects.

The relevance of emotional and cognitive connotations in the context of renewable transition is given by the complexity of the topic of energy supply. The public attitudes towards RETs can additionally be influenced by affect. (Huijts et al., 2012), emotional connotations of the energy source and its infrastructure, and risk perception (Upham et al., 2015). Furthermore, the salience of emotional and cognitive aspects depends on 1) the direct (perceived) effect that a RET technology has on a person; 2) the idea of what that specific RET means for well-being; 3) the potential coping perceived. Thus, people may perceive little or no control over the occurrence of energy projects and this can lead to negative emotions (e.g. fear, anger, etc.) (Vrieling et al., 2021) and 4) the perception of energy projects elicits morality-based emotions.

As highlighted in the SCA, the interrelations between emotions and language have achieved a significant scope and diversification (Kecskes, 2010). Through close attention to language, a schema can be reconstructed that systematically shows the relationships between concepts and experiences represented in written messages. The terms people use in their daily lives can provide important information about their beliefs, attitudes, and social relationships. Thus, mental associations imply proximity to another schema of words in the mind with cognitive, emotional, or neutral connotations. Mental representations are important and decisive because they reflect realities and perceptions that influence the decision for or against a specific energy supply solution and project (Zaunbrecher et al., 2018). Social media offers the manifestation, interpretation, and processing of emotions using natural conversations. Social media also cultivates massive public opinions through emotional and cognitive words (Li et al., 2019).

We hypothesize that there are differences in the words used to describe energy technologies on Instagram posts because there are different emotions and experienced cognitions underlying each RET. Going more into detail, we hypothesize that solar and wind energies are more linked to emotional words than the other RETs. A possible reason could be that people perceive wind energies as the most intrusive and this can rouse emotional reactions. Alternatively, solar energy is well-known, and usually, it is accompanied by high consensus and positive feelings. We hypothesize that powerlines, biomass, and geothermal evoke cognitive words, especially related to the physical aspect, biological process, and risk, assuming that people may include a greater concern for health thinking of biomass, geothermal, and powerlines.

2.2. Communication, Social Media Platforms, and Energy Transitions

The formation of public opinion has been conceptualized as a multilayered process, involving not only interpersonal communication among individuals but also mass communication over media platforms (Owolabi, 2014). Studies on communication and change of attitude describe the switch of perception or opinion, in terms of cognitive, affective, and (or) behavioral towards the *"attitude object"* (Alajmi et al., 2016). A high number of researchers on energy transitions have used different social media platforms as data sources. Social media provides an opportunity to examine the dynamics of social perception of energy issues (such as emerging technologies, energy conservation, and environmental impacts). Furthermore, social media contains temporal, spatial, relational, and contextual information that may be leveraged to represent and examine the dynamics of social perception on energy topics (Devine-Wright et al., 2021). Nuortimo and Härkönen (2018) studied the opinion mining approach to media-image of energy production with implications for public acceptance and market deployment. The findings support the notion of social media having an increasing role in shaping public opinion, which may need to be acknowledged largely by all the institutions, the public, and governments that could use this information appropriately. Kim et al. (2020) proposed a word network model in social media services and conducted a network analysis to examine the public perceptions of renewable energy resources. The results showed that the network model in social networking services could obtain latent and usually social, industrial, economic, and environmental issues related to renewable energies.

Insights from social psychology indicate that familiarity with an object influences preference formation, which in turn influences choices (Weber & Johnson, 2011). Several researchers illustrate that familiarity with energy technology is correlated with the social acceptance of renewable energy. Attitudes follow a U-shaped curve, in which projects initially show high acceptance levels but drop in their local acceptance rates during the permitting and construction phases (Dällenbach & Wüstenhagen, 2022). Research studies suggested that local newspapers play a significant role in the RET perception (e.g., Braunholtz, 2003). More generally, TV and social media platforms are the main sources of information about renewable energy, and only sometimes people have personally seen or visited RET farms (Devine-Wright, 2008). How this information is shaped influences the people's perception and evaluation of RETs. Thus, this study using a social media platform, gives an overview of the description of different energy technologies.

2.3. Word Associations in a Socio-Cognitive Approach

Theories of memory and association assume that the meaning of a word can be represented by a vector which places a word as a point in a multidimensional semantic space (Burgess & Lund, 2014). It is common practice in linguistics (e.g., Gries, 2010) To classify words not only based on their meanings but also based on their co-occurrence considering the probability of observing *"x"* and *"y"* together.

This paper presents an SCA to the language used in Instagram posts by investigating the interconnection between the salient words referring to RET hashtags. In SCA, language production and interpretation are governed by the mechanism of salience. A sign can be interpreted as a measure of how well an element stands out from other entities, and how it influences the preference of the individual in selecting words and constructs in the process of communication, considering the degree of familiarity, frequency, and conventionality (Kecskes, 2010). By socio-cognitive processes, we refer to those group-level factors known to moderate human decision-making (Morgan et al., 2010). This study based on the word and sentiment associations between RETs and powerlines gives information such as opinions and attitudes expressed in the text (whether the semantic orientation in positive, negative, or neutral classification words).

2.4. Aims and Hypotheses

This work aims to study two main points: 1) the co-occurrence of words referring to RETs; and 2) to what extent people express emotions and cognitions writing about RETs. The research questions that this study seeks to answer are[2]: Is there a repeated language association between some RETs and powerlines? What are the emotions/cognitions associated with the language description of RETs and powerlines?

Starting from the idea that there is a complementary thinking of RETs and powerlines, our first group of hypotheses is that solar and wind energies are more interconnected, belonging to the same category. These assumptions have been developed based on a review of the literature on RETs and power lines. We expect more interconnection between wind and solar energies and the reasons could be given by their greater visibility, familiarity, and knowledge than other RETs. Thus, the more familiar a person is with the RET farms, the more positively they are

[2] The following research has been pre-registered on https://aspredicted.org/create.php and made public on September 14th, 2020. The .pdf is available from https://aspredicted.org/mz9ti.pdf.

likely to support the RET development (Devine-Wright, 2005). On the other hand, there are different physical aspects of the technologies that create people's arguments and opinions. For example, the impact on the landscape causes visual intrusions (Yiridoe, 2014) and reduces the quality of the recreational area (Broekel & Alfken, 2015). The effects on wildlife have also been the reason for great criticism, as well as the construction on the local environment as on land use (Scherhaufer et al., 2017). These and many others are the critical components of the social acceptance of wind energy infrastructure. Instead, solar energy has a broad distribution, even though it is not conflict-related, as wind energy. We hypothesized that these two RETs evaluate bigger stimuli than the others and are mentally strongly interconnected.

Hypothesis 1. Different RETs are often named after each other.

> **H 1.1.** #windenergy Instagram posts have a higher frequency of words regarding solar energy and vice versa than #powerlines, #biomass, and #geothermalenergy.
>
> **H 1.2.** In the #renewableenergy posts, wind and solar energies and powerlines have a higher frequency of words that refer to each other than #biomass and #geothermalenergy.

According to appraisal theory, the emotional components are caused by an appraisal of the stimulus, goals, expectations, control, and circumstances (Moors, 2020). When confronted with a stimulus of renewable energy, people ask themselves questions such as: *Does this affect me directly? What does it mean for my well-being? Can I face the challenge?*

The answers to these questions will shape the congruency with moral considerations and, consequently, the approach/evaluation/feeling towards RETs. We hypothesize that solar and wind energies are more related to emotional words than other RETs. One possible reason could be that people perceive wind energy as the most intrusive (height, color, noise, etc.), but also evaluate it with positive aspects (economic, environmental, etc.) and this may elicit emotional reactions. Alternatively, solar energy is well known and is usually accompanied by high acceptance and positive evaluations. The appraisal of powerlines, biomass, and geothermal evokes cognitive words, especially related to the physical aspect, biological process, and risk, assuming that people may include a greater health concern. Based on the literature, the following hypotheses have been proposed.

Hypothesis 2. Different RETs are linked to distinct emotions and cognitions.

H 2.1. #windenergy Instagram posts contain more emotional than cognitive words.

H 2.2. #solarenergy and #windenergy Instagram posts contain more words of affective process and positive emotions than #powerlines, #biomass, and #geothermalenergy.

H 2.3. #powerlines Instagram posts contain more words of power, health, and risk than #windenergy, #solarenergy, #biomass, and #geothermalenergy.

H 2.4. #biomass Instagram posts contain more words about body and biological processes than #windenergy, #solarenergy, #powerlines, and #geothermalenergy.

H 2.5. #geothermalenergy Instagram posts contain more words of cognitive process, insight, and causation than #windenergy, #solarenergy, #powerlines, and #biomass.

3. Method and Procedures

This study provides an account of co-occurrence, emotional, and cognitive words elicited by wind, solar, geothermal energies, powerlines, and biomass on Instagram using the text available in published posts. The method used to collect and analyze the data followed a precise scheme shown in Figure 1.

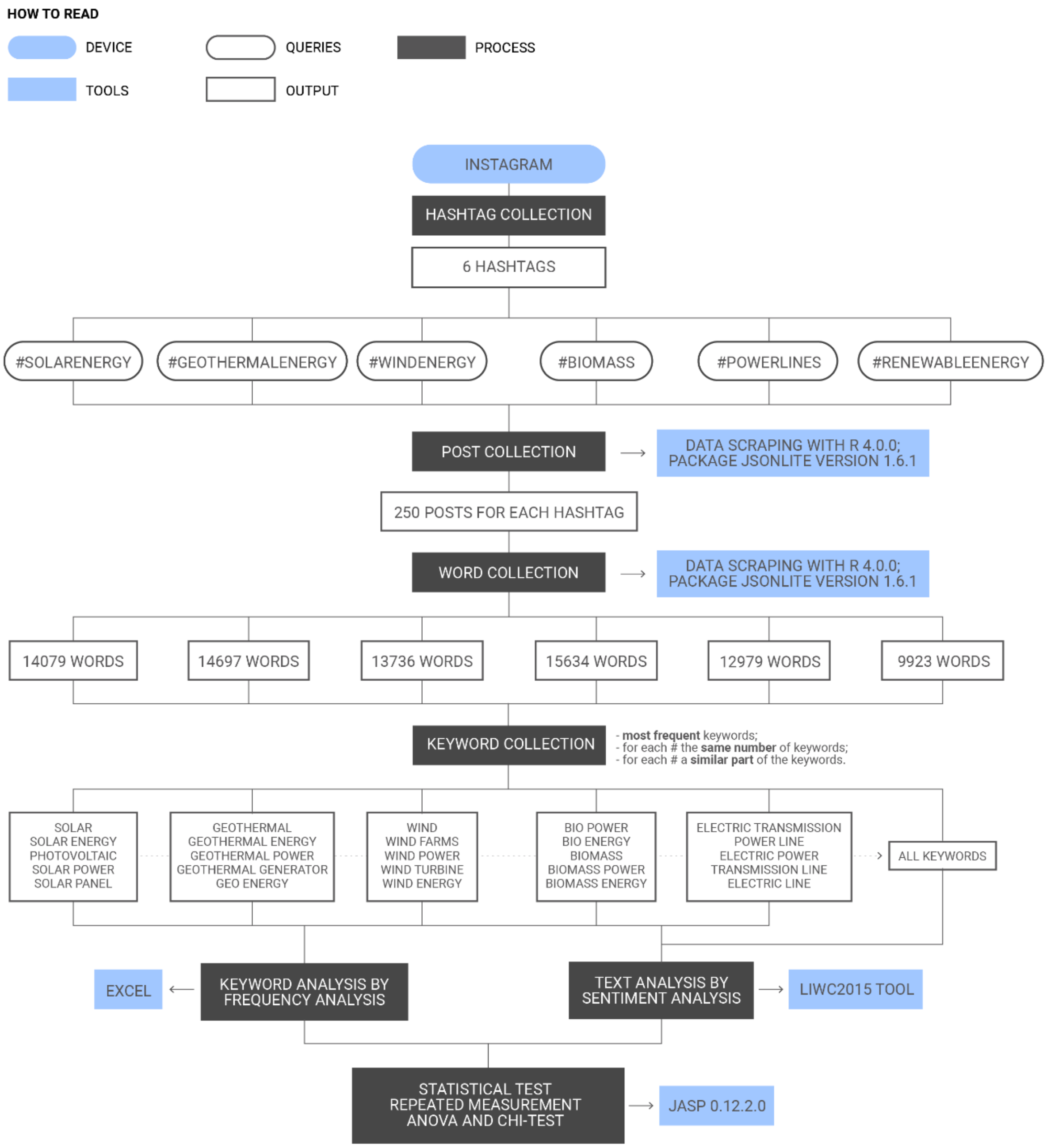

Figure. 1. Method process: from the data collection to the data analysis

First, Instagram posts were scraped with R version 4.0.0, package Jsonlite version 1.6.1. The analytical procedure to analyze the text had two main steps: 1) the frequency method analysis with the keywords; and 2) the sentiment analysis by the LIWC2015 tool with the hashtag and caption text. The frequency was statistically investigated through the one-way within-subjects ANOVA and chi-test on JASP 0.12.2.0. The following paragraphs explain in detail all the phases of the method.

3.1. Data Source: Scraping Data from Instagram Posts

The 1500 posts (250 for each hashtag) used in this study were scraped from public Instagram accounts (without privacy restrictions) on 17th September 2020. We chose to sample 250 posts for each hashtag because we expected a small effect size (see for example Boulianne, 2019). An important clarification is that on Instagram the data can be scraped for free only selecting a specific number of posts, not following a day-frame. Furthermore, the data collection by time series was not possible considering that the number of posts published is very different depending on the day and this means that it would not be possible to have a comparison between the RETs. For having the same number of posts, the dataset was filtered on "recent.[3]" not on "most popular" posts at the moment of scraping. We used the “following the hashtag” method for scraping data (instead of the “following people” method in which one or more public accounts are attained). In this way, all published posts containing the selected hashtags in the caption are obtained. Only posts written in English were taken in the analyses. To respect users' privacy, the public contents (in which there are no privacy restrictions) have been taken into consideration.

3.2. Sample Description

The sample is composed of 1500 posts and 82,616 words (see Fig. 1 for more details on the number of words in each hashtag), 250 posts for each hashtag which are #windenergy, #solarenergy, #biomass, #geothermalenergy, #powerlines, #renewableenergy. In detail, the length of the 1500 posts is M = 63.72 and SD = 51.72. The length varies from M = 47.56 for the #powerlines posts to M = 73.26 for the #windenergy posts. In addition, we made another validation step, scraping 30% of the posts, for a total of 450 posts. We evaluated them concerning their length. In this case, the length of the posts is M = 67.8 and SD = 49.15. To provide a criterion for assessing lexical richness, we calculated the type/token ratio (TTR) in the text for each selected hashtag. In detail, the TTR of the 1500 posts is TTR = 19.06. The TTR varies from TTR = 5.56 for #powerlines posts to TTR = 34.41 for #renewableenergy.

Posts containing more than one selected hashtag were analyzed for all hashtags present, provided they were among the 250 most recent posts. We chose to focus on specific RET hashtags - namely wind, biomass, and geothermal - due to their strong local relevance, which

[3] The 250 posts scraped of each hashtag have been posted on the same day. No hashtags had less than 250 posts on the day of the scraping.

makes them topics of significant interest and discussion within communities (Ochoa et al., 2019). Although solar energy is not directly related to conflicts like the other RETs, we included it because of its widespread distribution. Additionally, powerlines are crucial to energy infrastructure and are often subjects of contention, so they were also included. To gain a comprehensive overview, we incorporated the hashtag #renewableenergy.

Figure 2 shows an Instagram post as an example and it contains a picture, an ID name, a place in the geotag, and a caption.

Figure. 2. An example of an Instagram post

3.3. Analytical Procedure

3.3.1. Keyword Analysis with the Frequency Analysis Observation

The co-occurrence analysis aims to find similarities in meaning between and within word patterns and to discover latent structures of mental representation (Lancia, 2007). In this research, the frequency of keywords has been observed in the text of Instagram posts. The keywords are words that have been selected to analyze the frequency of times renewable energy was named in the posts. The words inserted are the nouns used about specific RET (see Fig. 1). The keywords were selected by analyzing Instagram posts and papers referring to the RETs. The goal was to identify the different words used for naming the RETs and a document was prepared with the frequency of times the keywords were named in the text. The frequency was statistically investigated through the one-way within-subjects ANOVA (H1.1) and chi-test (H1.2) on JASP 0.12.2.0. Appendix A shows the descriptive statistics of all the keywords of each hashtag.

3.3.2. Sentiment Analyses with LIWC

Broadly, there exist two types of methods for sentiment analysis: machine-learning-based and lexical-based. While one advantage of learning-based methods is their ability to adapt and create trained models for specific purposes and contexts, their drawback is the availability of labeled data and hence the low applicability of the method on new data. Instead, lexical-based methods make use of a predefined list of words, where each word is associated with a specific sentiment. In this research, the LIWC software was used for analyzing the hashtag and caption texts of Instagram posts, a version 2015 English dictionary. The LIWC is an example of a popular tool in the literature (e.g., cited and used) lexical method and the latest version captures over 86% of the words people use in writing and speech. Each word in a given text file is compared with the dictionary file and the percentage of each LIWC category is selected. The analyses include comments from over 80,000 writers or speakers totaling over 231 million words.

Table 1

Output Variable Information from LIWC2015 Development Manual.

		Hypotheses
Emotional Processes	Affective Processes	H2.1 – H2.2
	Positive Emotion	H2.2
	Negative Emotion	H2.2
Cognitive processes	Cognitive Processes	H2.1 – H2.5
	Insight	H2.5
	Causation	H2.5
	Biological Processes	H2.4
	Body	H2.4
	Health	H2.3
	Power	H2.3
	Risk	H2.3

Table 1 illustrates the emotional and cognitive processes taking for the analyses of different hypotheses. The output of the software are the percentages of total words within a text. The LIWC2015 output was statistically investigated through the one-way within-subjects ANOVA on JASP 0.12.2.0. Appendix B shows the descriptive statistics of LIWC2015 output.

4. Results

4.1. Different RETs are often named after each other. Wind and solar energies have a high frequency of words concerning each other in all the hashtags.

Part of the analysis was focused on the frequency observation in all the hashtags (see figure n. 3). As general founding, different RETs are named in the hashtags, except #powerlines. The highest frequency is given by solar words. In some hashtags there are specific places named, such as Africa (#biomass), India (#solarenergy), and Iceland (#geothermalenergy), underlining a place-RET word association. In all the posts, there is a high mental association between RETs, nature, and “green” words (such as landscape, environment, sky, clean, future, etc.).

Figure. 3. Frequency of words in the hashtags

Other analyses were focused on the frequency analysis observation (see Table 2) of the keywords (kw in the table). As an overall finding, the solar energy keywords have the highest frequency in all (except for powerlines) hashtags compared to the other keywords. The highest value is in the #renewableenergy, as for the wind energy keywords, showing that solar and wind energies are both salient in the general broad of renewable energy topic. A high percentage of solar keywords is in #windenergy, confirming the statement of the hypothesis. Looking at #solarenergy there are low general frequencies of RET keywords, with the highest value for the wind energy. It manifests that the solar energy keywords have a high frequency in all the posts, but in the #solarenergy, there is not the same elevated frequency of the RET keywords. From these results, we can consider that thinking of wind energy has a strong mental association with solar energy, but the association is not so strong in thinking of solar energy. The powerlines hashtag has only a few words referring to the other renewable energies, with the highest frequency of wind energy keywords. At the same time, the powerline keywords are less present in the other posts, with the highest frequency in the #biomass.

Table 2

Frequency of keywords in the posts and comparison by ANOVA

Hashtags	**Keywords**					**ANOVA**		
	wind	**solar**	**biomass**	**geothermal**	**powerlines**	**F**	**DF**	**P**
#windenergy		471	17	11	2	44.26	3	< .001
#solarenergy	25		6	7	0	9.46		< .001
#biomass	102	159		35	5	25.18		< .001
#geothermal	60	96	53		1	16.16		< .001
#powerlines	15	3	0	0		6.96		< .001
#renewableenergy	175	913	7	2	4	66,71	4	< .001

The frequency of keywords was statistically verified. In detail, for each hashtag, we conducted a repeated measures analysis of variance with one within the subjects' factor with four levels, five for #renewableenergy. With Bonferroni adjusted post hoc tests we analyzed pairwise which keywords differed from each other significantly. In cases where the sphericity condition was not met (Mauchly's test for sphericity became significant), the Greenhouse-Geiser correction procedure was used.

