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Energy Transition and its Societal Challenges. Themes, Gaps and Possible Developments in Sociology

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ABSTRACT

The issue of the energy transition, that can be defined as the transition from the use of fossil fuels (in particular coal) to low-carbon energy resources (such as wind, solar and natural gas), is assuming an increasingly central importance in the public debate and has increasingly become the focus of public concern. Scientifically speaking, the challenge and goal of achieving pursuing a more sustainable and fairer low-carbon energy sector globally has encouraged the proliferation of a series of scientific contributions, in various fields of knowledge.

The paper shows the results of a literature review on the topic of energy transition. The review takes into consideration a selection of papers taken from international scientific journals with the aim of mapping at a broader level the research on the topic and the issues that were mainly addressed in the years between 2015 and 2020. With the more specific aim of understanding the role of sociology in the international scientific debate on the energy transition, the paper aims to provide an overview of 1) research fields and disciplines; 2) places of publication; 3) research topics and questions.

KEYWORDS

Energy Transition; Literature Review; Sociology; Data Mining Analysis; Societal Challenges

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Energy Transition and its Societal Challenges. Themes, Gaps and Possible Developments in Sociology[2]

Introduction

The issue of the energy transition, that can be defined as the transition from the use of fossil fuels (in particular coal) to low-carbon energy resources (such as wind, solar and natural gas), is becoming increasingly important in the public debate (e.g., Leach, 1992).
In particular, the awareness that the growing increase in emissions of CO_2 and other polluting gases and their impact on the environment is exposing the planet to a systemic risk of catastrophic climatic events, exerting disruptive effects on economic growth, social stability and geopolitical equilibrium, and arousing the global need to define policies aimed at containing emissions (e.g., Kern and Smith, 2008; van den Bergh, 2013; Corbisiero and Minervini, 2016; Chapman and Itaoka, 2018).
Thus, this issue certainly concerns technological equipment, but also environmental, social, and territorial policies, as well as the challenges that companies must face in the context of defining a new model of social organization (e.g., Loorbach, Van Der Brugge, Taanman, 2008; Carrosio, 2014; Andrews-Speed, 2016; Magnani and Osti, 2016; Davidson, 2019; Magnani, Carrosio and Osti, 2020; Määttä, 2021). Consequently, the study of the societal challenges related to the energy transition bring together resources and knowledge across different fields, technologies and disciplines, including social sciences and the humanities.
The need to imagine a more sustainable future is the result of a long process. It began with the adoption of the United Nations Framework Convention on Climate Change in 1992 and culminated in 2015 with the signing of the Paris Climate Agreement which is now ratified by 185 countries (e.g., Duyck, 2015; Glanemann, Willner and Levermann, 2020).
More recently, various strategies have been defined from the East to the West of the world.
China, for example, is one of the biggest greenhouse gas emitters among the main developing countries (e.g., Feng et al., 2017; Cail and Criqui, 2021; Si, Aziz and Raza, 2021), and the current President Xi Jinping has paid great attention to the environmental issue since his inauguration. Considering the dangerous levels of pollution recorded in the country, the Chinese government has invested substantial capital in the research and development of renewable energy for creating a healthier environment. To reduce dependence on supplies imported from abroad, China has been devoting over the years to increase domestic production of gas and oil and at the same time achieving an energy mix in which renewable sources play a predominant role (e.g., Li, 2020; Mi and Sun, 2021; Yang et al., 2021).
Regarding decarbonification and the fight against climate change, although the disagreements remain on some issues (such as subsidies and access to the European market...), China is aligned with the European Union, which in 2019 approved the legislative "Clean Energy Package", a new set of rules renewing the European energy policy framework to facilitate the energy transition (e.g., Hewitt et al., 2021). The package is made up of 8 directives that regulate energy issues (including energy performance in buildings, energy efficiency, renewable energy, electricity market).
Europe's goal is to reduce carbon emissions in the electricity sector by 55% by 2030 and to achieve climate neutrality in 2050.
Finally, as far as the United States is concerned, the American administration led by the newly inaugurated Biden immediately worked to implement the "Clean Energy Plan". It is a document that contains a series of measures and incentives to lead America to the goal of possessing 80% clean energy by 2030.