In the #windenergy posts, only the frequency values of solar energy are significantly higher than all other levels, $p < .001$. In the #biomass posts the frequency values of solar energy are significantly higher than wind energy $p < .05$ as well as geothermal and powerlines (both $p < .001$). The frequency value of wind energy keywords was significantly higher than geothermal energy ($p < .01$) and powerlines ($p < .001$). The values of geothermal energy and powerlines keywords did not differ significantly from each other ($p > .05$). In the #geothermal posts the frequency values of solar energy keywords are significantly higher than biomass ($p < .05$) and powerlines ($p < .001$), and did not differ significantly from wind ($p > .05$). The frequency value of wind energy keywords did not differ significantly from biomass ($p > .05$), but the value was significantly higher than powerlines ($p < .001$). The values of biomass energy were significantly higher than powerlines keywords ($p < .01$). In the #powerline posts the frequency values of wind energy keywords are higher than all other levels ($p < .001$). The biomass and geothermal keywords did not differ significantly from each other ($p > .05$); the value of solar energy keywords is significantly lower than wind energy ($p < .05$). In the #solarenergy posts only the frequency values of wind energy are significantly higher than all other levels ($p < .001$). In the #renewableenergy posts only the frequency values of solar energy are significantly higher than all other levels ($p < .001$).

In the #renewableenergy posts, the frequency of times the RET keywords were mentioned together. The highest interconnection of words was between solar and wind (13 times), followed by biomass-solar (3 times), biomass-wind (3 times), geothermal-wind (2 times), geothermal-solar (2 times), and geothermal-biomass (2 times). Contrary to what we expected, the words referring to the powerlines were 0. In this case, as in the previous analyses, the words referring to powerlines are low if not completely absent showing a missing connection with all the RETs. The frequency value between the RETs named together in the posts was statistically verified by a Chi-squared test, resulting in $X^2 = 133.33$, $df = 1$, $p < .001$.

4.2. Different RETs are linked to different emotion and cognition words

A sentiment analysis has been done on the words of 250 #windenergy posts for section 4.2.1, and 1250 posts for the other hypotheses of this section. We have excluded the #renewableenergy posts from this analysis because these hypotheses were focused on the emotional and cognitive words used in describing specific RETs. The #renewableenergy was integrated to gain an overall overview of the topic, for this reason, we have used that dataset in the previous analysis.

The LIWC2015 output for each post was statistically verified. We conducted a repeated measures analysis of variance with one within the subjects' factor two-level (affect and cognition) for section 4.2.1 and five levels (#biomass, #geothermal, #powerlines, #solarenergy, and #windenergy) for all the other hypotheses. With Bonferroni adjusted post hoc tests, we analyzed pairwise which values differed from each other significantly (see Appendix C). In cases where the sphericity condition was not met (Mauchly's test for sphericity became significant), the Greenhouse-Geiser correction procedure was used.

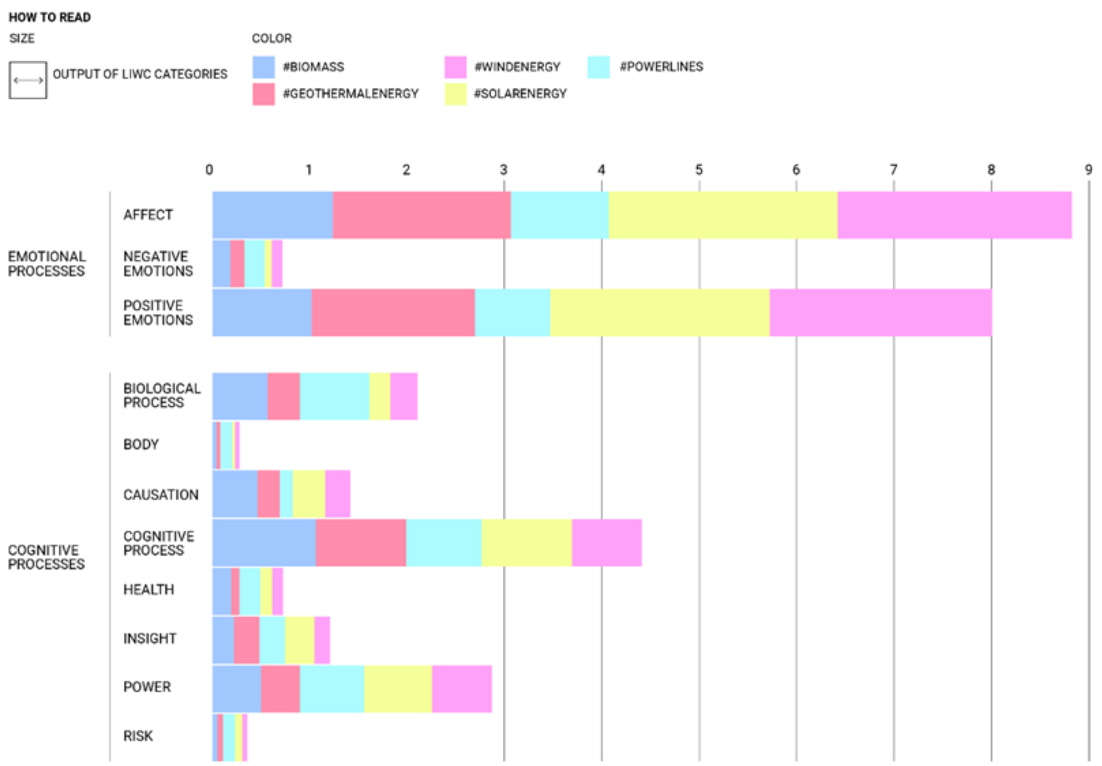

Figure. 4. Output (percentage) of LIWC categories emotional vs cognitive processes

Figure 4 shows the percentage of LIWC category on the emotional and cognitive processes. The following sections explain in detail the results.

4.2.1. #windenergy contains more emotional than cognitive words

The analysis revealed a significant overall effect ($F = 195.58$, $df = 1$, $p < .001$) meaning that there are significant differences in the frequencies between cognition and emotional words used. We found that the percentage values of affect are significantly higher than the cognitive processes $p < .001$. Our hypothesis was confirmed, stressing that the words used with #windenergy are more emotional than cognitive.

4.2.2. #solarenergy and #windenergy contain affective processes and positive emotions words

The analysis of affect values revealed a significant overall effect ($F = 49.07$, $df = 4$, $p < .001$). We found that the effect LIWC2015 category of #windenergy words was significantly higher than the powerlines, geothermal, and biomass factors ($p < .001$), and did not differ significantly from the solar factor ($p > .05$). The affect #solarenergy values were significantly higher than the powerlines, geothermal, and biomass factors ($p < .001$). The #powerlines affect values were, instead, significantly lower than geothermal values ($p < .001$) and did not differ significantly from biomass ($p > .05$). The #geothermal affect words were significantly higher than biomass ($p < .001$).

The analysis of positive emotion values revealed a significant overall effect ($F = 61.11$, $df = 4$, $p < .001$). We found that the positive emotion category of #windenergy words was significantly higher than the powerlines, geothermal, and biomass factors ($p < .001$), and did not differ significantly from the solar factor ($p > .05$). The affect #solarenergy values were significantly higher than powerlines, geothermal and biomass factors ($p < .001$). The #powerlines affect values were, instead, significantly lower than geothermal values ($p < .001$) and did not differ significantly from biomass ($p > .05$). The #geothermal affect words were significantly higher than biomass ($p < .001$).

The analysis of the negative emotion values revealed a significant overall effect ($F = 45.65$, $df = 4$, $p < .001$). We found that for the negative emotion category, only the #powerlines words were significantly higher than the solar factors ($p < .01$).

As expected, both #windenergy and #solarenergy posts evoke more affective processes and positive emotions than #biomass, #geothermalenergy, and #powerlines. A result that we want to underline is the high value of affective process and positive emotion words found in the #geothermalenergy posts. This result should be explored in further studies.

4.2.3. #powerlines contain the power, health, and risk words

The analysis of health values revealed a significant overall effect ($F = 7.65$, $df = 4$, $p < .001$) meaning that there are significant differences in the frequencies between the factors. We found that the health LIWC2015 category values of #powerlines were significantly higher than the geothermal ($p < .001$), wind ($p < .01$), and solar levels ($p = .01$), and did not differ significantly from biomass ($p > .05$). The geothermal values are significantly lower than biomass ($p = .01$) and did not differ significantly from the other factor level (solar and wind); $p > .05$. The wind energy values are significantly lower than biomass ($p = .05$).

For the power output, the analysis revealed a significant overall effect ($F = 6.16$, $df = 4$, $p < .001$). We found that the power category of #powerlines values was significantly higher than geothermal ($p < .01$) and the other levels (solar, wind, and biomass) did not differ significantly ($p > .05$). The geothermal values were significantly lower than solar energy ($p < .001$) and wind energy ($p < .01$). The solar energy values were higher than biomass ($p = 0.5$).

For the risk output, the analysis revealed a significant overall effect ($F = 4.19$, $df = 4$, $p < .01$). We found that only the risk category of #powerlines values was significantly higher than geothermal, wind energy, and biomass ($p < .01$).

Summarizing, the #powerlines posts evoke more health and risk words than the other hashtags. Contrary to what we expected, the power words are higher in the #solarenergy, following by #powerlines and #windenergy. Concluding, in our sample people described the solar posts with both emotional and cognitive words. The powerlines, instead, are perceived as the riskiest technology.

4.2.4. #biomass contains body and biological process words

The analysis of the biological process output revealed a significant overall effect ($F = 20.48$, $df = 4$, $p < .001$) meaning that there are significant differences in the values between the factors. We found that the biological process LIWC2015 category values of #biomass were significantly higher than solar and wind energies (both $p < .001$), and geothermal ($p < .01$). The geothermal values were significantly lower than powerlines ($p < .001$). The powerlines values were significantly higher than solar and wind energies ($p < .001$).

For the body process output, the analysis revealed a small significant effect ($F = 3.07$, $df = 4$, $p < .05$). We found that only the body process category values of #biomass were higher than solar energy ($p <.05$).

Contrary to what we expected, the body and biological process words were higher in the #powerlines posts, followed by #windenergy for the power category and biomass for the biological process words. Powerline posts had a high value related to the physical aspect of the people.

4.2.5. #geothermalenergy contains cognitive process, insight, and causation words

The analysis of the cognitive process output revealed a significant small effect ($F = 4.54$, $df = 4$, $p < .01$) meaning that there are small significant differences in the values between the factors. We found that only the cognitive process category values of #biomass were significantly higher than powerlines ($p < .05$) and wind energy ($p < .01$).

For the insight output, the analysis revealed a significant small effect ($F = 3.67$, $df = 4$, $p < .01$). We found that only the insight category values of #solarenergy were significantly higher than wind energy ($p < .01$).

For the causal output, the analysis revealed a significant effect ($F = 16.11$, $df = 4$, $p < .001$). We found that the causal category values of #geothermal were significantly lower than biomass ($p < .001$). The biomass values were significantly higher than powerlines and wind (both $p < .001$), and solar ($p < .05$). The powerlines values were significantly lower than solar ($p < .001$) and wind ($p < .05$).

Summarizing, the cognitive and causal processes were higher in #biomass posts and the insight values in #solarenergy. As we showed on the previous results, the #geothermalenergy posts have higher emotional than cognitive words.

5. Finding Overview and Discussion

Building on appraisal theory we studied the emotional and cognitive words used under the Instagram posts. With a SCA to the language, we investigated the interconnection between the salient words referring to RET hashtags. We hypothesized that each RET was linked to specific emotional and/or cognitive words. Several discussions arise from our analysis of the interaction between RETs, cognitive, and affective components.

First, all the RETs are linguistically connected on our Instagram sample, both in the dataset of different hashtags and in the #renewableenergy. As we expected, the linguistic interconnection is higher between solar and wind energies. Furthermore, the solar energy keywords are the most interconnected to all the RETs with the highest number of words mentioned in the posts. This aspect underlines that solar energy plays a key role in the relationship between people and energy transition, considering also that it is one of the fastest growing RET. Opinion polls also indicate that solar energy enjoys a high level of socio-political acceptance and is preferred to other renewables (Cousse, 2021). These reasons could influence the salience of the topic for Instagram users. In addition, it is also relevant to consider that the co-occurrence of words in Instagram posts can also depend on overall discourses and repertoires that provide the shared background in which the analyzed are embedded. For example, one or more energy technologies can be part of a figurative nucleus of a shared social representation, (Batel & Devine-Wright, 2015) which is also replicated in individual mental representations. Future studies could include these considerations into account.

In our data, the powerlines are not linguistically connected to the RETs. It seems that they are not mentally included when people write about RETs as if they belonged to another group of proximity between words. Powerlines are closely connected to the functioning of renewable energies, and physically they have an important environmental impact. Studies showed that powerlines are associated with more positive feelings, higher perceived benefit, lower perceived risk, and higher general and local acceptance when they are linked to the energy transition (Lienert et al., 2015). Although previous studies have confirmed the importance of connecting powerlines to the energy transition, our results showed that on Instagram this step has not yet taken place. This means that a future phase could be to build a stronger mental association between powerlines and RETs to increase a more general acceptance of powerlines. For these reasons, we encourage future studies and social initiatives in this direction.

Concerning the words named in the hashtags, there are specific places such as Africa (#biomass), India (#solarenergy), and Iceland (#geothermalenergy), underlining a place-RET word association. African countries, in fact, are gifted with a big bioenergy potential, with wood supply from surplus forests estimated at 520 GWh/year (Miketa et al., 2015); Iceland has a big geothermal potential based on the location of the country on the Mid-Atlantic Ridge (Ragnarsson, 2015); solar is a significant energy source in India which there are about 250–300 sunshine days yearly with regular solar radiation of 200 MW / km2 (KhareSaxena et al., 2020). An aspect that we want to underline is that the places named are all on a large scale (continents and countries). The major salience of RET-place word associations in our dataset is given by the global scale of place (including the "world" and "national" words used in #geothermaenergy). Existing studies of place attachments and place identities have taken a "local" vs "global" focus. The "psychological distance" (Milfont, 2010) is an important aspect of the 'localist' perspective, which argues that things of value to individuals must be close rather than distant. Future studies should consider the multiple scales of people-place bonds, in order to study their dynamics on social media platforms.

Second, solar and wind energies evoke more emotional and positive emotions than the other RETs and powerlines. The solar posts did not only have high values of emotional words but also high values in a few cognitive categories (insight and power), underlining that both, cognitive and emotional categories, were present significantly in our #solarenergy sample. The wind energy posts, instead, have more emotional than cognitive words. This is in line with a body of research that shows that there is a rich diversity of emotional perspectives on what influences individual attitudes towards wind energy projects, which can be grouped into three key themes: personal attributes; perception of the fairness of procedural justice; and perceived impacts of the project, including site location proximity, and project characteristic (Ellis & Ferraro, 2017). Some researchers have attributed the strongest response to wind energy projects arising from the changes to local landscapes and fears of the resulting visual disruption (e.g., Pasqualetti, 2011). This suggests that an individual's reaction to a proposed project may primarily be one of *"place-protection"*, stimulated as an emotional response to what they see as a disruption of places they have developed a close affinity to. This is a potentially expansive area, considering that if the project developers could predict sentiments and emotions early in the development of the project, interventions could be introduced to manage the community's emotions and behaviors and hopefully increase the likelihood of the project's acceptance (Ellis & Ferraro, 2017).

Geothermal posts also had a higher frequency of emotional than cognitive words. Researchers are still studying the affective responses elicited by geothermal energy. As a general point, people are confused about the difference between surface and deep geothermal energy projects, as well as geothermal energy in general (Cousse et al., 2021; Dubois et al., 2019). These reasons led us to think that this RET was addressed more at a cognitive level, with the aim of people to create a psychological distance. Indeed, confusion may cause resistance, risk perception, and strong emotional response. Thus, following the appraisal theory, perceived risks are predictors of a wide range of negative emotions toward perceived externally controlled energy projects (Vrieling et al., 2021). Incorporating affect and emotions into research may help to better understand drivers of public acceptance of geothermal projects, in turn helping policymakers and project developers in crafting new strategies for managing various elements of public acceptance.

Biomass posts have a high frequency of cognitive processes and causal words. Literature underlines that biomass is viewed as one of the critical renewable energies mainly due to concerns about negative sustainability impacts (Reißmann et al., 2020). For these reasons, we were willing to hypothesize that biomass energy was linked to the body and biological process words assuming a great concern for health. Future studies in this direction are needed for a deeper understanding of this renewable energy and its relationship with emotions and cognitions.

Powerline posts are linked to the words of risk, body, health, and biological process showing a concern for health and perceived threat. The literature confirms this statement having a dense corpus of papers studying the association between powerlines and possible health and body problems (e.g., Rathebe et al., 2019). Conflicting results have been established creating a public health concern to individuals. Furthermore, public response to powerline projects is mainly influenced by people's perceptions of risk and benefit (Bronfman et al., 2012). According to the affect heuristic and the appraisal theory, negative feelings towards a given technology can lead to lower perceived benefit, higher perceived risk, and consequently, lower public acceptance. One strategy is to reduce the perceived risks of energy projects as much as possible and increase trust in responsible parties. It is important to be clear in communicating risks and benefits linked to projects. Increasing trust and reducing morality-based emotions and feelings of powerlessness might be critical for stakeholders to have a social license to operate because such emotions can particularly lead to resistance (Vrieling et al., 2021).

To the best of our knowledge, this study is the first to carry out an analysis of people’s words concerning RETs on Instagram posts and our results show that significant differences exist between emotion and cognition words used for describing RET. Communication strategies should thus be targeted based on specific words and the linkage between infrastructures. The results reveal that emotions and cognitions are not related only to the energy source per se, but rather to the specific energy infrastructure and powerlines.

Limitations and Future Research

While this study has its merits, we identify four limitations that can be the starting point for further research. First, the results must consider the Instagram users and their variables, such as age, use possibility, needs, etc. The data can have a strong bias of a specific age (younger populations between 18 to 34 years old (*https://www.statista.com/)*. Second, the demographic factors, user personality, and cultural differences are some information that we cannot know with the data scraped. Third, the LIWC2015 software and the word count techniques are a coarse measure of language and devoid of context. Furthermore, while we crawled for English hashtags, some posts used multiple languages. Since the English dictionary of the LIWC, we were only able to analyze the English text of captions and hashtags**.** Fourth, the day used for scraping data was random. Therefore, one concern could be that the data (and consequently the results) can be influenced by a "significant day" (elections, events, etc.). Further research could expand on how the data scraping date can be controlled to show the significance of Instagram as a tool for expressing opinions about energy issues. Furthermore, it would be appropriate to do a replication study. This research could be also adapted to other social media, such as Facebook and Twitter, to compare data across multiple platforms. Considering that this study was focused on the analytical procedure of the text, future works may consider adding pictures and videos to the analyses. In addition, in the analysis of solar energy in the Instagram posts we have not made a distinction between distributed (e.g., rooftop) and more land-intensive installations. This distinction would help in understanding the degree to which emotional and cognitive words are used at different solar facilities so that more precise conclusions can be reached. We suggest more studies in this direction.

As with any data source, social media analysis presents both opportunities and challenges. One major critique of social media data is that the data are not generalizable outside of the platforms from which the data originate (Halford & Savage, 2017). However, in our research, we used the analyses of studies *with* social media, in which the goal was to use digitally derived data to analyze general social topics. On one hand, we agree that, in most cases, social media data are not generalizable to 'society' at large. On the other hand, social media are in everyday life and thus integral to larger social processes (Halford & Savage, 2017). We agree with other authors (e.g., Davis & Love, 2019) in claiming that "*researchers can maintain the full potential of social media data to inform a multitude of social phenomena while maintaining the integrity of theory-data through theoretical generalisability in the tradition of formal theory"*. With this in mind, we underline that the study of emotions and cognitions toward RETs is a guide to understanding peoples' reactions and social media data can help, for example, in developing communication strategies. However, we have to consider that it is not possible to isolate the study of energy from its socio-ecological contexts (Goodman & Marshall, 2018) because energy and society are strongly interlinked.

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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.

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Appendix A: Descriptive Statistics of all the Keywords (KW) of each Hashtag

	Solar KW	Wind KW	Geothermal KW	Powerlines KW	Biomass KW
#biomass					
Mean	0,64	0,41	0,14	0,02	
Std. Deviation	1,64	1,23	0,59	0,26	
#geothermalenergy					
Mean	0,38	0,24		4,00e -3	0,21
Std. Deviation	1,20	0,76		0,06	0,73
#powerlines					
Mean	0,01	0,06	0		0
Std. Deviation	0,14	0,31	0		0
#renewableenergy					
Mean	3,65	0,70	8.00e -3	0,02	0,03
Std. Deviation	6,24	2,66	0,09	0,25	0,17
#solarenergy					
Mean		0,13	0,03	0	0,02
Std. Deviation		0,61	0,27	0	0,22
#windenergy					
Mean	1,88		0,04	8,00e -3	0,07
Std. Deviation	4,38		0,34	0,09	0,37

Appendix B: Descriptive Statistics (Standard Deviation and Means) of LIWC2015 Output

Hashtags	Descriptive Analyses of LIWC2015 Output										
	Affect	**Cognitive process**	**Positive emotions**	**Negative emotions**	**Heath**	**Power**	**Risk**	**Biological process**	**Body**	**Insight**	**Causal**
Standard Deviation											
#windenergy	6,45	3,36	6,37	2,26	1,09	2,8	0,6	2,43	1,62	1,27	1,51
#biomass	4,98	4,54	4,72	2,04	1,53	3,36	0,72	3,24	0,57	1,56	2,76
#geothermal	5,85	4,05	5,81	1,43	0,91	2,29	0,71	2,45	0,73	1,81	1,86
#powerlines	4,4	4,07	3,9	2,29	1,77	4,11	1,6	4,19	2,33	2,21	1,38
#solarenergy	6,64	3,85	6,69	0,81	1,18	2,94	0,95	1,88	0,53	2,1	1,94
Means											
#windenergy	9,62	2,86	9,14	0,43	0,44	2,47	0,21	1,11	0,18	0,64	1,02
#biomass	4,95	4,23	4,07	0,73	0,77	1,99	0,21	2,27	0,17	0,88	1,86
#geothermal	7,3	3,71	6,69	0,59	0,33	1,59	0,22	1,32	0,16	1,05	0,91
#powerlines	4,01	3,11	3,1	0,82	0,87	2,64	0,51	2,86	0,48	1,04	0,53
#solarenergy	9,39	3,71	8,99	0,29	0,48	2,78	0,29	0,86	0,11	1,21	1,34

Appendix C: ANOVA Post-hoc Comparisons of the most Relevant Outputs with Bonferroni Correction

Post Hoc Comparisons						
		Mean Difference	**SE**	**t**		**P Bonf.**
Affect_Wind	Affect_Solar	0.2300	0.5128	0.4484	1.0000	
	Affect_Powerlines	5.6092	0.5128	10.9380	2.2395e -25	***
	Affect_Geothermal	2.3217	0.5128	4.5273	6.6947e -5	***
	Affect_Biomass	4.6752	0.5128	9.1167	4.1685e -18	***
Affect_Solar	Affect_Powerlines	5.3792	0.5128	10.4896	1.7257e -23	***
	Affect_Geothermal	2.0917	0.5128	4.0789	0.0005	***
	Affect_Biomass	4.4452	0.5128	8.6683	1.7543e -16	***
Affect_Powerlines	Affect_Geothermal	-3.2875	0.5128	-6.4107	2.2331e -9	***
	Affect_Biomass	-0.9340	0.5128	-1.8213	0.6886	
Affect_Geothermal	Affect_Biomass	2.3535	0.5128	4.5893	5.0137e -5	***
Positive Emotion (Posemo) _Wind	Posemo_Solar	0.1426	0.5003	0.2850	1.0000	
	Posemo_Powerlines	6.0337	0.5003	12.0613	2.3009e -30	***
	Posemo_Geothermal	2.4488	0.5003	4.8951	1.1458e -5	***
	Posemo_Biomass	5.0634	0.5003	10.1218	5.4709e -22	***
Posemo_Solar	Posemo_Powerlines	5.8911	0.5003	11.7763	4.5901e -29	***
	Posemo_Geothermal	2.3062	0.5003	4.6101	4.5479e -5	***
	Posemo_Biomass	4.9209	0.5003	9.8368	7.4454e -21	***
Posemo_Powerlines	Posemo_Geothermal	-3.5849	0.5003	-7.1663	1.4988e -11	***
	Posemo_Biomass	-0.9702	0.5003	-1.9395	0.5272	
Posemo_Geothermal	Posemo_Biomass	2.6147	0.5003	5.2267	2.1015e -6	***
Health_Powerlines	Health_Geothermal	0.5422	0.1186	4.5716	5.4493e -5	***

Post Hoc Comparisons						
		Mean Difference	**SE**	**t**		**P Bonf.**
	Health_Solar	0.3881	0.1186	3.2727	0.0110	*
	Health_Wind	0.4316	0.1186	3.6393	0.0029	**
	Health_Biomass	0.0958	0.1186	0.8075	1.0000	
Health_Geothermal	Health_Solar	-0.1540	0.1186	-1.2989	1.0000	
	Health_Wind	-0.1106	0.1186	-0.9323	1.0000	
	Health_Biomass	-0.4464	0.1186	-3.7641	0.0018	**
Health_Solar	Health_Wind	0.0435	0.1186	0.3666	1.0000	
	Health_Biomass	-0.2924	0.1186	-2.4652	0.1386	
Health_Wind	Health_Biomass	-0.3358	0.1186	-2.8318	0.0472	*
Biological Process (Biopro) Biomass	Biopro_Geothermal	0.9494	0.2642	3.5940	0.0034	**
	Biopro_Powerlines	-0.5918	0.2642	-2.2402	0.2530	
	Biopro_Solar	1.4077	0.2642	5.3292	1.2200e -6	***
	Biopro_Wind	1.1523	0.2642	4.3622	0.0001	***
Biopro_Geothermal	Biopro_Powerlines	-1.5411	0.2642	-5.8342	7.3015e -8	***
	Biopro_Solar	0.4584	0.2642	1.7352	0.8301	
	Biopro_Wind	0.2029	0.2642	0.7682	1.0000	
Biopro_Powerlines	Biopro_Solar	1.9995	0.2642	7.5694	8.5227e -13	***
	Wind	1.7440	0.2642	6.6024	6.5676e -10	***
Biopro_Solar	Wind	-0.2554	0.2642	-0.9670	1.0000	
Causal_Geothermal	Causal_Biomass	-0.9477	0.1759	-5.3871	8.9347e -7	***
	Causal_Powerlines	0.3845	0.1759	2.1858	0.2906	
	Causal_Solar	-0.4239	0.1759	-2.4096	0.1615	
	Causal_Wind	-0.1105	0.1759	-0.6280	1.0000	
Causal_Biomass	Causal_Powerlines	1.3322	0.1759	7.5730	8.3080e -13	***
	Causal_Solar	0.5238	0.1759	2.9776	0.0298	*
	Causal_Wind	0.8372	0.1759	4.7591	2.2321e -5	***
Causal_Powerlines	Causal_Solar	-0.8084	0.1759	-4.5954	4.8735e -5	***
	Causal_Wind	-0.4950	0.1759	-2.8139	0.0499	*
Causal_Solar	Causal_Wind	0.3134	0.1759	1.7815	0.7513	

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Empirical Studies: Paper 2

Not All Places are Equal: Using Instagram to Understand Cognitions and Affect to Renewable Energy Infrastructures[1]

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Abstract: the research on people-place relations makes an important contribution to the understanding of the public responses to renewable energy technologies (RETs). Social media not only provides easy access to the sentiment and attitudes of online users towards RETs, but social media content can also shape discourse, both on- and offline, about RETs. Hence, social media content analysis provides valuable insights into the public responses to RETs. However, as of now, only a small number of studies have investigated people-place relations in the context of the energy transition via online content. To address this lack of knowledge, this study aims to increase the understanding of people-place bonds by investigating the relationship between the place scales mentioned in Instagram posts (categorized from local to planet) and the sentiment words, depending on different energy infrastructures (solar, wind, biomass, geothermal, powerlines, and renewable energy in general). Our analysis of 1500 Instagram posts shows that place scales that are mentioned in the Instagram posts are related to some differences in the post emotionality and that these effects differ across the different hashtags that are related to

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RETs. By using a socio-cognitive approach, this study is the first to investigate Instagram posts in the context of the energy transition and people-place relationships.

Keywords: renewable energy infrastructures, people-place relationships, social media analysis, Instagram, mapping posts.

1. Introduction

To achieve the goals of the Paris Climate Agreement, a massive expansion of renewable energies will be necessary in the coming years (Masson-Delmotte et al., 2021). This will inevitably lead to more points of contact between people and renewable energy systems. The physical impact of renewable energy technologies (RETs) on a place can be perceived as an interference with the personal meanings that are associated with that location by individuals. The changes can make the bonds between person and space that are often latent and explicit. Disruption and development affect not only the physical aspects of places but also the social networks that are sources of support to individuals. For the surrounding communities, energy projects can provide benefits, but they can also initiate significant conflicts (Fried, 2000).

It has been shown that there is a fundamental relationship between the structures of cognitive processes (e.g., memory) and the production of written or verbal discourse (Schacter & Addis, 2007). Place meanings and people-place relations in speech and interaction are dynamically and strategically constructed. Place dynamics can be researched through the discursive research approach, which addresses two features of person-place bond: 1) the social dimension of place meaning, and 2) the action orientation of everyday discourse (Edwards & Potter, 2001). Studies that use the discursive approach have shown the constructions of place-identity features within the discourse about intra-national migration (McKinlay & McVittie, 2007) environmental threat (Hugh-Jones & Madill, 2009), and tourism (McCabe, 2009).

In recent years, social media has become integrated into many aspects of our daily language use through sharing and interaction with online content and through connecting between people. Social media has experienced tremendous growth in its user base and has influenced public discourse and communication in society. One example of social media shaping offline language is one of the German youth words of the year, 2021, which was, “Wednesday”, which was made popular through the meme “It is Wednesday, my dudes”. Furthermore, as platforms for interpersonal exchange, social media content often conveys information about the author’s emotional state, his or her judgment or evaluation of a certain topic (according to Rowan, 2015), memes may be defined as “sets of images that are normally accompanied by an amusing text that may or may not be directly related to the image"). Furthermore, as platforms for interpersonal exchange, social media content often conveys information about the user's emotional state, and judgments or evaluations of a certain topic (Bollen et al., 2011). Despite the importance that social media has for modern discourse, to the best of the authors' knowledge, no study has yet investigated place-relationships in the context of RETs on social media. We seek to fill this research gap by examining the potential relationship between the sentiments that are articulated in Instagram content that is related to RETs and places. Therefore, this article addresses the following research questions: *which places do people associate with RETs on Instagram posts? How is the place connected to the emotions and cognitions toward RETs in Instagram posts?*

Previous findings from various disciplines have confirmed that emotions are as important as cognitive information in online and interpersonal communication (Myrick, 2017). The common goal of both cognitive and affective information is to make an impact on the message receiver. Furthermore, it has been shown that affective information could be transferred through computer-mediated communication (Harris & Paradice, 2007). In detail, the goals of this research are:

1) to increase the understanding of how place-level is used to describe RETs on Instagram;
2) to analyze the cognitive and emotional words that are linked to the scales of place (from local to global) that describe the RETs on Instagram.

The study of people-place relations on Instagram provides insights into both the affective and cognitive factors in the study of the public perception of energy technologies. Online platforms, such as Instagram, allow free social interactions and conversations, and they provide a lens through which to assess the competing visions on different energy-related public issues (Li et al., 2019). Emotions and cognition-related variables have an explanatory power with energy-related decisions (Cousse et al., 2020). Affective reactions to energy technologies influence energy technology preferences and people´s responses to energy projects (Sütterlin & Siegrist, 2017). Thus, Instagram can be a driver of the use of renewable energy, and it plays a role not only in shaping the perceptions of various technologies but also in influencing the intentions of people to use renewable energy sources (Zobeidi et al., 2021).

This paper applies the Socio-Cognitive Approach (SCA) to the investigation of the language in Instagram posts. An SCA to discourse applies the general theory of social constructionism, which holds that social members construct social reality. Thereby, the mental constructions are understood as mental representations that are implemented by the brain (Van Dijk, 2017).

The results of this study highlight how place level and the sentiment words named on Instagram posts are dependent on different energy infrastructures. This investigation is particularly relevant for visually focused social media platforms, such as Instagram, since a common criticism of RETs is their negative visual impact on the landscape (Burch et al., 2020). Thus, this paper provides insights into individual considerations of RETs on Instagram, which contributes to a better understanding of the emotions and cognitions that are related to RETs at different place levels.

The remainder of this article is structured as follows: In Section 2, “Theoretical background”, we address the prevailing theories on renewable energies, place relations, emotions, and cognitions; Section 3, “Method and Procedures”, explains the methodology that was used to obtain and analyze the data; Section 4, “Results”, describes the sentiment, content, and mapping analyses of the dataset; and Section 5, “Finding Overview and Discussion”, presents an overview of the results and the discussion.

2. Theoretical Background

2.1. People-Place Relations

Place attachment has become an increasingly popular concept for understanding local responses to large-scale RET (e.g., Dang & Weiss, 2021). Van Veelen and Haggett (2017) show that place bond was an important motivator for the development of renewable energy projects, but that different degrees of place attachment also formed a key source of disagreement. Studies have focused on different levels of attachment: 1) individual-level attachments which concern emotional and cognitive components (Fornara & Caddeo, 2016), and 2) community-level attachments, in which the attachments are understood as socially constructed, discussed, and negotiated among groups (Di Masso et al., 2017).

“Psychological distance” (Milfont, 2010) is an important aspect of the “localist” perspective, which argues that the things that are of value to individuals must be close rather than distant. For example, climate change is a psychologically distant event, and for that reason, people mentally construe climate change in terms of high-level, abstract, and stable characteristics (Wang et al., 2019). However, some research shows that 80% of people label themselves as “global citizens”, which underlines the importance of the interplay between global and national attachments (Devine-Wright et al., 2015).

People-place bonds, when compared across different place scales, sometimes show dissimilar results. Already in 1975, Tuan claimed that cities are the perfect exemplification of the place concept and defined them as the center of meaning. In fact, compared to countries, that may change their territories and frontiers, cities are stable and continuous through time (Lewicka, 2008). Gustafson (2009) instead, observed no difference between the attachment to cities and regions in Sweden. Regions can be targets of strong identifications, but this happens when (usually for historical reasons) they have acquired strong nationalistic meaning. In his studies, Laczko (2005) compared the attachment to five places: the neighborhood, the town or city, the province, the country, and the continent. The findings show that participants reported that they felt the strongest attachment to their country and the weakest attachment to their continent. These results were also confirmed from Swedish survey data (Gustafson, 2009) in which the strongest attachment was to the country of Sweden, and the weakest to the continent of Europe. Furthermore, being away from home (city and/or country), for example, may make home ties more salient, and some circumstances may contribute to the maintenance of local identity rather than to its disruption (Lewicka, 2010). The available research, which mostly comes from large national surveys and cross-national comparisons, suggests that people not only show strong attachments to their residence places, but that self-categorizations in terms of larger place scales do not destroy their local sentiments and that different place scales are not mutually exclusive (Lewicka, 2011).

In our research, we focus on four place categories: city, region, state, and planet. The aim is to study different place scales in the context of social media. Following the psychological distance approach, we suggest that people on Instagram use emotional words when referring to the RETs at the micro-level (city and region), and cognitive words when referring to the RETs at the macro-level (planet), which includes issues that are related to the protection of the planet and climate change. The national level, however, evokes particularly strong emotional reactions, which are linked to socially constructed symbols of the group identity (Lewicka, 2011). For these reasons, we assume that people use more risk-related words (e.g., danger, doubt, disaster, etc.) when referring to the RETs at the national level than at the other place scales. The research offers insights that are useful to practitioners who struggle with knowing how to deal with people's responses in an adequate way (Cass & Walker, 2009).

2.2. Word Associations in a Socio-Cognitive Approach

This paper presents an SCA to the language that is used in Instagram posts through an investigation into the interconnection between the place words that refer to RET hashtags. Co-occurrence and frequency analyses aim to find similarities in the meanings between and within word patterns to uncover the latent structures of mental and social representations (Lancia, 2007). Network analysis, on the other hand, provides, through graphical representations, the ability to estimate complex patterns of relationships, and structure can be analyzed to reveal the basic characteristics of a network (Hevey, 2018). The study of the words and sentiment associations between places and RETs is highly relevant because it allows us to detect the information, such as opinions, attitudes, and feelings, that is expressed in text. The study of media representations is relevant for different stakeholders, whose goal is to inform, involve, or inspire a considerable number of different actors and potential consumers of RETs.

2.3. Aims and Hypotheses

The following research applies a social media analysis of energy-related Instagram posts. The goal is to understand the public consideration of RETs, places, and their ties. A good understanding of the public's affective reactions and communication that are elicited by energy technologies is crucial to anticipating the signs of public concern. The developer, for example, can communicate directly with consumers through blogs, online content, and videos with the keyword language that is used by consumers (Lin & Kant, 2021). Knowing more about the emotions and cognitions that are linked to RETs in different places is a starting point for understanding how to promote and support projects at different place scales (local vs. regional vs. national). For this purpose, we map the places that are named in the Instagram posts by using four geographic scales: village or city, region, state, and planet. One of the advantages of this approach is that Instagram is a space where people express themselves through words, without having preset questions and prescribed language. It is open to anyone to talk on their terms about places and RETs. Furthermore, the mapping can be combined with text analysis to understand the use of cognitive and emotional phrasings to the place scale. The hypotheses of this research are[6]:

Hypothesis 1 (H1). Different place scales are associated with emotional and cognitive words.

> **Hypothesis 1.1 (H1.1).** Instagram posts that include city and region words are more strongly connected to affective words about RETs than posts with country and planet words.
>
> **Hypothesis 1.2 (H1.2).** Instagram posts that include country words are more strongly connected to risk words about RETs than posts with city, region, and planet words.
>
> **Hypothesis 1.3 (H1.3).** Instagram posts that include planet words are more strongly connected to cognitive words about RETs than posts with city, region, and country words.

[6] The hypotheses have been preregistered on, https://aspredicted.org/create.php, and were made public on 14 September 2020. The pdf is available from: https://aspredicted.org/mz9ti.pdf, accessed on 3 February 2022).

3. Method and Procedures

This study provides a summary of the linguistic associations that are elicited by wind, solar, geothermal energies, powerlines, and biomass on Instagram by using the text from captions and hashtags. The central idea is to analyze the words, the places, and their connection, to understand how place scales are linked to the respective RETs that are named. The element of analysis can be broken down into text analysis and the geo-localization of the posts through the mapped places. The method that was used to obtain and analyze the data followed a precise scheme, which is shown in Figure 1.

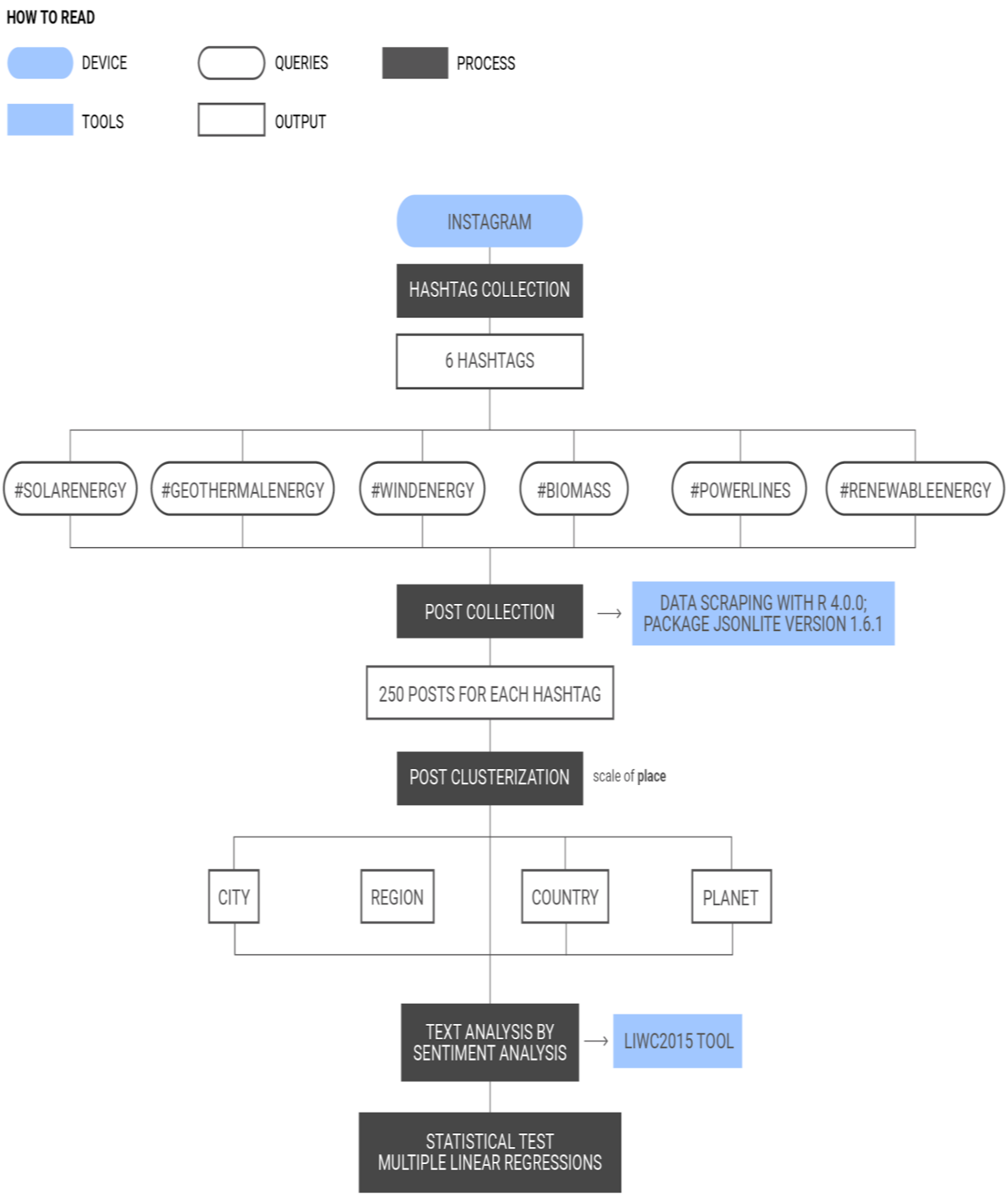

Figure 1. Method process: from the data collection to the data analysis

First, a total of 250 posts for each selected hashtag were scraped by using R, Version 4.0.0, and the Jsonlite package (Version 1.6.1). The hashtags that were selected were as follows: #windenergy; #solarenergy; #geothermalenergy; #biomass; #powerlines; and #renewableenergy, which resulted in 1500 posts in total. We decided to use these specific RET hashtags (wind, biomass, geothermal, etc.) because they have strong local penetrations, and they have become subjects that are highly considered and discussed by the communities (Ochoa, 2019). The solar hashtag was added because of its broad distribution, even though it is not conflict-related, as are the others. Powerlines are central for energy infrastructure and are often contested, thus, they were also included. To gain an overall overview, we integrated the hashtag, #renewableenergy. In the second step, we coded the posts about four place categories (city, region, country, and planet) based on the available information in the hashtags, the place geotags, and the captions. One author categorized all of the posts (1500) into categories. A second author coded 20% of the posts, for a total of 300 posts, independently from the first author. The inter-rater reliability achieved satisfactory significance (85.7%) between the two coders. If an association was not categorized into the same category by both authors, a discussion ensued to find a common and adequate solution. We repeated this procedure until all of the places were assigned to one category by common accord. At times, the users mentioned several different places (e.g., #Sydney, #Tokyo, #Canada). In these cases, all of the places were coded. In the end, 821 posts mentioned a place. The following sections explain, in detail, all of the steps of the applied method/procedure.