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Scientifically speaking, the challenge and goal of achieving a more sustainable and fairer low-carbon energy sector globally has encouraged the proliferation of a series of scientific contributions. The paper shows the results of a literature review on the topic of energy transition. The review takes into consideration a selection of articles taken from international scientific journals with the aim of mapping at a broader level the research on the topic and the issues that were mainly addressed during the years between 2015 and 2020. With the more specific aim of understanding the role of sociology in the international scientific debate on the energy transition, the document aims to provide an overview of: 1) research fields and disciplines; 2) places of publication; 3) research topics and questions.
It should be specified that the proposed analysis is limited to studies published in English in peer reviewed academic journals present on the main databases that host scientific contributions. Therefore, it cannot be considered a complete representation of the whole field of study on energy transition. However, this exploratory research still provides useful information on the main research trends and questions in general and critically addresses the question: how sociology research on energy transition can contribute to innovation in practice, policy and understanding of the new social scenario.

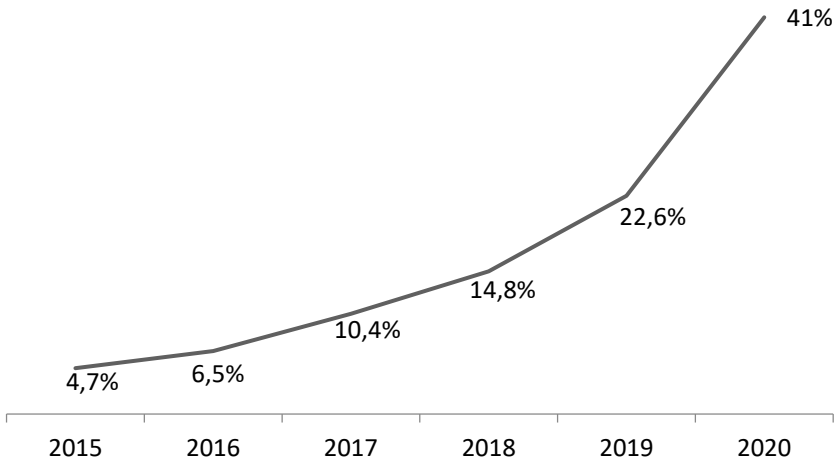
1. Methodology

In order to investigate how much the international scientific community has shown interest in the topic of energy transition, which disciplines in particular have directed the focus of scholars to the issues related to the phenomenon and whether and to what extent sociology contributes to increasing knowledge on this topic, a textual analysis on international scientific production published in the years between 2015 and 2020 has been completed.
The articles involved in this research were identified through the PROQUEST and Web of Science platforms.
In particular, in scientific journals all the articles written in English that contained the expression “energy transition” which appeared at least once in the abstracts were downloaded. In total, 4,143 articles published in 153 peer-reviewed academic journals were selected for the analysis.
A content analysis was carried out on the selected articles using the T-Lab data-mining software. This methodology allows to analyze, through a series of standardized procedures, the qualitative information contained in the textual material (Krippendorff, 2004), offering a synthesis between statistical analysis and hermeneutic analysis of the texts, capable of highlighting the main recurring themes, the connections between them and the vocabulary used.
It is a solution that has already been successfully tested to conduct data mining analysis on literature in various fields (e.g., Waltman, van Eck and Noyons, 2010; Assefa and Rorissa, 2013; Pattaro and Setiffi, 2014; Monaco and Nothdurfter, 2021).
In a following phase, to better understand how and with respect to which themes sociology is interested in the energy transition, 229 sociological articles were analyzed using the Thematic Analysis. It is a bottom-up grouping tool, which highlights the emerging themes present in the textual corpus. More specifically, the T-Lab software allows to proceed in an automated manner with a data mining operation, offering a Cartesian representation of the most recurring topics proposed in the form of a cluster. Thus, this type of operation therefore makes it possible to immediately identify the main themes under study, which are further explored at a later stage with a hermeneutic analysis of the texts.

2. Dating literature on the energy transition

The first objective of the proposed analysis was to temporally place the analyzed papers. As the *Graph 1*shows, the papers’ publication has not been constant over time, but it has undergone an interesting annual increase.