3.1. Data Source: Scraping Data from Instagram Posts

Instagram provides metadata, such as usernames, the time and date of creation, captions, comments (and the user and time information for comments), tags, and likes, as well as location information when users have geotagged their posts. These metadata fields of public posts are publicly available to not only researchers, but also to other Instagram users, corporations, or anyone who accesses Instagram via either the app or third-party tools (Highfield, 2015). With this data, the present research aims to provide both quantitative and qualitative analyses. The quantitative analysis maps the posts based on the places that are named in the hashtags, captions, and/or geotags. The qualitative analysis investigates the contents of the posts in the captions and hashtags. On Instagram, it is possible to geotag a location from the databases of predefined places, or by naming the location oneself. In either case, coordinates are included in the post along with the location name and an identifier. The information that is considered here is the location that was provided by the user's geotag (if provided), the caption (if provided), and the hashtag (if provided).

Figure 2 presents an example of an Instagram post and the information that it contains, which includes a picture, an ID name, a place in the geotag, and a caption (which includes hashtags). Going into more detail, the example names three places: a state, a region, and a city. For this reason, it will be included in each of the place category groups. Because of the vast number of Instagram posts, a pragmatic decision was made to limit the number of crawled posts.

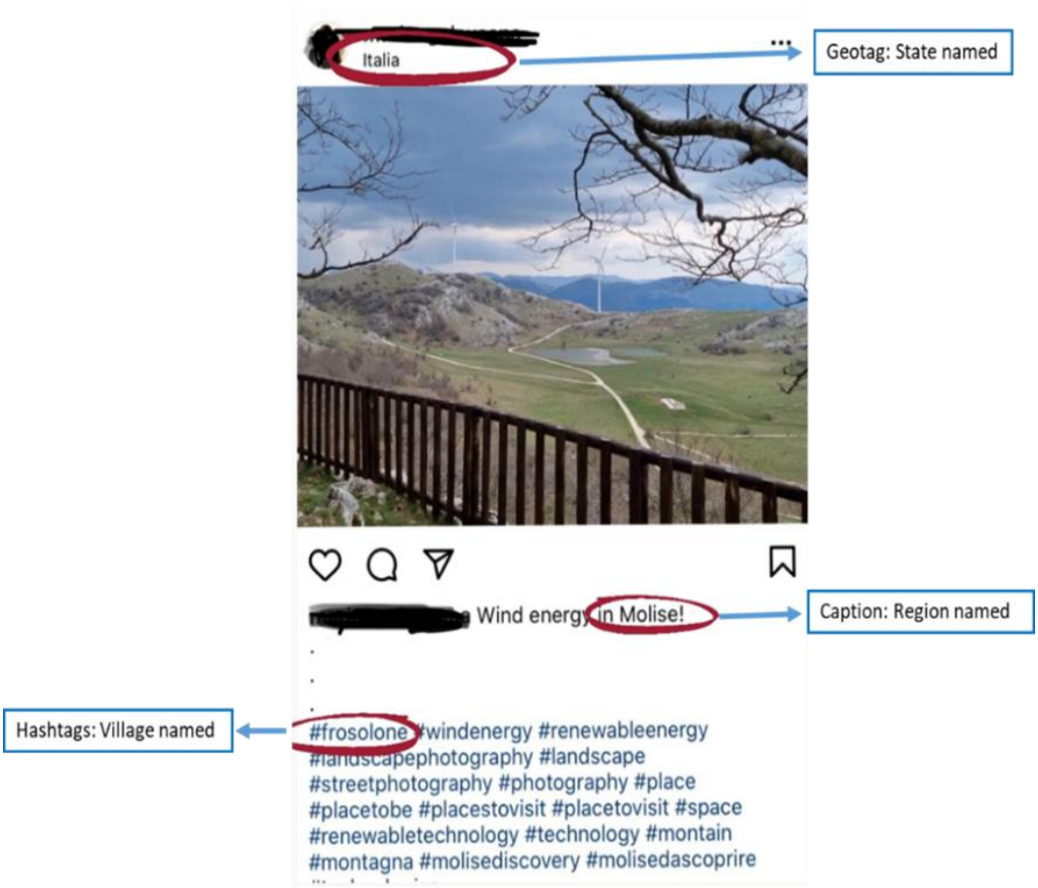

Figure 2. Example of an Instagram post

The 1500 posts (the 250 most recent posts for each hashtag) that were used in this study were scraped from public Instagram accounts (without privacy restrictions) on 17 September 2020. We chose to sample 250 posts for each hashtag because we expected a small effect size (see, for example, Boulianne, 2019). We performed manual post scraping, which is not feasible over a large number of posts. Instagram restricts the number of posts that can be scraped for free, and it does not allow crawling for specific timeframes. As such, crawling a relatively small number of the most recent posts per hashtag is the next best alternative. Furthermore, data collection by time series would not have been possible considering that the amounts of the daily published posts per hashtag are very different. To achieve the same number of posts per hashtag, the dataset was filtered on the "recent", and not on the "most popular", posts at the moment of scraping. The advantages of using Instagram for this research are:

1) the number of words that are used in the caption is unlimited, which is contrary to other platforms (e.g., Twitter), and this is an important advantage for this research, which is based on the analysis of text. In detail, the length of the 1500 posts is: M = 63.72 and SD = 51.72. The length varies from M = 47.56 for the #powerlines posts, to M = 73.26 for the #windenergy posts. In addition, we have made another validation step by scraping 30% of the posts, for a total of 450 posts. We evaluated them about their lengths. In this case, the length of the posts is: M = 67.8 and SD = 49.15;

2) Instagram is known for its strong use of hashtags, both as descriptions of pictures/videos and as search terms for particular topics (Handayani, 2015). The extensive use of hashtags allows us to study the sets of words that are associated with the RET descriptions;

3) Instagram, as a web source, has never been used to study RETs. While we are aware of the fact that Instagram is social media for sharing videos and pictures, as well as text, we want to clarify that the analyses of this paper are focused on the analytical procedure of the text, and not on the images. Since this paper focuses on linguistic and mental word associations with regard to RETs, an analysis of the images would not have provided useful insight.

3.2. Mapping the Instagram Post

The posts were mapped using the “rworldmap” R package. Thereby, we merged the map by using the region level (which consists of Africa, Australia, Asia, North America, South America, Europe, and Antarctica) with our place-coded dataset. This resulted in six maps, one for each hashtag. The maps show how often a hashtag (e.g., #windenergy) was used in the different regions. For example, in terms of the solar power hashtag, 26 posts mentioned Africa (or places within Africa), 66 mentioned Asia, 12 mentioned North America, 3 mentioned South America, 12 mentioned Australia, and 36 mentioned Europe.

3.3. Sentiment Analysis with LIWC

A sentiment analysis represents a systematic computer-based analysis of written text or speech excerpts to extract the attitude of the author towards specific topics. It provides a fine-grained examination that aims to establish the overall orientation (positive or negative) and intensity (weak or strong) of the sentiments that are expressed by the statements (Pang & Lee, 2008). The Linguistic Inquiry and Word Count software (LIWC) (Pennebaker et al., 2015) is a popular text analysis tool for researchers. It is a lexical method with similarities to other methods, such as PANAS-t, SASA, and SentiWordNet, etc. (Gonçalves, 2013). In this research, the LIWC was used for analyzing the hashtag and caption texts of Instagram posts by using the Version 2015 English dictionary. The dictionaries of the tool accommodate numbers, punctuation, and even short phrases. This allows the user to read the “Internet slang” language that is common on Twitter, Instagram, and Facebook posts, as well as on SMS (short messaging service). In evaluating the program, the authors of the software analyzed the degree to which language varies across settings, and, since 1986, they have been collecting text samples from a variety of studies.

Table 1 illustrates the emotional and cognitive processes that are included in the analyses. The output of the software is the percentages of the total words within a text. The LIWC2015 output was statistically investigated through the multiple linear regression on JASP 0.12.2.0.

Table 1. Linguistic Inquire Word Count 2015 Output Variable Information from LIWC 2015 Development Manual.

		Hypotheses
Emotional Processes	Affective Processes	**H1.1.** Instagram posts that include city and region words are more strongly connected to affective words about RETs than posts with country and planet words.
	Positive Emotions	
	Negative Emotions	
Risk	Risk	**H1.2.** Instagram posts that include country words are more strongly connected to risk words about RETs than posts with city, region, and planet words.
Cognitive Processes	Cognitive Processes	**H1.3.** Instagram posts that include planet words are more strongly connected to cognitive words about RETs than posts with city, region, and country words.

4. Results

4.1. Sample Description

The scraped posts (N = 1500) were divided into four place-scale categories (city, region, country, and planet). After a double coding from the authors (explained in Session 3), the sample was divided as shown in Figure 3. The highest frequencies of mentions are for: country and city words that occur in #geothermalenergy posts; region words that occur in #powerlines posts; and planet words that occur in #renewableenergy posts. The city and national scales have the highest frequencies in the posts. These data confirm the strong association between RETs and the city and national place scales. Planet, instead, is only mentioned in 7 of all 1500 Instagram posts. The construct planet may elicit an emotional attachment and may evoke fewer mental associations. Region words, as we expected, were less frequently tagged compared to city and country words, and this result is in line with the recent literature cited above. Words that refer to places appear in our sample 1244 times.

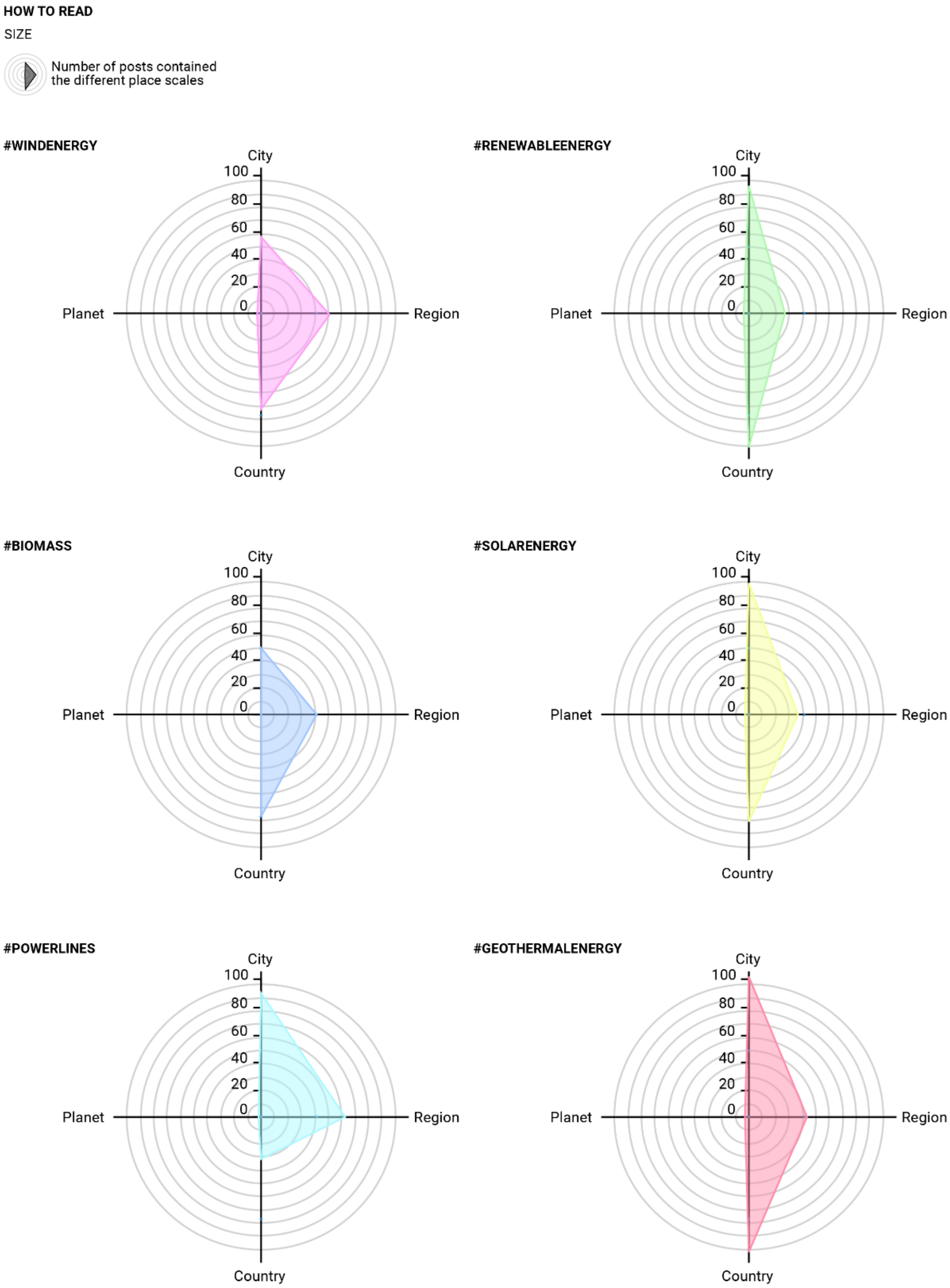

Figure 3. Number of posts containing different places.

A visual inspection of the six maps reveals several patterns (see Figure 4): first, North America and Europe were mentioned more often in Instagram posts about different energy sources, while none of the posts across all of the investigated forms of energy mentioned Antarctica. Notably, the solar energy posts referred to places in North America less often than other energy posts: (places in) North America was mentioned only 12 times, while (places in) Asia was mentioned 66 times. Second, South America is consistently among the least mentioned places, with zero to five mentions, which suggests that discussing energy sources on Instagram is less common in South America than in other regions, despite Brazil ranking third in worldwide Instagram users (Salunke & Jain, 2022).

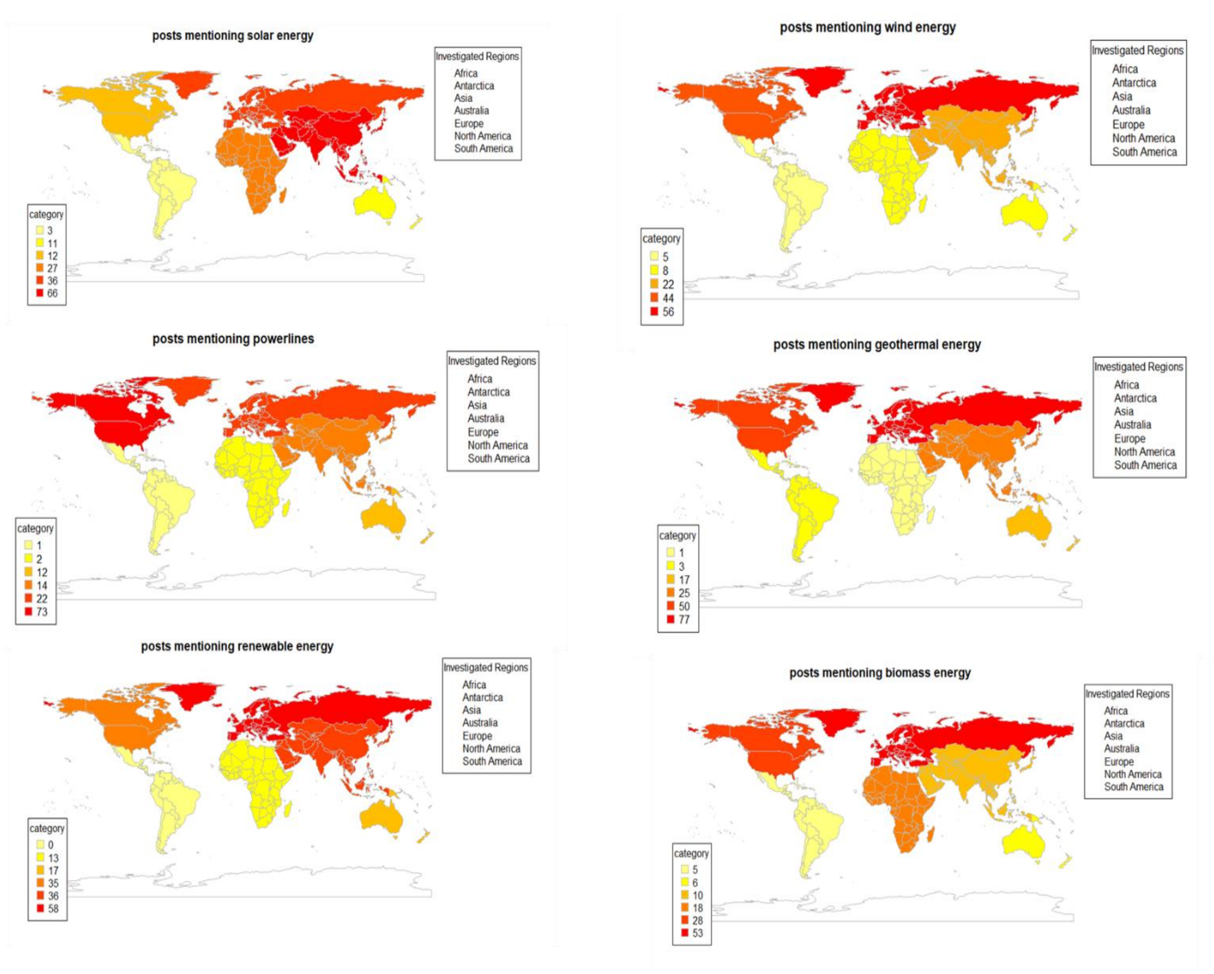

Figure 4. Posts mapped using the “rworldmap”

4.2. Cluster Analysis in the Instagram Posts

The cluster analysis (see Figure 5) shows a similar pattern of words in all the places (e.g., "energy", "clean", "photography", etc.). In all the places, there are at least some specific renewable energies that are named. For example, wind, geothermal, powerline, and solar energy words were named in the city posts; solar, wind, and geothermal words were named in the posts with country words; and wind and solar energy words were named in the posts with "planet". All the renewable energies that are included in the study (geothermal, solar, wind, powerlines, and biomass) are named in the posts with region words. Solar energy has the highest frequency in all the place levels. In the planet block, as was supposed, some words are linked to the earth and climate change.

The word, "justice", also has a high frequency in the planet cluster. The importance of justice expectations and perceptions is highlighted in the existing acceptance models for RETs (Karakislak et al., 2021). The environmental justice concerns include distributive and procedural claims, as well as recognition and participation factors (Schlosberg, 2007). Environmental justice research has expanded to a more essentially involved field that examines additional layers of the relationship between people and environmental issues (Walker, 2009). However, attachment to the planet may mean altogether different things to British, German, Polish, or Lithuanian people, and so on (Lewicka, 2011). In this case, we can emphasize that the construct planet is linked to the idea of justice, as well as to climate change and health issues. This result should be studied in future research.

Figure 5. Cluster analysis in 1500 posts divided into place scales: city, country, region, and planet.

4.3. Sentiment Analysis and Multiple Linear Regressions

We conducted a sentiment analysis with all of the words from every post. Five multiple linear regressions were calculated to investigate the associations of the city, region, country, and planet word counts with the affect, positive emotion, negative emotion, cognitive process, and risk variables (see Table 2). These five multiple linear regressions were performed, first, on the whole sample (N = 1500 posts). The analysis of the sample shows the following results.

Table 2. Results of the multiple linear regressions on cognitive processes affect positive and negative emotions, and risk.

	Cognitive Process					**Affect**					**Positive Emotions**				
Predictor	***beta***	***p***	***F***	***df***	***p***	***beta***	***p***	***f***	***df***	***p***	***beta***	***p***	***f***	***df***	***p***
<u>Whole sample (N = 1500)</u>															
			1.78	4, 1491	0.13			**4.57**	**4, 1491**	**0.001**			**4.98**	**4, 1491**	**<0.001**
City	-0.05	0.07				**-0.07**	**0.009**				**-0.05**	**0.05**			
Region	0.01	0.61				-0.05	0.07				**-0.07**	**0.006**			
Country	0.0005	0.98				0.05	0.08				0.04	0.12			
Planet	0.05	0.06				**-0.06**	**0.03**				**-0.06**	**0.03**			
R^2	0%					1%					1%				
<u>#renewableenergy (N = 250)</u>															
			0.71	4, 245	0.58			**6.20**	**4, 245**	**<0.001**			**6.72**	**4, 245**	**<0.001**
City	-0.10	0.19				**0.18**	**0.01**				**0.19**	**0.009**			
Region	-0.04	0.54				**-0.22**	**<0.001**				**-0.22**	**<0.001**			

Country	0.01	0.85				0.05	0.47				0.07	0.34			
Planet	-0.02	0.80				**0.05**	**0.04**				**-0.13**	**0.03**			
R^2	1%					9%					10%				
#windenergy (N = 250)															
			1.37	4, 245	0.24			0.45	4, 245	0.77			0.40	4, 245	0.80
City	-0.09	0.16				-0.05	0.45				-0.02	0.78			
Region	*-0.07*	*0.28*				*-0.009*	*0.88*				*-0.03*	*0.70*			
Country	-0.04	0.54				-0.06	0.34				-0.06	0.32			
Planet	-0.06	0.37				0.01	0.84				0.03	0.66			
R^2	2%					1%					1%				
#solarenergy (N = 250)															
			1.52	4, 245	0.19			0.68	4, 245	0.60			0.72	4, 245	0.58
City	-0.09	0.16				-0.07	0.32				-0.06	0.35			
Region	0.04	0.52				-0.08	0.23				-0.08	0.21			
Country	0.02	0.79				0.04	0.59				0.03	0.70			
Planet	0.12	0.06				-0.04	0.58				-0.05	0.48			
R^2	2%					1%					1%				

#biomass (N = 250)															
			1.10	4, 242	0.35			0.28	4, 242	0.89			0.12	4, 242	0.97
City	-0.03	0.62				-0.01	0.84				-0.006	0.92			
Region	0.006	0.92				-0.03	0.62				-0.02	0.71			
Country	0.08	0.24				0.06	0.36				-0.007	0.91			
Planet	0.10	0.10				-0.02	0.75				-0.03	0.59			
R^2	2%					0%					0%				
#powerlines (N = 250)															
			1.29	4, 245	0.27			**5.33**	**4, 245**	**<0.001**			**2.79**	**4, 245**	**0.02**
City	-0.001	0.98				**-0.29**	**<0.001**				**-0.21**	**0.002**			
Region	**0.14**	**0.04**				0.13	0.05				0.06	0.34			
Country	0.004	0.94				0.11	0.07				0.10	0.10			
Planet	0.02	0.72				0.01	0.81				0.02	0.79			
R^2	2%					8%					4%				

#**geothermalenergy (N = 250)**															
			1.86	4, 244	0.11			**7.06**	**4, 244**	**<0.001**			**9.89**	**4, 244**	**<0.001**
City	-0.02	0.72				**-0.27**	**<0.001**				**-0.30**	**<0.001**			
Region	0.05	0.39				-0.03	0.61				-0.11	0.06			
Country	**-0.13**	**0.04**				-0.10	0.12				-0.11	0.08			
Planet	0.11	0.08				-0.06	0.33				-0.05	0.38			
R^2	3%					10%					14				

Dependent variable	**Negative Emotions**					**Risk**				
Predictor	***beta***	***p***	***f***	***df***	***p***	***beta***	***p***	***f***	***df***	***p***
Whole sample (N = 1500)										
			3.59	**4, 1491**	**0.006**			1.78	4, 1491	0.49
City	**-0.06**	**0.03**				0.02	0.55			
Region	**0.09**	**<0.001**				0.02	0.37			
Country	0.03	0.20				0.002	0.93			
Planet	-0.02	0.55				-0.04	0.15			
R^2	1%					0%				
#renewableenergy (N = 250)										
			0.43	4, 245	0.78			0.26	4, 245	0.90
City	-0.07	0.36				0.02	0.76			
Region	0.005	0.93				-0.06	0.39			
Country	-0.02	0.74				-0.005	0.93			
Planet	-0.009	0.88				-0.03	0.65			
R^2	1%					0%				
#windenergy (N = 250)										
			0.49	4, 245	0.74			0.90	4, 245	0.46
City	-0.08	0.20				0.04	0.52			
Region	0.05	0.46				0.09	0.18			
Country	0.007	0.91				0.02	0.73			
Planet	-0.04	0.53				-0.06	0.38			
R^2	1%					1%				
#solarenergy (N = 250)										
			0.86	4, 245	0.48			0.49	4, 245	0.74
City	-0.04	0.58				0.01	0.88			
Region	-0.005	0.92				0.05	0.39			
Country	0.12	0.08				0.06	0.41			
Planet	-0.03	0.59				-0.03	0.68			
R^2	1%					1%				
#biomass (N = 250)										
			1.23	4, 242	0.29			1.35	4, 242	0.25
City	-0.02	0.79				0.07	0.28			
Region	-0.004	0.94				0.11	0.09			
Country	**0.14**	**0.02**				-0.07	0.26			
Planet	0.00008	0.99				0.01	0.84			
R^2	2%					2%				
#powerlines (N = 250)										
			2.20	4, 245	0.06			0.70	4, 245	0.59
City	**-0.19**	**0.006**				-0.03	0.68			
Region	0.12	0.06				-0.002	0.96			
Country	0.05	0.41				0.10	0.12			
Planet	0.007	0.91				-0.05	0.45			
R^2	3%					1%				
#geothermalenergy (N = 250)										
			9.32	**4, 244**	**<0.001**			0.40	4, 244	0.81
City	0.10	0.10				-0.03	0.67			
Region	**0.33**	**<0.001**				-0.02	0.80			
Country	0.01	0.86				-0.01	0.86			
Planet	-0.02	0.71				-0.07	0.28			
R^2	13%					1%				

One multiple linear regression was calculated to predict the affect of the city, region, country, and planet word counts. The regression model was significant ($F(4, 1491) = 4.57$, $p = 0.001$) and accounted for 1% of the variance of the dependent variable. City ($\beta = -0.07$, $p = 0.009$) and planet ($\beta = -0.06$, $p = 0.03$) words were significant predictors of affect. This means that, if city and planet words (1 or several) are mentioned, this is associated with 0.07 (for city) and 0.6 (for the planet) decreases in the affect that is used in the captions and hashtags.

A second multiple linear regression was calculated to predict positive emotions by the city, region, country, and planet word counts. The regression model was significant ($F(4, 1491) = 4.98$, $p < 0.001$) and accounted for 1% of the variance of the dependent variable. The city ($\beta = -0.05$, $p = 0.05$), region ($\beta = -0.07$, $p = 0.006$), and planet ($\beta = -0.06$, $p = 0.03$) words were significant predictors of positive emotions.

A third multiple linear regression was calculated to predict negative emotions by the city, region, country, and planet word counts. The regression model was significant ($F(4, 1491) = 3.59$, $p = 0.006$) and accounted for 1% of the variance of the dependent variable. City ($\beta = -0.06$, $p = 0.03$) and region ($\beta = 0.09$, $p < 0.001$) words were significant predictors of negative emotions.

4.4. Exploratory Findings

In total, five multiple linear regressions were calculated to investigate the effect of the city, region, country, and planet word counts on the affect, positive emotion, negative emotion, cognitive process, and risk variables (see Table 2). The second step was to break down and analyze each of the five multiple linear regressions according to the hashtags that represent the types of renewable energy.

The following results are based on the #renewableenergy posts. One multiple linear regression was calculated to predict the affect of the city, region, country, and planet word counts. The regression model was significant ($F(4, 245) = 6.20$, $p < 0.001$) and accounted for 9% of the variance of the dependent variable. City ($\beta = 0.18$, $p = 0.01$), region ($\beta = -0.22$, $p < 0.001$), and planet ($\beta = -0.12$, $p = 0.04$) words were significant predictors of affect. One multiple linear regression was calculated to predict the positive emotion by the city, region, country, and planet word counts. The regression model was significant ($F (4, 245) = 6.72$, $p < 0.001$) and accounted for 10% of the variance of the dependent variable. City ($\beta = 0.19$, $p = 0.009$), region ($\beta = -0.22$, $p < 0.001$), and planet ($\beta = -0.13$, $p = 0.03$) words were significant predictors of affect.

The following results are based on the #biomass posts. One multiple linear regression was calculated to predict negative emotions by the city, region, country, and planet word counts. The regression model was not significant ($F (4, 242) = 1.23$, $p = 0.78$) and accounted for 2% of the variance of the dependent variable. Country ($\beta = 0.14$, $p = 0.02$) words were significant predictors of negative emotions.

The following results are based on the #powerlines posts. One multiple linear regression was calculated to predict cognitive processes by the city, region, country, and planet word counts. The regression model was not significant ($F (4, 245) = 1.29$, $p = 0.27$) and accounted for 2% of the variance of the dependent variable. Region ($\beta = 0.14$, $p = 0.04$) words were significant predictors of cognitive processes. One multiple linear regression was calculated to predict the affect of the city, region, country, and planet word counts. The regression model was significant ($F (4, 245) = 5.33$, $p < 0.001$) and accounted for 8% of the variance of the dependent variable. City ($\beta = -0.29$, $p < 0.001$) words were significant predictors of affect. One multiple linear regression was calculated to predict positive emotions by the city, region, country, and planet word counts. The regression model was significant ($F (4, 245) = 2.79$, $p = 0.02$) and accounted for 4% of the variance of the dependent variable. City ($\beta = -0.021$, $p = 0.002$) words were significant predictors of positive emotions. One multiple linear regression was calculated to predict negative emotions by the city, region, country, and planet word counts. The regression model was not significant ($F (4, 245) = 2.20$, $p = 0.06$) and accounted for 3% of the variance of the dependent variable. City ($\beta = -0.19$, $p = 0.006$) words were significant predictors of negative emotions.

The following results are based on the #geothermalenergy posts. One multiple linear regression was calculated to predict cognitive processes by the city, region, country, and planet word counts. The regression model was not significant ($F (4, 244) = 1.86$, $p = 0.11$) and accounted for 3% of the variance of the dependent variable. Country ($\beta = -0.13$, $p < 0.05$) words were significant predictors of cognitive processes. One multiple linear regression was calculated to predict the affect of the city, region, country, and planet word counts. The regression model was significant ($F(4, 244) = 7.06$, $p < 0.001$) and accounted for 10% of the variance of the dependent variable. City ($\beta = -0.27$, $p < 0.001$) words were significant predictors of affect. One multiple linear regression was calculated to predict positive emotions by the city, region, country, and planet word counts. The regression model was significant ($F(4, 244) = 9.89$, $p < 0.001$) and accounted for 14% of the variance of the dependent variable. City ($\beta = -0.030$, $p < 0.001$) words were significant predictors of positive emotions. One multiple linear regression was calculated to predict negative emotions by the city, region, country, and planet word counts. The regression model was significant ($F(4, 244) = 9.32$, $p < 0.001$) and accounted for 13% of the variance of the dependent variable. Region ($\beta = 0.33$, $p < 0.001$) words were significant predictors of negative emotions.

5. Finding Overview and Discussion

In this preregistered study, we investigated place-level mentions and how these relate to people's written language. Specifically, we conducted multiple linear regressions to investigate the associations of the city, region, country, and planet word counts with the sentiments in the Instagram posts' captions and hashtags. Our findings partially contradict our expectations, although we can partially accept our hypothesis (H1: Different place scales are associated with emotional and cognitive words). Indeed, when looking at the entire sample of all of the investigated hashtags, we found relationships between emotionality and the mentions of cities and regions. However, and contradictory to our hypothesis (H1.1: Instagram posts that include city and region words are more strongly connected to affective words about RETs than posts with country and planet words), mentions of cities and mentions of the planet had about an equal number of negative associations with affect generally. Similarly, when looking at positive emotions, specifically, we found that the mentions of cities, regions, and the planet show negative associations with positive emotions in the text. In other words, when people mentioned places at a small (city or region) or at a very large scale (planet), they also tended to use fewer positive words in the image captions and hashtags. Notably, this pattern changed when we looked at the use of negative emotions. Here, H1.1 was confirmed: the posts that referred to cities (regions) showed negative (positive) associations with the use of negative words in texts, while the mentions of the planet had no predictive power for negative words. Importantly, while the mentions of cities are related to less positive words, they also are associated with less negative words.

In terms of our expectations about the use of risk-related words (H1.2: Instagram posts that include country words are more strongly connected to risk words about RETs than posts with city, region, and planet words), we found no effects of the place mentions at all for the entire sample of hashtags. The social media users did not use relatively more risk words for any of the place scales that we investigated in this study. This is in line with prior studies where (acceptance of) renewable energy technologies, such as biogas, are connected to risk perceptions, while place attachment is unconnected (Kortsch et al., 2015). Similarly, we found no effects for the use of cognitive words (H1.3: Instagram posts that include planet words are more strongly connected to cognitive words about RETs than posts with city, region, and country words) when looking at all of the investigated hashtags together. Importantly, the planet words were only mentioned in a few posts (N = 7). For this, the number of planet posts is not enough to draw conclusions. One idea could be to collect multiple posts that mention RETs and planet words together to have a larger sample, and then perform a sentiment analysis. So far, we can only conclude that, in our sample, there are no strong relations between the Instagram posts, RETs, and planet. The construct planet may evoke fewer mental associations than other place levels. These results are in line with the "psychological distance" (Milfont, 2010) theory, which argues that the things that are of value to individuals must be close rather than distant. On the other hand, our results are not in line with other studies that claim that people label themselves as "global citizens" (Devine-Wright, 2013). Heise (2008) claims that we need a "sense of planet" as much as a "sense of place". As we have already shown in our dataset, the construct planet evokes more words that are related to climate change or justice topics, rather than words that are strictly related to RETs. We encourage future studies in this direction.

However, as our exploratory analyses show, the effects of the investigated renewable energy infrastructure hashtags differ. Specifically, neither #windenergy nor #solarenergy showed any relationships between the place mentions and the sentiments that were used in the texts and captions. This is somewhat surprising since wind energy is often criticized by local opponents for its negative impact on the surrounding landscape (e.g., Mordue et al., 2020). Based on this finding, one could assume negative emotions in posts that mention smaller places, especially when using a medium that focuses heavily on visuals, such as Instagram. With the current analysis, we are unable to tell why this association does not exist. Wind energy opponents might not use Instagram to make themselves heard, they may use more specific project-related hashtags, or they might rely on other hashtags altogether (e.g., the German wind opposition, at times, does not use the hashtag, "Windkraft" (wind power), but rather, "Vernunftkraft" (power of rationality)). While one could argue that Instagram is a platform that primarily focuses on positive self-presentation and "showing-off" and, as such, it is unsuitable for analyzing energy-related sentiments, we argue that investigations of Instagram for important societal topics are essential. Instagram is no longer a personal social networking site but it is a platform where people are engaged with politics and social movements. For example, the hashtag, #JusticeForGeorgeFloyd, was used over 2 million times, and the hashtag, FridaysForFuture, was used over 1 million times. As such, Instagram is not only a place for self-presentation, but it is also a place to share opinions about, and insights on, societal issues.

In comparison to the solar and wind power hashtags, the analysis for the hashtag for renewable energy generally showed some patterns: the mentions of cities had positive associations with positive emotions, while the mentions of regions and planet showed negative relations with positive emotions. This difference between the city and region mentions might be due to people viewing renewable energy infrastructure as a solution to the energy needs of cities (e.g., words that were frequently used on the city scale included, "heat", "new", "life", and "sustainable"), while, on the regional level, RETs are associated with the reality of their implementation (e.g., mentions of lineman for the powerlines hashtag). Overall, our findings show that the place scales that are mentioned in the Instagram posts are related to some differences in the post emotionality, and, importantly, our exploratory analyses show that these effects can differ across the different hashtags that are related to RETs.

Place attachment research suggests that, in mobile lives with multiple place attachments, the time that is spent at the different places that are important to us shapes our attachments to those particular places (Gustafson, 2009). Different places are important for diverse social, cultural, and emotional reasons, as well as for practical purposes (Dang & Weiss, 2021). Seen in this light, the hypothesis that particular uses of, and particular attachments to, place levels can inform the stakeholder perceptions of RETs seems plausible. This suggests that there are differences in the reactions toward the potential local RET-related changes among diverse stakeholders with specific attachments to those same local places and that each place level appeals to several emotions and cognitions. However, the available literature does not provide much information to form a clear hypothesis on the relationship between RETs and place on social media platforms. For this reason, this field should be investigated to obtain a clearer picture of how these dynamics are expressed on social media. In fact, our hypotheses have been only partially confirmed, and we can conclude that the place–RETs relationship follows different dynamics on Instagram that need to be investigated further.

Limitations and Future Research

The present study has some limitations. First, while we crawled for English hashtags, some posts used multiple languages, and we were only able to analyze the English captions and hashtags. Second, people may, at times, have used hashtags for different reasons, other than to refer to RETs. For example, “CBD” (cannabidiol), was mentioned commonly in the biomass hashtags, and the geothermal energy hashtag is, at times, also used by people visiting Iceland. Third, the LIWC2015 software and the word count techniques are coarse measures of language, are devoid of context, and are unable to interpret subtleties such as irony and sarcasm. Fourth, our independent variables have little explanatory power: on average, they only explained 1% of the outcome variables. This is a strong contrast to our expectations, which were built on the relationship between the sense of place and the emotional and cognitive reactions to RETs. We can hypothesize that the link between places, emotions, cognitions, and RETs on Instagram (and on other social media platforms) follows different structures than those studied so far via different research tools (such as surveys, interviews, focus groups, etc.). To the best of our knowledge, this study is the first to link place-level mentions with affective, cognitive, and risk-related words in the context of energy development on social media. Our analysis mainly focused on testing the patterns of the emotions and cognitions to the place levels, which required numerous separate regression analyses. Because of the early stage of this form of analysis, we refrained from a more conservative approach to test the patterns (e.g., reducing the alpha level). Ideally, this research is a first step towards a more intense study that will include social media and other sources, such as mass media, newspapers, etc. Understanding the social dynamics of Instagram has practical implications. For example, companies and developers can use the interface, with the expected values, geographic span, and expression of emotions/cognitions, to disseminate a message and make users aware. The identification of a user's restricted social circle will move marketing campaigns, social movements, developers, etc., away from simply segmenting by demographics and psychographics, towards, instead, conveying their message by segmenting along social network structures (Halford & Savage, 2017).

Author Contributions

Conceptualization, M.V.; data curation, M.V.; formal analysis, M.V., and T.K.; funding acquisition, M.V.; methodology, M.V., and T.K.; supervision, T.K., J.H. and P.S.-R.; validation, M.V.; visualization, S.A.V.; writing-original draft, M.V.; writing-review and editing, M.V., T.K. and S.A.V. All authors have read and agreed to the published version of the manuscript.

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Conflict of 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.

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Empirical Studies: Paper 3

A World of Words: Investigating Topics on the Web of Renewable Energy Technologies Through Content Analysis[1]

Mariangela Vespa [2, 3]

Abstract: Topics related to energy technologies and their description on the web influence the evaluation of renewable projects. Some influences are not fully perceived consciously, but what flows daily before our eyes affects our attitudes and behaviors toward a particular topic. This paper focuses on studying how renewable energy technologies (solar, wind, biomass, and geothermal) and the cumulative impact topics (environmental and human-centred) are expressed and linked to each other on the news on the Internet. The links with the highest total engagement used and shared on Facebook, Twitter, Pinterest, and Reddit platforms were collected and a content analysis was conducted. The results showed that the topics shared about wind energy are more related to arguments connected to the environmental impact (e.g., *eagles, offshore, and landscape*) and emotional words (e.g., *guilty and plead*). Topics related to solar and geothermal energies were more linked to the economy and benefits with slogans like: *help the world and help your bill*. The biomass URLs were more focused on the explanation of its process to provide *knowledge and awareness*. This study has implications for practitioners and policy-makers to effectively plan and develop a variety of communication strategies focused on *each* renewable energy project.

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Keywords: renewable energy infrastructures, content analysis, cumulative impact, social media platforms, communication

Highlights:

- There are significant differences among the topics used to describe RETs in social media platforms.
- Each technology should be addressed differently in targeted communication strategies, based on specific words, key topics, and infrastructure links.
- On the web, wind energy topics are more related to arguments connected to the environmental impact (e.g., eagles, offshore, and landscape) and emotional words (e.g., guilty and plead).
- The URLs of solar and geothermal energies were more linked to the economy and benefits topics.
- The biomass URLs were more focused on the explanation of its process to provide knowledge and awareness.