Graph 1 - Temporal distribution of the papers

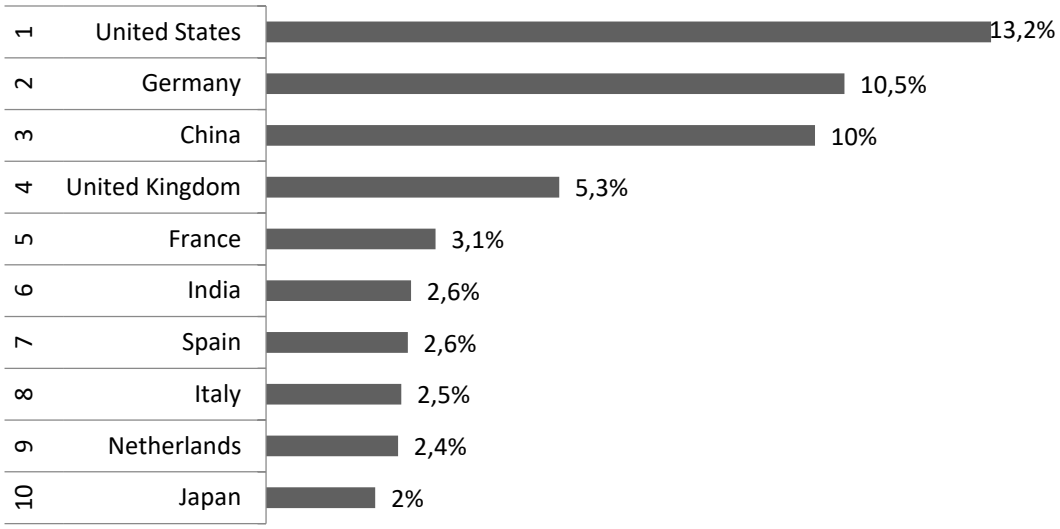


In particular, the greatest growth occurred between the years of 2019 and 2020, when the number of papers published on the energy transition almost doubled. Indeed, the growing interest of the scientific community can be considered as the result of a series of closely interrelated factors. In the first place, in the world since the first half of the 2010s, various movements to fight for climate change have emerged. On November 29th, 2015, in 150 countries, over 600,000 demonstrators took to the streets on the eve of the Paris COP21 summit to ask world governments for the adoption of renewable sources for energy production (e.g., Shannon, 2016; Kinley, 2017). The concern for the protection of the planet has involved a growing number of people and has found the main spokespersons for change especially among the younger generations (e.g., Cancel, 2014; Bardazzi and Pazienza, 2018). Millennials and Generation Z, along with new technologies, had the opportunity to discuss and learn about the topic, imagining a greener future (e.g., Farrell and Hurt, 2014; Burgess et al., 2018; Honeybun-Arnolda and Obermeister, 2019; Luqman, 2021; Corbisiero, Monaco and Ruspini, 2022). This ferment culminated in the so-called #FridaysForFuture movement, in which the young Greta Thunberg has become the symbol. On September 20th, 2019, the largest climate strike of all time brought hundreds of thousands of demonstrators to the streets around the world (e.g., Fisher, 2019; Schinko, 2020).
The ferment and the social attention paid to climatic and environmental issues have ensured that the theme of ecological and energy transition also acquired an unprecedented resonance. The directives promoted by the United Nations and by various local governments have encouraged the adoption of new greener and more sustainable policies ranging from the abolition of single-use plastics, the increase of hybrid buses that travels across many cities, up to the latest funding for the use of renewable energy sources.

3. Placing the energy transition literature

The second objective of the analysis was to territorially and scientifically place the papers that were published in the years between 2015 and 2020.
As can be seen from the graphical representation (*Graph 2*), 10 countries have published about half of the papers on energy transition (54%). These are mainly countries where the debate on the protection and safeguarding of the environment is particularly intense.

Graph 2 - Territorial distribution of the papers



In particular, the first position occupied by the United States (13.2% of total publications) can have different interpretations. The first explanation is related to the methodological choices of this study. In fact, this study considers only the articles in English, excluding by default the papers published in other languages, probably in journals of other countries. Likewise, most of the most prestigious scientific journals are American; consequently, it is very likely that authors from all over the world have preferred to send their contributions to American journals, giving more visibility to their papers.

Finally, a more socio-cultural consideration is needed. Politically speaking the fight against climate change has been a highly debated issue in recent years. More specifically, one of ex-U.S. President Trump's most controversial actions was to unilaterally pull the United States out of the Paris climate accords. The Trump administration defined a series of revisions to existing regulations, removing some obstacles that American companies had to face in the endeavor of protecting the environment. It is no coincidence that during the years between 2015 and 2019, the United States has recorded over $ 500 billion in costs for weather and climate disasters.

In this scenario, Columbia University had developed the Climate Deregulation Tracker, a scientific observatory monitoring the efforts undertaken by the Trump administration to downsize or eliminate federal climate mitigation and adaptation measures altogether.

On the contrary, Biden's political line (already presented in his electoral program) was also partly oriented to the great fears of the American electorate on the environmental future, focusing on the clean energy revolution and environmental justice.

After having placed the question of the energy transition territorially, the analysis also focused on the editorial position of the papers, in order to detect how much the topic is dealt with in sociological journals.

From *Table 1* it is clear that the issue of the energy transition in the period between 2015 and 2020 was mainly addressed in the context of the so-called STEM disciplines (science, technology, engineering, and mathematics). More specifically, the editorial position of the selected papers highlights that the energy transition has so far been studied and deepened mainly with reference to the management managerial and engineering aspects. The scientific journal that collected most of the published articles (almost 700 in number) is in fact "Energies", an international and multi-disciplinary journal devoted to energy engineering and applied research.

The analysis revealed that the second block of scientific disciplines that have focused on the theme of the energy transition are the natural sciences (such as biology, physics, and chemistry).

Tab. 1 - List of journals

Journal	*Papers*
Energies	680
Sustainability	533
Energy Policy	143
IOP Conference Series. Earth and Environmental Science	100
Scientific Reports (Nature Publisher Group)	88
Journal of Physics: Conference Series	84
Energy, Sustainability and Society	65
Nature Communications	62
Applied Sciences	59
IOP Conference Series. Materials Science and Engineering	58

The papers written at least by one sociologist (also in multidisciplinary research groups) that have been published in these journals are in total 229. They constitute just over 5,5% of the published articles.
In the list of journals that have dealt with the energy transition there are only 5 concerning the specific field of social sciences (*Tab. 2*).

Tab. 2 - List of top five social sciences journals

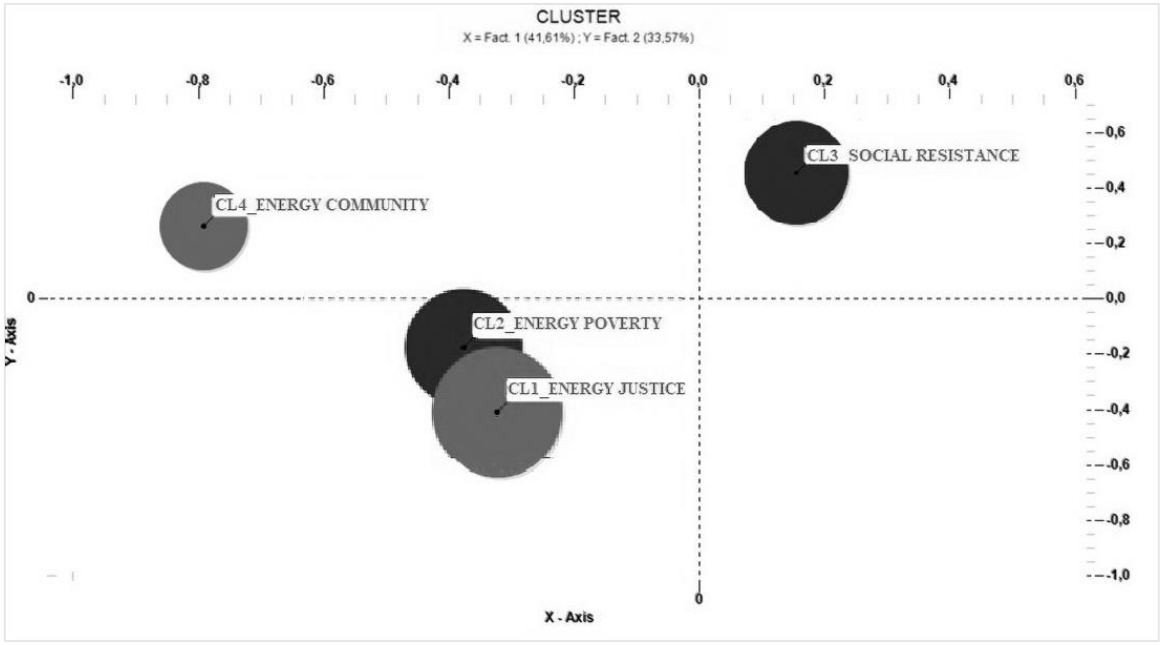
Journal	*Papers*
Energy, Sustainability and Society	65
Socialism and Democracy	26
Technological Forecasting and Social Change	16
GAIA - Ecological Perspectives for Science and Society	13
Social Sciences	9

Obviously, some sociological contributions are present in other journals not specifically devoted to the social sciences. The theme of the energy transition lies on the border among different disciplines. For this reason, some sociologists have decided to send their contribution to interdisciplinary or more general journals.
The analysis carried out on the distribution of the papers among the various scientific journals allows to argue that until now sociology has shown a still too limited interest in the energy transition.
Summarizing, despite the societal challenges that every transition inevitably brings with it, the study of the energy transition still appears almost exclusive in the domain of other areas of knowledge.