1. Introduction

Energy resource usage has been considered one of the most important and ongoing issues of modern times (Andrews & Jelley, 2022). For years the European Commission has been trying to reduce the EU's dependence on energy imports from other countries. This has sparked a debate on how best to replace fossil energy supplies in the future focusing on the energy transition to green energy sources (Bricout et al., 2022). The use of renewable energy technologies (RETs) is one way to reduce the use of carbon-intensive technologies, which are a relevant factor in climate change mitigation. The availability of resources indicates the positive development of RETs and their strong potential for the future. By reducing fossil fuel consumption, many countries are increasing the amount of renewable energy produced (e.g., Holechek et al., 2022). It must be taken into account that the use of RETs is a complex and multi-dimensional process, influenced by multiple factors. Thus, all forms of RETs have some impacts on the ecosystem including wildlife and changes of environments and landscapes. Every time a new energy production system emerges, the socio-spatial configurations profoundly change: the interdependence between energy and spatial systems is so strong that it is impossible to imagine a transformation of the former without repercussions on the latter and vice versa (Hussain et al., 2017). The individual's valuation of RETs depends in part upon their physical setting, whether it currently includes energy infrastructure or not, and the nature of their experiences with that place (Baxter et al., 2020). Consequently, the emotional responses to place changes are multivalent, also involving ambivalent feelings and experiences having implications for individuals, collective identity, and psychological well-being (Gieryn, 2000). This complexity means that large attention needs to be paid to how energy systems engage with communities and citizens and how this is approached by local and national media.

In recent years, great power in the dissemination of information has been presented by the media. With the rise of the use of electronic media in the 20th century, the nature of mass communication changed significantly. The effects on our faculties of perception and cognition have given rise to various psycho-sociological theories. During the 1930s and 1940s, scholars in political science and social psychology tested various models, such as the effects model (Lavidge & Steiner, 1961) according to which the media were believed to be capable of producing any effect on their audiences considered passive. More recent theories, such as the uses and gratifications theory (Katz et al., 1973), have emphasized how the audience does not have such passive behavior and consists of active individuals. Katz (1987) claimed that *"the media exert a role not so much on our ideas as on what ideas to think about"*.

In this study, the theories of selectivity and indirect influence (Forgas & Williams, 2016) have been considered. These, grafting on the tradition of social learning theory, argue that exposure to the patterns of behavior offered by the media can be a source of learning for the individual. This aspect leads people to adopt forms of action that may become a more or less permanent part of their way of dealing with life's problems. Moreover, mass media are an important part of the communication process and play a significant role in defining and stabilizing the meanings people attach to the symbols of everyday language. These theories emphasize that although the audience plays an active role in the perception and processing of information, there is also information that is processed, despite there is not total attention to it. Thus, social influence has direct and indirect processes which play a key role in human behavior. Society and media influence each other in explicit, direct, and implicit ways and strategies and the automatic mechanisms require relatively little cognitive effort (Frith & Frith, 2012).

Scholars (Borch et al., 2020; Zobeidi et al., 2022) have conducted several studies on the impact of propaganda, scientific publications, and media on the perception and acceptance of renewable energies. For example, studies (e.g., Vespa et al., 2022a) have brought on the coexistence of the technologies at different place levels (from local to global) underlining that people are more willing to use emotional words on social media referring to the RETs at the micro-level and cognitive words at macro-level, including issues related to the protection of the planet, justice, and climate change. Other researchers have shown that solar power has been shown to elicit highly positive imagery in the media (Sütterlin & Siegrist, 2017), while wind power projects have, in some cases, faced negative emotions (Cass & Walker, 2009). The changes associated with the energy infrastructure projects can be evaluated in different ways and the reaction depends on a variety of moderators such as expectations, perception of the distribution of costs and benefits, landscape changes, justice, etc. (e.g., Karakislak et al., 2023). All these factors are clustered under the concept of the cumulative impact of RETs, which includes both environmental (Akella et al., 2009) and human-centred aspects (Khan et al., 2020). How moderators influence public opinions depends not only on the moderators themselves but also on how they are discussed in the media and their association with some content rather than others.

Despite it being clear that different RETs elicit distinct emotions and contents in the media (e.g., Cousse et al., 2020; Vespa et al., 2022b), there is still a research gap in understanding what technologies are more linked to which topics are on the web and, consequently, how to approach them. For these reasons, the research questions that this study seeks to answer are: *What are on the Internet the topics used for sharing information about RETs? What are on the Internet the key environmental and human impact topics used to describe different technologies?*

Although stakeholders are aware that public emotions cannot simply be ignored (Perlaviciute et al., 2018), it is still difficult to know how to address people's emotions and public opinion. This research paper contributes to studying what people share most on the web about energy technologies and which topics are associated with specific RETs. This will help to create effective communication strategies in all phases of an energy project. To answer the research questions, a content analysis is applied to the RET URLs with the most engagement on the link shared on Facebook, Twitter, Pinterest, and Reddit, to study the topics related to solar, wind, biomass, and geothermal energy.

The remainder of this article is structured as follows: *Section 2,* Theoretical background, some prevailing theories on the communication on media and the impact of RETs on environmental and human-centred aspects have been addressed, as well as the hypotheses and goals of the manuscript. *Section 3*, Method, explains the methodology giving an overview of the content analysis. *Section 4,* Results and Discussion shows the findings of the analyses on the dataset, explaining them by referring to the research hypotheses. Furthermore, it presents an overview of the results and their discussion also referring to scientific literature. *In Section 5,* Conclusion and Policy Implications, the advanced research questions have been answered and some ideas on future research direction have been given.

2. Theoretical Background

2.1. Media Communication and Cumulative Impacts of RETs

The way technologies appear in various forms of media tends to shape public opinion (Nuortimo et al., 2017). Social networking sites appear as virtual spaces that bring together different functions and services on a single platform and make them interact with each other. The topics covered are the most varied and how these different topics are addressed in the media influences how they are perceived and processed (McCombs & Valenzuela, 2020). Various models in the field of psychology and communication (e.g., Pratkanis, 2011) emphasize that people are aware of the results of, for example, solving logical problems, negotiating high-speed turns, making information-based decisions, and making judgments, precisely because in that case concentration is focused on the task. On the other hand, perception, attitude, and behavior are also influenced by stimuli to which one does not consciously pay attention (e.g., Perrotta, 2019). These stimuli can also influence the emotions felt, emphasizing how sometimes the cause of emotion can be very different from the reasons people use (consciously) to explain it afterward. This leads scholars to the conclusion that media stimuli influence not only people's actions but also their emotional states (Bargh, 2022).

Through various methods of data collection, experts (Wüstenhagen et al., 2007) have examined several moderators based on socio-political, community, and market moderators and their effects on the local population's opinion towards RET. These moderators, such as expectations (Walker et al., 2011), familiarity (Weber & Johnson, 2011), etc. inclusion and financial participation (Lienhoop, 2018), perception of justice (Wolsink, 2007), risks and uncertainty (Upham et al., 2015), identity of place (Pasqualetti, 2011) are included in a large cluster of cumulative impact of the RETs, which can be divided into two big categories: the environmental (Akella et al., 2009) and human-centred impacts (Khan et al., 2020). With regard to environmental impacts, there are three main issues in determining the applications of RET development (Sayed et al., 2021): 1) landscape and visual impact; 2) ecological, influencing the ecosystem through direct impacts on individual organisms, habitat structure, and functioning (biodiversity, birds, and bats); and 3) noise, where sound may become noise, due to other negative impacts (annoyance, anger, etc.) becoming psychological stress (Haac et al., 2022). The human-centred impacts of RETs, instead, can be divided into three clusters (Kumar, 2020): 1) personal, having impacts on human health and wellbeing (e.g., the use of electricity generation), economic and fiscal impacts, pro-environmental behavior, and local responses to projects; 2) social and cultural, influencing tourism, historic, sacred, archaeological, and recreation sites; and 3) economic, for example, tax credits and other monetary incentives to encourage energy production (benefits and regional value added).

2.2. Goals and Hypotheses

Although there are several studies in the literature that have used the media as a data collection tool for the study of RETs (e.g., Haber et al., 2021; Vespa et al., 2022a), an identified gap is that there are no articles that provide a content analysis to identify which topics and words are presented on the web with reference to different RETs. This article aims to fill this aspect and make a contribution to the scientific literature.

The impacts of wind energy development on the environment have been the subject of numerous studies. Visual impacts of wind energy infrastructures as well as their effect on landscape change can create concerns that may endorse negative emotions (Wolsink, 2007). Scholars (e.g., Stadelmann-Steffen & Dermont, 2021) argue that project-related aspects such as the environmental impact of a wind energy project have a stronger influence on the community acceptance of such projects than more process-related factors, such as the justice (both distributional and procedural) (Langer et al., 2017). Minimizing the environmental impact of a wind energy project, taking into account elements such as the effect of the project on the local ecosystem, technology assessment, wildlife safety, etc. has a strong positive influence on public opinion of wind energy (Enevoldsen & Sovacool, 2016). Over the years a very strong and ruthless campaign was made against the possibility of wind turbines killing various types of birds, and fishes and having an impact on both flora and fauna.

On the other hand, biomass energy is particularly seen to require a collective effort (social, economic, and political climate) by various actors (Ahmad & Tahar, 2014). Data indicate that biomass power has attracted much positive and neutral attention at a global level and a larger amount of negative reactions at the local level (Nuortimo et al., 2017). The attitude of public opinion can influence new construction of biomass plants, since, for example, biomass projects fail due to two characteristics, namely resistance to landscape changes (accusation of indiscriminate non-use of pasture, forest, or virgin land) by public opinion and closure to investment by developers. The topics underlined by no-supporters of biomass are: competition with food production, encouragement of deforestation, a lower reduction in CO2 emissions than claimed, etc. Conversely, the ability to reduce emissions is presented as an important motivation for the use of biomass for energy purposes, as well as the ability to prevent the degradation of land otherwise left uncultivated and, in general, to foster sustainable development. For this renewable energy, as well as for wind energy, aspects of environmental impact are often taken into consideration and used as argumentations in supporting people's ideas. On these two renewable energy infrastructures (wind and biomass) state the following hypothesis:

> **Hypothesis 1** Environmental impact topics (landscape and visual impact, ecological, and noise) emerge most frequently to describe wind and biomass power on the web.

For solar energy, the economic benefits and the transfer of economic benefits to the local community have been found to positively influence community acceptance (Vuichard et al., 2019). The existence of compensation mechanisms (e.g., sharing benefits with individual residents in the form of financial transfers to households) has been shown to reduce project objections and delays for all RETs (Hyland & Bertsch, 2017). Although these benefits can be realized with several RETs, they are more emphasized for solar than the other energies. In fact, opinion polls indicate that solar energy enjoys a high level of socio-political acceptance and is preferred to other renewables (Cousse, 2021). For this reason, it is expected that economic, personal, social, and cultural topics are more often mentioned on the web in solar energy articles.

The growing awareness and popularity of geothermal (ground-source) heat pumps have had the most significant social impact on the direct use of geothermal energy reported in 58 countries (Lund & Toth, 2021). The use of low- or medium-temperature geothermal resources for direct heating applications and, given the right conditions, geothermal projects are economically feasible and can contribute significantly to a country's energy mix, especially in the long term. However, a major obstacle is the high initial investment costs. Research has pointed out that the public seems to be disoriented about geothermal energy, especially regarding the expenses-revenues, benefits-challenges, the difference between shallow and deep geothermal energy projects, etc. (Dubois et al., 2019). Furthermore, people are confused about the difference between surface and deep geothermal energy projects, as well as geothermal energy in general. Most people do not understand what geothermal is and they are worried that this development will have an impact on public health. Thus, authors (e.g., Vespa at al., 2022b) showed that for describing geothermal energy on social media platforms people use more emotional than cognitive words and a possible explanation is that, following the appraisal theory (Scherer, 1999), perceived risks are predictors of a wide range of negative emotions. In summary, geothermal energy has a big human-centred impact, which is why it is expected to find economic, personal, social, and cultural topics more frequently on the URLs. These two renewable energy infrastructures state the following hypothesis:

> **Hypothesis 2** Human-centred impacts (economic, personal, social, and cultural) emerge most frequently to describe solar and geothermal energy on the web.

Figure 1 graphically summarises the hypotheses and variables of cumulative impacts and how they are interrelated with the various RETs. The results of this research are useful for project developers so that interventions can be introduced to manage community opinions to increase project acceptance. Knowing how and where to communicate a message is critical to a successful renewable energy project and its social acceptance (Ellis & Ferraro, 2016).

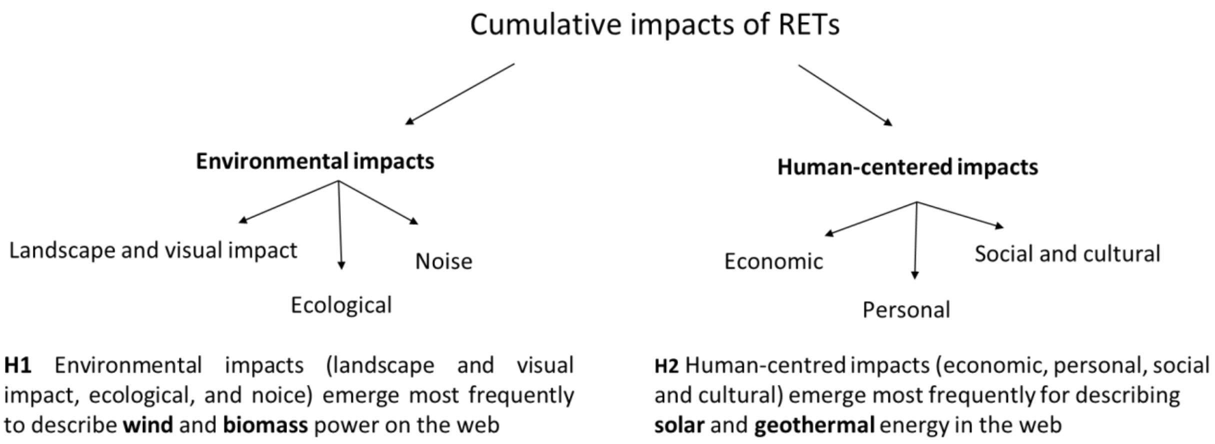

Figure 1. Conceptual framework of cumulative RET impacts and summary of hypotheses

3. Method

3.1. Content Analysis

Content analysis is a method designed to identify and interpret meaning in recorded forms of communication by isolating small pieces of the data that represent salient concepts. The next step is to apply and/or create a framework to organize the components in a way that can be used to describe or explain a phenomenon, through a systematic process of interpretation (Kolbe & Burnett, 1991). Content analysis is particularly useful in situations where there is a large amount of unanalyzed textual data like on the web. Thus, content analysis is one of the most commonly used research methodologies in media research (Drisko & Maschi, 2016).

The following study provides an account of content research analysis elicited by wind, solar, geothermal, and biomass keywords. The content analyzer of the Buzzsumo tool (Drisko & Maschi, 2016) was used to research the top-performing articles, infographics, lists, interviews, newsletters, posts, reviews, and blogs shared on the web. Searching for keywords (wind energy, solar energy, biomass energy, and geothermal energy), the tool brought up a list of all the top pieces of content related to those keywords, alongside insights about them, such as their total number of backlinks, social engagements, and evergreen score. The results were sorted according to their performance in the metrics of an average number of engagements and link domains for all articles shared on Facebook, Twitter, LinkedIn, and Pinterest, and external links for each article. The idea was to study the news items that were re-shared and followed on the web, so the number of engagements of each news item was a good criterion to use. The textual contents of the Websites to which the URLs linked were entered into Voyant (https://voyant-tools.org/) for a semantic overview and a more contextualized visualization, on WordTree (https://www.jasondavies.com/wordtree/). Analysis software MAXQDA was used for the systematic URL review, transcribing the URL contents, coding the data, and identifying the frequencies. This was done for both the full texts of the URLs (full-length articles) and the titles of each article. A qualitative thematic analysis has been used to systematically identify and organize the patterns of themes for the data set, exploring similarities and differences within the data set. The coding procedure combined both the descriptive and interpretative approaches to identify the data. This study followed the six main steps of the thematic analysis approach: getting familiar with the data, generating initial codes, searching for themes, reviewing potential themes, defining and naming themes, and finally producing the report (Clarke & Braun, 2017).

4. Results and Discussion

Of the 1.077 URLs in the corpus, 272 links were of wind energy with the sum of 749.591 total engagement links, of which 539.948 were shared on Facebook, 197.533 on Twitter, 6.306 on Pinterest, and 4.910 on Reddit. The total corpus of words in the URLs of wind energy was 450.223,65, with M=1.679,93 and SD=2.024,59 per article. The total corpus of words in the title of wind energy articles was 4.182 with M=15,84 and SD=10,58 per article.

Of solar energy, the links were 270. The sum of total engagement links was 1.367.528, of which 786.550 were shared on Facebook, 542.261 on Twitter, 23.472 on Pinterest, and 17.553 on Reddit. The total corpus of words in the URLs of solar energy was 405.217, with M=1.512 and SD=1.345,66 per article. The total corpus of words in the title of solar energy articles was 3.707 with M=13,83 and SD=9,65 per article.

Of biomass energy, the total links were 254. The sum of total engagement links was 2.497.681, of which 1.190.940 were shared on Facebook, 1.242.454 on Twitter, 31.649 on Pinterest, and 34.071 on Reddit. The total corpus of words in the URLs of biomass energy was 593.108, with M=2.353,60 and SD=3.169,38 per article. The total corpus of words in the title of biomass energy articles was 3.483 with M=13,82 and SD=9,57 per article.

Of geothermal energy, the total links were 281. The sum of total engagement links was 1.361.619, of which 752.869 were shared on Facebook, 553.369 on Twitter, 13.680 on Pinterest, and 25.158 on Reddit. The total corpus of words in the URLs of geothermal energy was 440.547, with M=1.584,70 and SD=1.705,08 per article. The total corpus of words in the title of geothermal energy articles was 4.432 with M=15,89 and SD=9,98 per article.

These specific RET keywords (wind energy, solar energy, biomass energy, and geothermal energy) have been used because they are the main RETs in the research publication and the goal is to evaluate their evolution on social media. Furthermore, these keywords also have a strong local presence and widespread recognition, making them subjects of considerable discussion within communities (Ochoa et al., 2019). Data collection took place on January 15, 2024, until the total engagement for the links reached zero. The filters applied included: English language only, no videos, and no geographical limitations.

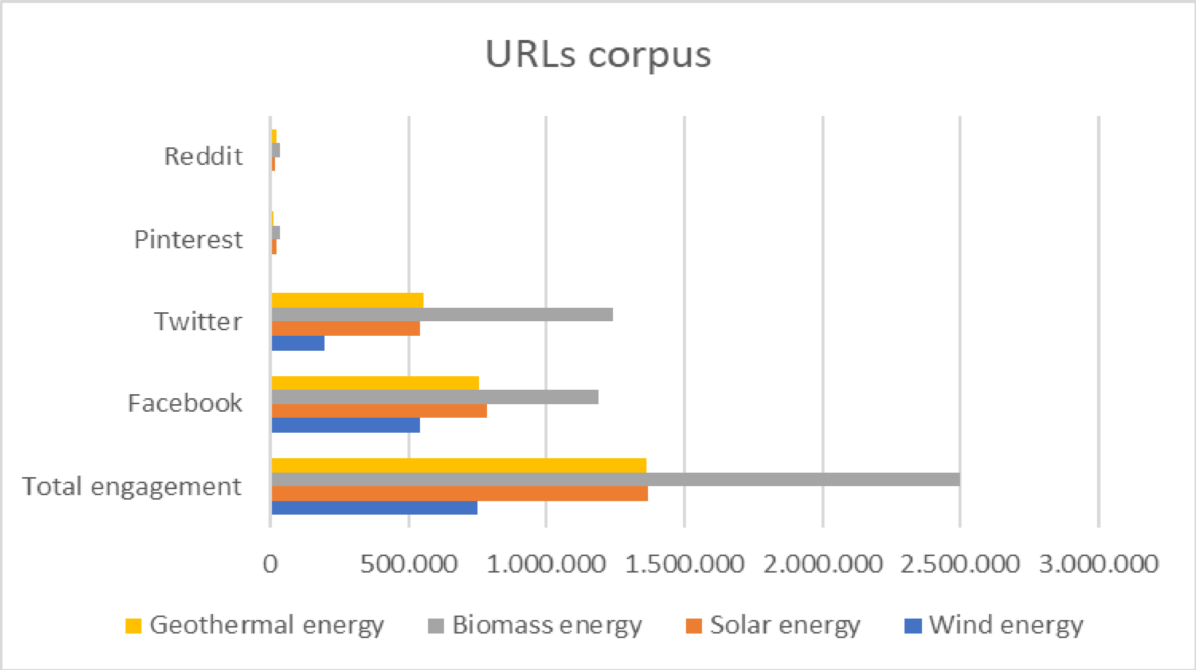

Figure 2. URLs engagement of renewable energies in social media platforms

As shown in Figure 2, Reddit and Pinterest have the lowest number of URLs shared, a number expected considering that these media are mainly for sharing images and photos. Biomass energy is the renewable energy with the highest number of shares. This leads us to think that it´s an energy that is taking hold and that discussions on social media are increasing to give clarity and share information and knowledge. A valid alternative to fossil resources is biomass and its conversion into food, feed, and bio-based products such as bioplastics, biofuels, and bioenergy. Several countries have developed bioeconomy strategies and the growing use of biomass leads to a need to share articles to make clarity and awareness. Solar and geothermal energy have almost the same total engagement and, contrary to what is expected, wind energy articles are less shared.

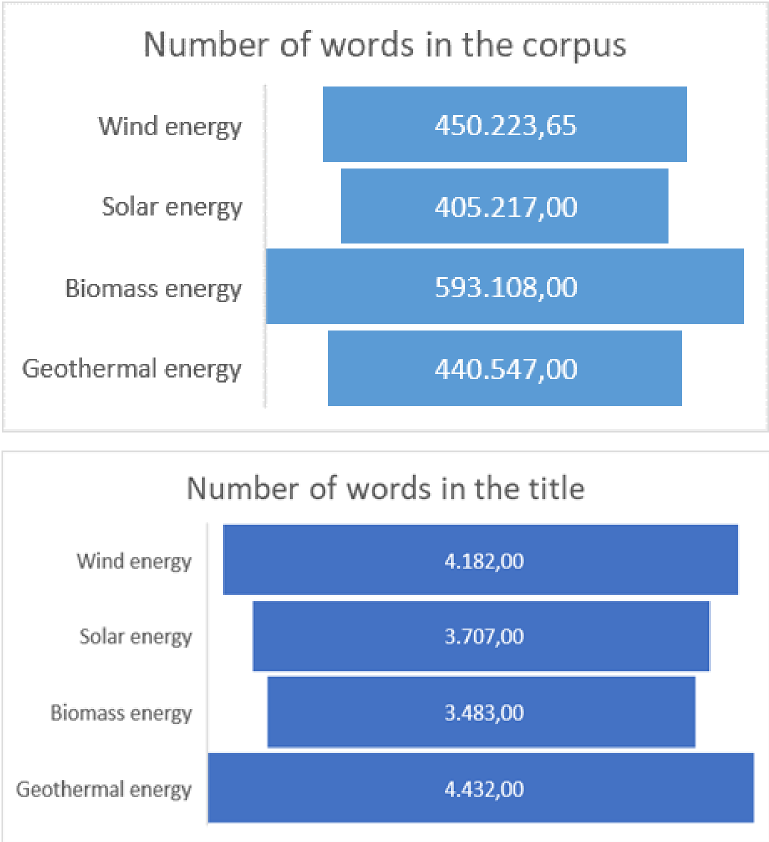

Figure 3. Number of words in the corpus and title

Figure 3 shows that articles on biomass energy contain the greatest number of words, followed by wind, geothermal, and solar. The longest titles are those on geothermal, followed by wind, solar, and biomass. A detailed analysis of the corpus and titles of each renewable energy is presented in the following paragraphs.

4.1. What are on the Internet the topics used for sharing information about RETs?

Table 1 gives an overview (frequency and percentage) of the words used in the text and the title of the URLs analyzed.

In detail, in web articles on wind energy, words referring to *offshore* were found with high frequency. Mostly, the topics covered were the significant costs of offshore for installation and maintenance, but also other positive aspects, namely that winds tend to flow at higher speeds than onshore, thus enabling turbines to produce more electricity. Overall, the offshore wind farms compared with land, must be fixed on the seabed, which demands a more solid supporting structure. Submarine cables are needed for the transmission of electricity, and special vessels and equipment are required for building and maintenance work creating high costs. On the other hand, another relevant topic underlined in the URLs is that offshore wind turbines are less obtrusive than turbines on land, as their apparent size and noise can be mitigated by distance. In summary, the positive aspects highlighted for offshore in the articles analyzed are: the availability of large continuous areas, suitable for major projects; mitigation of the issues of visual impact and noise; higher wind speeds, which generally increase with distance from the shore; less turbulence, which allows the turbines to harvest the energy more effectively and reduces the fatigue loads on the turbine. The articles also pointed out that the offshore is having considerable development in America (central and north), Scotland, and Denmark.

Regarding fauna and flora, sentences like *"So many fishes died over the past decade because of the wind turbines"* lead to the need for more regulations and studies on the case. Instead, the onshore has stressed a noteworthy death of birds: *"Birds killed when they fly into the blades of wind turbines, especially migratory birds".* These sentences had been reported especially in the titles of the articles. The birth arguments were often used as a reason to limit the installation of more wind turbines. The first European study on this topic took place in Lekuona, Navarra (Spain), in 2001 (Lekuona, 2001). This area is home to many birds of prey and serves as an important migratory corridor to and from the Pyrenees. The study found that wind installations were significantly disturbing numerous migratory birds. Conversely, some studies, such as Linder et al. (2022), indicate that certain species are more susceptible to collisions with wind turbines. Conducting a thorough investigation could help identify suitable locations for turbine installation that would protect the fauna and flora. Additionally, research conducted by Chang et al. (2022) found that the positive effects of wind turbines on environmental sustainability significantly outweigh the negative impacts. Furthermore, the issue of bird mortality can be addressed through careful study of the phenomenon.

Climate change has emerged as a significant topic in the analyzed URLs, particularly regarding the role of wind energy in addressing this challenge. Numerous online conferences have been organized to raise awareness about climate change. Increasing awareness can lead to meaningful changes in attitudes and behaviors, ultimately helping to mitigate both potential and existing threats associated with this phenomenon (Halady & Rao, 2010).

In article titles, the most frequently used words tend to relate to emotional themes, such as *guilty* and *plead*. These words highlight the negative effects of wind turbines, including changes to the landscape and impacts on wildlife. The purpose of these titles is to capture readers' attention, which is why they often feature catchy phrases that appeal more to emotions than to rational thought. Furthermore, the negative connotations of the words amplify the effectiveness of the arguments being presented (Whissell, 2004).

Over the years, wind energy has become associated with various negative aspects that resonate both cognitively and emotionally (Punch & James, 2016). Concerns in this area include tangible issues like land damage, noise pollution, and human health, alongside emotional responses that evoke feelings of guilt related to the impact on birds and the disruption of tourist sites (Bartczak et al., 2021). This situation necessitates a deeper examination of why wind energy tends to elicit such strong emotional reactions and protests. Research shows that specific negative emotions can have unique influences on cognition, and emotions are key factors in shaping social cognition (e.g., DeSteno et al., 2004; Forgas, 2008). Additionally, analyses within this study indicate that online discussions often emphasize negative and emotional language, reinforcing existing concerns. Therefore, it is crucial to develop and promote new positive associations, such as those related to decarbonization and climate change with RETs, through online platforms.

In web articles about solar energy, references to *cost* are frequently mentioned. Over the past decade, the cost of installing solar systems has decreased by more than 40%. This reduction includes expenses related to labor for installation, customer acquisition, permitting, and inspections (Allouhi et al., 2022). The price of solar panels largely depends on the availability of incentives. Consequently, there is an increasing demand for subsidies and support from the state.

Another word with high frequency was *home*. The articles emphasized that adding solar panels is a long-term investment for heating and electric vehicles, which can help reduce a home's electricity bill by an average of 4% and lower its carbon footprint. This approach highlights the importance of social and personal responsibility, as each individual can contribute to environmental protection. It follows that another significant term was *needed*. The articles stressed the necessity of solar energy to achieve the level of clean energy required for an efficient electrical system. By combining private sector innovation with stable, long-term public policies, the solar industry can be set on a path to meet climate change goals and promote the decarbonization of the economy (Rashid Khan et al., 2021).

Another word was *business.* Overall, solar energy is presented as a need for climate protection but also as a business that leads to personal gains and savings. This approach means that people can see, concrete, gains on a global, local, and personal level. The same is reached with the word help, intended to *"help the world"* and "*help your bills*". This line has emerged as valid to increase social acceptance and positive attitudes toward specific renewable energy, especially when communities become aware of the positive contributions of energy projects to the local economy and employment (Sharpton et al., 2020).

The titles emphasize that solar energy is *green*, beneficial for the *economy*, represents the *future,* and is essential for both *global* and local energy *transitions*.

In web articles on biomass energy, words referring to *fuel* were found with high frequency. Many articles focused on giving information and knowledge about the operation and use of biomass. For example, some articles focused on the use of biomass as fuel in boilers. Thus, the purchase of bioenergy boiler fuel affects stock prices, contributing to a gradual energy transition, with a significant impact on efficiency and climate change (Picciano et al., 2022). The articles emphasized how market participants stressed the need to expand subsidies and present more advantages over the purchase of existing fuels to further encourage the transition to bio-bunkers. In addition, it is outlined that the most pressing issue is the reduction of greenhouse gas emissions generated from product manufacturing and fuel combustion. Therefore, it is aimed to accelerate the development and market deployment of renewable fuels.

The term *carbon* is frequently mentioned in various articles, especially regarding its processes. Carbon absorbed from the soil during the decomposition of organisms can be recycled. Under suitable conditions, the decomposing organism can transform into peat, coal, or oil, which can then be extracted through natural or human activities. When fossil fuels are extracted and burned for energy, the sequestered carbon is released back into the atmosphere. Unlike fossil fuels, which do not reabsorb carbon, biomass originates from recent living organisms. The carbon in biomass can continue to be exchanged in the carbon cycle (Gayathiri et al., 2022). However, for the Earth to maintain the carbon cycle, biomass materials such as plants and forests must be cultivated sustainably.

One topic of discussion in the URLs is the potential of advanced biofuels to contribute to the decarbonization of the aviation industry, which is crucial for both airplanes and airline manufacturers. The concept involves utilizing hydrotreated esters and fatty acids derived from vegetable oils, fats, and animal *waste* (Monteiro et al., 2022). While the commercial shipping industry continues to rely on fossil fuels for the transportation and international trade of goods, there is an opportunity to transition towards cleaner energy sources. In the realms of government, industry, and NGOs, several *issues* arise, including the integration of renewable fuel policies, carbon removal strategies, lifecycle analyses, and land use changes within market frameworks. Additionally, discussions have focused on *policies* related to sustainable development goals, addressing the following key points: i) the current roles and policies of the advanced biofuels market; ii) the challenges that limit flexibility, efficiency, and cost performance; iii) the implications of sustainable development goals; and iv) the outlook for the future.

In the titles, words with mention of the *European Union* are included with a high frequency. For example, it is emphasized that EU policies aim to provide safe, sustainable, and affordable energy for citizens and businesses, and biomass is a resource to achieve these goals. In addition, the European Energy Ministries ask countries to formulate plans for the co-firing of biomass in power plants and the use of biomass should be included in the tariff regulations. Achieving the EU's ambitious goal of reducing CO2 emissions by 55 percent by 2030 will require fundamental changes in the energy sector (Rivas et al., 2021). Thus, it is critically important to promote all sustainable fuels and their infrastructure.

Among the most frequently mentioned terms in the title is *plastic*. Scientists are currently developing a new type of plastic similar to polyethylene terephthalate (PET), which is created directly from waste biomass. This plastic is durable, heat-resistant, and provides an effective barrier to gases such as oxygen, making it a promising option for food packaging (Vats & Sharma, 2025). Another key term is *hydrogen*. Researchers are advancing technology to generate green hydrogen from biomass, which is an abundant source of renewable energy. Green hydrogen has the potential to meet the energy demands of industries and heavy transportation. For this reason, techniques are being developed to produce green hydrogen from biomass at an affordable cost. One such method is biomass gasification, a stable technology that utilizes high-temperature steam to break down biomass into hydrogen and other combustion by-products. This process is considered renewable and carbon neutral, and when paired with carbon capture and storage, it can even be carbon-negative. Thus, via steam-based hydrogen production, it is possible to generate 100 grams of hydrogen from 1 kilogram of biomass (Aziz et al., 2021). Globally, there is a lack of understanding about the production process of hydrogen and biomass energy, their interconnection, and the benefits they provide, which leads to concerns regarding the consistency of their use (Gordon et al., 2022). Another frequently used word in URL titles is *process*. Biomass for energy must be produced, processed, and used sustainably and efficiently to optimize greenhouse gas reduction and maintain ecosystem services. In the articles, information is provided trying to fill the gap where knowledge about renewable energy is sometimes confusing and unclear. Knowledge about how technology works and the effects of the technology can influence people’s perception of the costs, risks, and benefits of technology and indirectly the attitude, behavior, and acceptance of technology (Huijts et al., 2012).

In the geothermal energy articles, there is a high frequency of the *solar* word. Authors have shown that among these renewable energies, there is a strong mental association on the web (Vespa et al., 2022b). In addition, hybrids of geothermal and solar power systems (e.g., photovoltaic and concentrated solar power) are mutually beneficial and a promising combination of renewable energy sources (Thirunavukkarasu et al., 2023). Worldwide there are many areas with both high geothermal heat flux and surface radiation, which makes integration of geothermal and solar energies possible. Thus, solar energy could be used to increase the temperature of geothermal fluids, significantly improving the efficiency of geothermal power generation. Geothermal fluids can serve as storage systems for solar energy, which may solve many problems of solar systems such as weather dependence and instability. On the other hand, the inclusion of photovoltaic panels in a geothermal power plant may be able to cope with the peak power demand during the daytime, which helps extend the lifespan of geothermal fields (Li et al., 2020).

The use of geothermal energy for *home* heating is one of the topics highlighted in the articles. Geothermal energy has a low carbon footprint and is a reliable and constant energy base. It can be developed without relying on external factors. For instance: "*It is not necessary to wait for the sun to shine or the wind to blow*"; *"There are no troublesome imports and exports laden with price shocks and political disputes",* as reported in the text. On the other hand, there are negative aspects that sometimes lead to low social acceptance of geothermal energy. For example, scholars have noted that the population perceives certain environmental and social risks (Mahamoud Abdi et al., 2024). Specifically, concerns about air, soil, and water pollution, resettlement of local communities, and misunderstandings of local culture can significantly impact the acceptance of geothermal technologies. It is essential to consider local culture and land use before implementing a geothermal energy project. Additionally, water availability poses a significant challenge in rural areas of the region, particularly due to ongoing droughts that are intensified by climate change.

Also, the articles emphasize how geothermal can be attractive for the *business* it brings and for *industries.* Industrial processes can be realized with low- and medium-temperature geothermal resources. In this context, the reduction of CO2 emissions into the atmosphere would mean several million tons per year, and 15 years would be the payback period of this investment for the initial industrial processes. Many companies and industries are switching to renewable energy as an ethical commitment and as a strategic move to strengthen their bottom lines (Palomo-Torrejón et al., 2021). On the other hand, problems of local acceptance of deep geothermal plants have emerged due to a lack of information and trusting relationships between citizens and energy companies (Karytsas & Polyzou, 2021). Business strategies in the geothermal energy market are key to establishing mechanisms to facilitate the adoption of geothermal by building trust between the parties. In recent years, companies have begun to look for effective ways to engage citizens because it is *"a type of investment"* that *"always brings a return"*, as cited in the articles. Despite this effort, it may be difficult for energy companies and technology providers to identify appropriate strategies and actions to take, due to the high heterogeneity of situations in terms of citizens with different cultural backgrounds and local needs, as well as different personal characteristics that they face. Therefore, an in-depth study of the media can help disseminate information efficiently and increase trust, fostering citizen involvement (Contini et al., 2019). It was also remarked that the *oil* and gas and geothermal industries have numerous similarities that provide new opportunities for geothermal expansion, from advances in drilling and well construction to co-production possibilities in existing oil and gas basins.

In the title, new grants to *help* local businesses and community groups were stressed. Despite geothermal energy has been a niche energy source for more than a century, daily advanced techniques drawn from the oil and gas industry could help geothermal energy enter the mainstream. In the headlines, it is pointed out that the *potential* and development of the geothermal energy market in some countries such as Poland, the United Kingdom, the Baltic States, Indonesia, New Mexico, Singapore, Chicago, Texas, and East Africa. Furthermore, new research says that geothermal energy could also be better than existing technologies like *batteries* for storing excess renewable energy from wind and solar power (Green et al., 2021). Words like *research* and *scientists* have a high frequency. Addressing the scientific aspect, especially in the headlines, causes people to rely on that article, and this leads to a higher likelihood that the article will be opened and read.

Table 1. Words used in text and title

Articles	**Words more used in the text**	**Words more used in the title and subtitle**
Wind energy	Offshore (N=481, 0,44%); eagles (N=358, 0,33%) and kill (N=155, 0,21%); country (N=281, 0,26%); climate change (N=245, 0,22%); solar (N=218; 0,20%)	Kill (N=40, 1,29%); eagles (N=34, 1,10%); offshore (N=34, 1,10%); plead (N=32, 1,03%), guilty (N=19, 0,61%)
Solar energy	Cost (N=275, 0,24%); home (N=250, 0,22%); need (N=238; 0,21%); business (N=221; 0,19%); help word (N=215, 0,19%)	Green (N=12, 0,46%); economy (N=6, 0,23%); future (N=6, 0,23%); transition (N=6, 0,23%); global (N=5, 0,19%)

Biomass energy	Fuel (N= 431, 0,44%); carbon (N=419, 0,42%); waste (N=353, 0,36); pellet (N=334, 0,34%); policy (N=238, 0,24%)	European Union (N=17, 0,67%); plastic (N =10, 0,39%); green (N=9, 0,35%); hydrogen (N=8, 0,31%); process (N=7, 0,27%)
Geothermal energy	Solar (N=384, 0,30%); home (N=355, 0,28%); business (N=257, 0,20%); industry (N=236, 0,19%); oil (N=235, 0,19%)	Help (N=14, 0,41%); potential (N=14, 0,41%); researcher (N=12, 0,36%); scientist (N=12, 0,36%); battery (N=10, 0,30%)

4.2. What is on the Internet the key environmental and human impact topics used to describe different technologies?

As expected from the assumptions, the articles on wind energy primarily focused on its environmental impacts, often using language that appealed to emotions. Consistent with other studies (Nazir et al., 2019), wind energy is a subject of considerable controversy due to its effects on living spaces, biological systems, noise pollution, and its impact on fauna and flora. These concerns can hinder the development of wind energy and reduce social acceptance and support. The emphasis on these topics in online discussions further increases public resistance. Therefore, the information on the web should leverage how to mitigate this environmental impact and how to solve related problems.

One surprising result was that biomass, instead of being related to environmental impact, had more articles focused on explaining its processes and uses. Thus, the articles focused on providing information and raising awareness. Overall, the public´s knowledge of energy technologies is not very thorough, and this is especially applicable to biomass. Studies, such as those conducted by Boudet (2019), highlight that a lack of knowledge can lead the public to take "cognitive shortcuts" when they are suddenly asked to make decisions that directly impact them, like the construction of a plant near their homes. Instead of relying on complex, objective information, individuals often base their attitudes on hearsay, personal experiences, opinions from acquaintances, political viewpoints, online information, prejudices, or deeply held core values. Therefore, providing articles that then gain interest in the population by considering the number of shares that focus on practical information related to this energy turns out to be a convincing strategy, to decrease the knowledge gap and lead to greater social acceptance.

Geothermal and solar are both, as expected, strongly linked to words related to human-centred impacts, with articles aimed at emphasizing economic feedback and business. Research by Li et al. (2020) highlights the advantages of hybridizing geothermal and solar power systems, including photovoltaic and concentrated solar power. This combination enhances the efficiency of renewable energy generation. Plus, by leveraging the strengths of both energy sources, it is possible to unlock their full potential and make a meaningful impact in the transition to renewable energy. For example, one of the benefits of hybrid solar and geothermal power systems is that they can be implemented in various locations around the world. This is possible because many areas have both high geothermal heat flux and ample surface solar radiation.

Regarding the economic aspect, authors have shown that the economic considerations of a particular renewable energy system, viewed as a favorable cost-benefit analysis by individuals, are among the strongest predictors of acceptance (Zoellner et al., 2008). Therefore, utilizing a web-based approach to provide information on the economic, environmental, and social benefits of these renewable energy sources is effective and convincing.

To conclude, social media has a real language and, as in real life, every action and topic has its importance in creating public opinion. Over the years, the media have become more important, which is why nowadays it’s difficult to study social phenomena without investigating what is proposed in the media daily.

5. Conclusions

In this study investigating web topics on renewable energy technologies through URLs shared on various social media platforms, the following questions have set out: What are on the Internet the topics used for sharing information about RETs? What are on the

Internet the key environmental and human impacts topics used to describe different technologies?

It has emerged that the themes shared on the web follow a pattern in describing different renewable energies. By understanding and studying these patterns, a clearer idea of how to approach each renewable energy has been given. There is, indeed, a need to conduct more studies on emotions and transition, opening the debate on what kinds of systems and information people want in the future, what people's needs are, and how these needs are determined. The information shared online covers various themes, including a focus on environmental impact issues for wind energy, the economic benefits of geothermal and solar energies, and knowledge about the biomass process.

The sharing of information plays a crucial role in shaping attitudes and behaviors toward a topic. When energy companies are unwilling to disclose certain types of information, it can lead to a loss of public trust (Bearth & Siegrist, 2022). This, in turn, creates a perception of danger and increases public opposition. Therefore, renewable energy companies should develop effective strategies and actions, including information campaigns and trust-building activities, that take into account the perspectives and involvement of citizens. Gaining the acceptance of local communities is essential for the successful implementation of energy projects and the achievement of energy policy goals (Stadelmann-Steffen & Dermont, 2021).

To the best of my knowledge, this study is the first to analyze the words and topics used by individuals to describe RETs on the web through URLs. The findings indicate significant differences in the topics used to describe various RETs, suggesting that each technology requires a unique approach when managing social acceptance processes. Consequently, communication strategies should be customized according to specific terminology, key themes, and connections to pertinent infrastructure.

While this study has its strengths, two limitations have been identified that could serve as a foundation for further research. First, the results should take into account the variables associated with social media users, such as age, usability, and needs. Second, demographic factors, including personality traits and cultural differences, were not controlled in the data collected. Future research could explore methods for controlling the data scraping data and conducting a replication study would be beneficial. Given that this study focused on text analytics, upcoming studies might consider incorporating images and videos into their analyses. Further investigation in this area is recommended.

In conclusion, to effectively plan for the energy transition and share information on renewable energy, decision-makers must understand public attitudes toward renewable energy technologies and the perceived impacts of these installations. To assess the sustainability of the energy transition, it is essential to evaluate the effects - both positive and negative - on local communities. These concerns should be treated as valid, just like the environmental impacts and economic feasibility of the projects.

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Chapter 3: Discussion and Conclusions

This chapter discusses the research project as a whole and presents final reflections and conclusions. Key insights are shared about the methodological and theoretical choices made in this thesis. Then, the results of three research papers and their contributions to the literature and practice are presented, as well as the contribution to the field of environmental psychology.

1. Summary of Key Findings

To provide an overview of the key findings of this work, the research questions of this thesis have been used as a starting point to explore the contribution to the literature, along with a general discussion and reflection on the main outcomes.

How are RETs described and discussed on social media platforms?

Energy systems consist not only of various technologies and infrastructure but also form a sociotechnical system that is deeply embedded in society (Miller et al., 2013). These systems have significant environmental, social, and economic impacts (Devine-Wright & Batel, 2017). Understanding RETs and their associated topics is essential for comprehending their social perception.

In our digital age, communication spreads rapidly and evolves through social media platforms. While social media serves as an asset in many ways, it also allows a diverse range of voices to express their opinions and garner support/opposition (Coleman & Blumler, 2009). This phenomenon makes it relevant to study social issues through social media, offering valuable insights that can inform future actions. Several studies have illustrated the substantial impact of social media communication on everyday behaviors (Vevere, 2015). Effective communication is essential for the success of community-based renewable energy projects, as it influences perceptions and overall impact. Therefore, the diverse needs, perspectives, and concerns of people create a complex environment that necessitates a strategic and transparent communication approach (Adebayo et al., 2024).

The three papers discussed here utilize social media for data collection. By exploring media platforms, public opinions and attitudes toward RETs have been illustrated. The use of sentiment-based classifications and analyses has provided knowledge of the emotions and cognitions associated with different RETs. To date, no existing articles provide a comprehensive overview of how several renewable energies are discussed and commented on in social media.

Taking this aspect into consideration, my thesis aims to enhance the understanding of the public perception of RETs and to provide insights for more effective communication campaigns. In detail, the findings indicate that mental associations between different RETs vary, with some connections being stronger (like between wind and solar energy) than others. Interestingly, power lines were not associated with any RETs in the analyzed data. Literature suggests that linking power lines with RETs can enhance social acceptance and mitigate negative emotions (such as anxiety, fear, etc.) (Batel, 2018). The study of Lienert et al. (2015) has confirmed the importance of connecting powerlines to RETs to have positive feelings, perceived benefits, lower perceived risk, etc. Therefore, paper 1 emphasizes that there is still little association between RETs and power lines on media platforms, indicating the need for further work in this area. Furthermore, taking this data into account, an inclusive communication strategy, associating RETs with power lines and respecting local cultural values and practices, could help reduce this lack of mental connection and facilitate smoother progress towards the project's goals. Projects introduced in communities without robust communication plans may face resistance or misunderstanding, especially when they influence local resources, land use, or social dynamics (Babayeju et al., 2024).

A remarkable result of Paper 2 was the infrequent use of the term "planet" in the analyzed posts, which contrasts with literature highlighting the importance of fostering a sense of attachment to the planet, alongside local attachments (Manzo et al., 2021). This attachment is seen as crucial for advancing broader topics, such as climate change and decarbonization. Considering these data, a clear communication framework, emphasizing the benefits of RETs not only at the level but also globally, could foster long-term support, improving the resilience and adaptability of renewable energy projects.

These studies have shown that social media analysis is a solid research method in social science. Although each research method has its advantages and disadvantages, media data analysis allows for the study of opinions without participants knowing they are being ‘interviewed’, thus respecting users' privacy. Plus, social media platforms provide access to a large and diverse pool of participants (Drahošová & Balco, 2017) and provide a wealth of data that was used to answer my research questions. In particular, Instagram is highly suitable for real-time data collection as it allows users to write captions and describe photos and videos without word limits, facilitating content analysis (Cornelio & Roig, 2020). In addition, qualitative reports on URLs serve as a tool to narrate the dynamics of social media, helping researchers to understand the topic more deeply (Page, 2018).

What are the most frequent themes and topics shared on the web about RETs?

All three papers of this thesis focus on the themes shared across media platforms. In detail, paper 1 examines the mental associations between RETs and the words with emotional and cognitive value used in Instagram posts. Paper 2 primarily explores the concept of place and its expression in Instagram posts. Paper 3, specifically helps answer this research question by giving insight into what themes are shared on the web about each RET. In particular, paper 3 presents an overview of which topics relate to which RETs, and, considering the existing literature, it offers a key to understanding the mental associations involved.

Studies (e.g., Ishola et al., 2024) have shown that defining communication objectives is a crucial step in establishing a stakeholder communication framework that supports the successful implementation of community-based renewable energy projects. Consequently, examining the relationship between topics and RETs presents an opportunity to facilitate open communication, build trust, and promote active engagement, ensuring that the needs and expectations of stakeholders, particularly local communities, are met.

Paper 3 highlights that solar and geothermal energies are more commonly associated with economic benefits. Specifically for solar energy, the most shared URLs on media platforms often emphasize the connection between economic and environmental advantages. This association tends to be positive, particularly in light of the social perception of this renewable resource. Indeed, solar energy enjoys a high level of public acceptance and is generally preferred over other renewable energy sources (Cranmer et al., 2017). In contrast, research on wind energy indicates that the implementation of renewable energy projects primarily involves landscape issues, including physical siting options and the assessment of landscape values affected by infrastructure (Wolsink, 2018). The results of paper 3 confirm that wind energy is also more frequently linked to emphasizing environmental impacts and negative emotional responses on online pages. This finding underscores the importance of framing wind energy in a more positive light. If the information circulating on social media continues to focus on the negative aspects of wind energy, such as the impact on the landscape and wildlife, etc., negative perceptions may be strengthened. To clarify, it is relevant to be transparent and acknowledge the weaknesses and/or negative aspects of renewable energy technology. However, it is equally important to highlight its positive attributes to provide a clearer and more balanced perspective. This research shows that, in the field of wind energy, there are significant challenges that require further study and support to be effectively addressed.

For biomass, the URLs tend to concentrate on explaining its processes to enhance knowledge and awareness. Studies indicate that the biomass process is complicated and not well understood, which can negatively affect its social perception. Therefore, there is a need to simplify the information, the funding applications, and improve coordination between European, national, and local institutions (Van Dijk et al., 2024). The analysis of the data indicates that the simplification process has already started, and social media mirrors the public's demand for clearer and more accessible information. Future research could investigate whether efforts to provide information about this RET will lead to increased support and acceptance within communities in the coming years.

What are the mental associations (emotional, cognitive, place-level) about RETs on the media platforms?

In literature, most theoretical approaches aimed at understanding energy-related decisions have primarily focused on cognitive processes (Brosch & Steg, 2021). Cognitive processes involve analytical and effortful thinking, including thoughts, beliefs, and perceptions. In contrast, affective processes are based on associative and intuitive thinking, which requires less effort (Weber & Johnson, 2009). More recent research on emotions posits that emotion and cognition are not separate or opposing processes; rather, they are complementary and deeply intertwined (Sander, 2013). Several studies emphasize that affect and emotions should be regarded as essential processes that provide valuable information alongside cognitive processes, rather than as factors that hinder them (Brosch, 2014). Furthermore, in the field of people-place bond research, several studies have shown the relevance of the people-place relationship in the evaluation of local and national projects (Devine-Wright & Batel, 2017). Although these studies provide valuable insights and highlight the importance of affect in decision-making, we still have a limited understanding of how emotions, cognitions, and places about RETs are expressed on social media. This gap in knowledge underscores the need for better understanding in this direction. This understanding could help policymakers and project developers communicate more effectively by considering the emotional dimensions of energy technologies and their connection to place.

Particularly, papers 1 and 2 offer data and analysis to answer this research question. In these studies, all the RETs are linguistically connected, with a stronger linguistic connection between solar and wind energies. Additionally, solar and wind energy sources tend to evoke more positive and emotional responses compared to other RETs and powerlines. Several studies have noted that wind energy projects elicit a diverse range of emotional reactions (e.g., Pasqualetti, 2011). However, our study suggests that while wind energy generates a more emotional than cognitive linguistic association, this association does not correlate with negative emotions.

Geothermal posts tended to include a higher frequency of emotional words compared to cognitive ones. Other researchers, such as Dubois et al. (2019), have shown that people often feel confused about geothermal energy projects. This confusion can lead to resistance, heightened risk perception, and strong emotional reactions. According to appraisal theory, perceived risks can predict a range of negative emotions related to externally controlled energy projects (Vrieling et al., 2023). Given this information, a more targeted approach that focuses on providing knowledge and information could help people better understand geothermal energy and reduce negative emotions associated with it.

The findings regarding biomass are also linked to cognitive processes and causal language. Despite an increase in the share of biomass within the overall energy supply over the past decade, social acceptance remains fragile. This is primarily due to concerns about potential negative sustainability impacts (Reißmann et al., 2020). Future studies in this area are essential to gain a deeper understanding of this renewable energy source and its connections to emotions and cognitive processes.

Powerline posts are associated with concerns related to risk, health, and biological processes, highlighting significant worries about health threats. There is a substantial body of research investigating the link between powerlines and potential health issues (e.g., Rathebe et al., 2019). Thus, it is relevant to communicate the risks and benefits associated with powerline projects, aiming to enhance public confidence and alleviate feelings of powerlessness, as well as foster trust in the responsible parties.

The people-place bond, on the other hand, was further explored in paper 2, focusing on four place categories: city, region, state, and planet. This study originated because researchers have shown that place bond is an important motivator for the development of renewable energy projects, but that different degrees of place attachment also formed a key source of disagreement (Van Veelen & Haggett, 2017). Hence, there is interest in understanding how these dynamics are expressed on social media. To date, only a small number of studies have investigated person-place relationships in the context of energy transition through online content.

The findings indicate that the scales of place mentioned in the Instagram posts are associated with variations in the emotionality of the posts. In detail, places at a small (city or region) or vast scale (planet), are linked to fewer positive words in the captions and hashtags of the Instagram posts. The analysis of renewable energy hashtags revealed notable patterns: mentions of cities were associated with positive emotions. In 2010, Lewicka highlighted that people's attachment to their city can often be stronger than their attachment to their district, neighborhood, region, or even country. This finding suggests that fostering a positive connection between the benefits of renewable energy for the city (on the local level) can enhance public perception of renewable energy technologies. Interestingly, in the field of environmental studies, the emotional bond people have with cities is less frequently explored compared to attachments to other places, such as homes or countries. My research highlights the need for further studies in this area.

2. Discussing the Contributions of the Three Papers

Paper 1 proposes an analytical framework for the relationship between emotions, cognitions, and RETs.

Overall, paper 1 found that all the RETs were linguistically connected on the Instagram sample analyzed. The linguistic interconnection was higher between solar and wind energies. Furthermore, the solar energy keywords were the most interconnected to all the RETs, underlining that solar energy plays a key role in the relationship between people and energy transition. In contrast, powerlines have not been linguistically associated with RETs. It appears as though powerlines are mentally excluded when discussing RETs as if they belong to a separate category of terminology. Furthermore, powerline posts were linked to risk, body, health, and biological processes, showing a significant concern for health and perceived threat. The literature confirms this statement, as a dense corpus of papers studies the association between powerlines, possible health issues, and the negative affective evaluation of the landscapes (Lienert et al., 2017). The data of paper 1 underlines the need to further study how to include power lines and RETs and how they relate to the concerns of local communities, as well as the appropriation and history of these infrastructures at the local level. Therefore, the next step could be to build a stronger mental association between power lines and RETs to increase the general acceptance of power lines.

In this study's sentiment analysis, solar energy is the most emotionally positive and well-received RET. Public opinion polls consistently demonstrate that this energy source enjoys significant socio-political acceptance and is favored over other RETs. However, this favorable outlook often dissipates when examining large-scale deployments or case studies (Wolsink, 2018). More studies in this direction are needed.

Instagram posts frequently feature emotional rather than cognitive language when discussing geothermal energy. Ongoing research is delving into the affective responses triggered by geothermal energy. Gaining a more profound and precise understanding of the technical dimensions of geothermal generation could pave the way for a more nuanced appreciation of this technology. Addressing the confusion often associated with it is crucial, as this can generate resistance, amplify risk perception, and provoke strong emotional reactions (Renoth et al., 2023).

Biomass, conversely, is associated with a higher frequency of cognitive and causal words. While it is recognized as a necessary renewable energy source, its social acceptance is precarious, primarily fueled by concerns regarding its sustainability impacts (Reißmann et al., 2020). Scholars support the idea that to increase social acceptance of new biomass energy plants, it is necessary to emphasize the role of the short wood supply chain in the raw material supply (forest and sawmill woodchips), highlighting the positive impacts in terms of job opportunities and local economy growth (Paletto et al., 2019).

In conclusion, it is pertinent to communicate the risks and benefits linked to RET projects. There is a general need to create confidence, trust, and knowledge among the population. Information should be made available concerning related costs and effects on health and the environment and targeted at specific words and ties between infrastructures. The results reveal that emotions and cognitions are related to specific energy infrastructure and powerlines, and studies in this direction would help provide a better understanding of the public perception of RETs.

Paper 2 proposes an analytical framework of the relationship between place-level and RETs.

Overall, paper 2 found a relationship between emotions and the mentions of cities and regions. There were no effects of the place mentions about using risk-related words for the entire sample. Research on people-place relations has contributed to understanding human responses to RETs. However, there has been little research on how to place attachments at multiple scales, particularly the global (planet) and individual level ideological beliefs, combined to influence renewable energy attitudes and opinions (Devine-Wright & Batel, 2017).

The analysis of renewable energy hashtags revealed notable patterns: mentions of cities were associated with positive emotions, while mentions of regions and the planet showed different associations. These findings indicate that the scales of place mentioned in the Instagram posts are associated with variations in the emotionality of the posts. Moreover, exploratory analyses indicate that these effects may differ across hashtags related to RETs. In summary, multiple studies have highlighted the importance of people-place bonds in understanding the acceptance of RET projects. However, the contribution of this study is to provide an overview of the description of different energy technologies linked to emotions, cognitions, and levels of place. The results reveal that posting about RETs on media platforms should consider the levels of place of specific projects shared in the media. In this way, communication can be more effective, considering the effect it can have on the audience by considering the characteristics of the various target groups.

Paper 3 proposes an analytical framework of the relationship between the cumulative human-centred and environmental impacts and RETs.

Overall, paper 3 found significant differences among the topics used to describe RETs in social media platforms. In detail, the URLs of solar and geothermal energies were more linked to the economy and benefits topics; the biomass URLs were more focused on the explanation of its process to provide knowledge and awareness; wind energy was more related to arguments connected to the environmental impact and emotional words. Furthermore, the URLs about wind energy were more focused on the environmental impacts of the infrastructures, even with words that appealed to the emotional sphere. Wind energy is controversial because of its impact on living space, biological systems, and regional earth surface systems, including noise pollution, birds, etc. These topics are stressed and highlighted on the web, which could increase some resistance from the public. Therefore, the information on the web should leverage how to mitigate this environmental impact and how to solve related problems. An unexpected result of the study was that biomass, rather than being related to environmental impact topics, presented more articles to explain its process and use. Thus, articles focused on information and awareness-raising. In literature, several studies have explored the links between social media and public awareness of the RETs and other environmental issues (e.g., climate change). For example, Anderson (2017) analyzed the effects of social media on opinion, knowledge, and behavior, showing there is some evidence that information sharing through social media can raise awareness and encourage more environmentally friendly behavior in people. On the other hand, little research has been done on the role of social media as a trigger or a support tool for bottom-up initiatives and the extent to which those effectively lead to practical change in policy development and implementation. Other scholars, however, emphasize that the public's knowledge of energy technologies is not very thorough, and this is especially applicable to biomass (e.g., Boudet, 2019).

Geothermal and solar were strongly linked to words related to human-centred impacts, with articles emphasizing economic feedback and business. For these energies, the economic aspect emerges as a powerful and convincing theme. In line with the literature, some studies showed that, in the case of geothermal and solar energies, social acceptance is affected by prevailing economic, political, and social conditions (Hanbury & Vasquez, 2018). In detail, the techno-economic analysis of geothermal and solar projects gives developers, investors, and policymakers a complete view of the financial pre-feasibility of these investment decisions. This knowledge would also help citizens understand these technologies' pros and cons, including economic terms (Moya et al., 2018).

In conclusion, these three papers from this study make an important contribution to the field of energy social science by creating a framework to understand the impact of emotions, cognitions, place-level, and cumulative impact of RETs on the web. Furthermore, these papers indicate valuable reflections and avenues for practitioners to develop better approaches to local communities through communication strategies. Thus, the results emphasize the significance of employing social network methods to facilitate the widespread acceptance and utilization of renewable energy sources. For example, communication strategies could provide valuable guidance to the energy industry in designing a successful social marketing campaign. Indeed, these articles contribute to understanding how to raise awareness of the benefits of renewable energy, prevent the spread of misinformation, and overcome potential barriers. In the end, using the right communication strategies in different channels suitable for the target audience can cost-effectively promote behavioral change for the benefit of society.

3. Limitations and Future Research Trajectories

Although this study has its merits, some limitations that can be the starting point for further research have been identified.

First, the results must consider social media users and their variables (e.g., age, usability, needs, etc.).

Second, demographic factors, users' personalities, and cultural differences are some information not commanded by the collected data. Further research could investigate how the data scraping date is controlled, and a replication study would be appropriate. Since this study focused on the text analytic procedure, future work could consider adding images and videos to the analyses. Social media analytics, like any other data source, offers both opportunities and challenges. It is a complex process that involves various aspects depending on the specific application domain and the methods used. It is, therefore, valuable and necessary to standardize this phenomenon to a process model, considering each step: discovery, collection, preparation, and analysis (Stieglitz et al., 2014). For example, some criticism of the "big" data, which show the key factors by which this new phenomenon differs from traditional analytics are: a) volume, the storage space required; b) velocity, the speed of data creation coupled with the advantage gained from analyzing the data in real-time; c) variety, the fact that data takes many different forms and d) veracity, uncertainty, especially concerning data quality. Social sciences that use social media as research methods and tools promise a complete and real-time record of "natural" user activities. On the other hand, issues relating to validity and representativeness have often been discussed and explored (Diaz et al., 2016). It has even been debated and explored whether social media analysis can replace traditional and more expensive ways of data collection, such as population surveys (Schober et al., 2016). However, it was also criticized that there is a lack of tested standard procedures for data collection (Jungherr, 2016) and a danger of data-driven, non-theoretical approaches (Kitchin, 2014). Furthermore, a significant criticism of social media data is that they are not generalizable outside the platforms from which they originate (Halford & Savage, 2017). However, some scholars (Page, 2018; Davis & Love, 2019) argue that although social media data have empirical limitations, they retain their integrity if they are strongly linked to theoretical concepts and assumptions.

Third, the software used for sentiment analysis, LIWC2015, has some limitations. For example, the word count techniques are coarse measures of language, devoid of context, and unable to interpret subtleties such as irony and sarcasm.

Conclusion: Ideally, this research is a first step towards a more intense study that will include social media and other research sources. Because of the early stage of this form of analysis, I refrained from a more conservative approach to testing the patterns.

4. Overall Conclusions

The findings presented in this study, along with related research, indicate that as the deployment of renewable energy increases to combat climate change, policymakers and project developers should pay close attention to the feelings and emotions that energy infrastructure generates within the community during various stages of project development. Improving communication efforts based on a deeper understanding of these emotions and thoughts is essential.

If policymakers or project developers attempt to share rational information about the benefits of renewable energy projects without considering the emotional aspects, they may not achieve the desired behavioral changes. This work demonstrates that each type of RET evokes specific emotions and cognitions, as well as being linked to specific topics. Furthermore, analyzing social media can provide valuable insights into public perceptions.

Measuring emotions, cognitions, and the connection between people and places concerning energy technologies can provide important information about how the community views these technologies. This understanding offers project developers, policymakers, and researchers a foundation for tailoring communications about each RET, ultimately helping to manage public perceptions more effectively.

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