4. Mapping the sociological literature on the energy transition

In the subsequent phase of the study the 229 sociological articles that have been identified were analyzed using the Thematic Analysis. From the analysis based on the first two main factors (that explain 75,18% of the overall variability), 4 main clusters emerged (*Fig. 1*).

Fig. 1 - Thematic analysis



On the basis of the relationship between elementary contexts contained in the cluster and the total set of elementary contexts present in the textual corpus, each cluster has a different weight in percentage terms (*Tab. 3*).

Tab. 3 - Elementary context in each cluster

Cluster 1	Energy Justice	31.83%
Cluster 2	Energy Poverty	25.56%
Cluster 3	Social Resistance	24.81%
Cluster 4	Energy Community	17.80%

The first and deepest cluster (CL1) is related with “Energy Justice”. Papers on this subject have underlined that the energy transition can be considered ambivalent in some respects. Indeed, while it can bring a number of social benefits such as better health, new consumer choice, social bonds creation and innovation, at the same time, it could increase social inequalities since not all citizens will be given new opportunities or they will likewise bear the burdens of change. Starting from these concerns, some of the indications present in the Green New Deal and in the United Nations 2030 Agenda identify inequity and social justice as two of the main objectives to support individuals and communities that could be negatively affected by the transition to new energy sources (e.g., Healy and Barry, 2017; Carley and Konisky, 2020).
Energy justice is based on the idea that all citizens should be given access to affordable, safe, sustainable energy and should be able to lead a decent and health life. In order to pursue a smooth transition, some of the sociological studies on this topic argue that the government and others involved in the energy transition (such as non-profit organizations and private industry) must work to redistribute well-being to avoid excessive burdens on a specific population and provide sufficient energy services for all (e.g., Osti, 2018). Furthermore, they should also provide an adequate safety network for all populations, especially the most marginalized or oppressed (e.g., Owen-Smith and Powell, 2008).
The second most discussed cluster (CL2), which partly overlaps with the first both conceptually and lexically, is labeled “Energy Poverty”. Several publications stress the need to monitor the energy

transition so that it does not increase the already existing energy poverty. This expression refers to the social condition that concerns people who live in a state of discomfort since they use most of their income to pay their energy bills or because they do not have the opportunity to purchase essential energy services (e.g., Guruswamy, 2011; González-Eguino, 2015). In less developed countries this phenomenon involves as many as around 800 million people who lack electricity. Also in Europe the dimension of energy poverty is very remarkable. According to data published by the European Commission (2019), in 2018 around 80 million European citizens were unable to purchase minimum energy goods. For this reason, National Observatories have been set up in many European countries to monitor the phenomenon of energy poverty and plan intervention policies both socially and environmentally (e.g., Galvin, 2020; Bouzarovski, Harriet and Marine, 2021).
Some forward-looking studies point out that the energy transition will possibly result in higher energy costs at least in the short and medium term, due to the need to cover the costs of new infrastructures and technologies. If energy costs were to increase, not only would this cause damage to people living in a condition of energy poverty, but it would also risk expanding the size of this social group, incorporating people who do not have sufficient income to pay higher bills.
The third cluster by weight in percentage terms has the label "Social Resistance" (CL3) and includes studies and research that focus in particular on the sometimes-hostile attitude of citizens towards systems such as wind turbines or photovoltaic panels. Generally, the places where renewable energy technologies are to be used are chosen on the basis of their geo-physical characteristics (e.g. average wind speed, soil characteristics, proximity to the electricity grid, accessibility). Sociology has highlighted that forms of resistance and public opposition take place in social contexts in which technological alteration is not experienced as a possibility for improvement, but seen as the risk of undermining the identity of the place (e.g., Magnani, 2018). The studies that are part of this cluster insist on the need to activate participatory territorial governance, in which decision-making processes are negotiated with the local communities. Moreover, many national and European sustainability policies call for the activation of governance processes and for citizens to assume the role of prosumer (e.g., Pellizzoni, 2011; Lowitzsch, 2019).
The last cluster (CL4) concerns the so-called "Energy Communities". They can be defined as group of people who, in a voluntary and coordinated manner, actively participate in the process of production, distribution and consumption of energy using systems powered by renewable sources (e.g., Walker, and Devine-Wright, 2008; Bruchell, Rettie and Roberts, 2014). In fact, the new technologies for distributed energy production are reaching such a level of maturity to form and develop some bottom-up initiatives in the constitution of local energy systems. To share the energy produced, users of energy communities can use existing distribution networks and use forms of virtual self-consumption. The recent sociological literature on the subject has focused its attention on various aspects of this new model of social organization, concentrating on economic, environmental and social benefits, but also on the specific regulatory framework and on possible risks. Depending on the energy policies in force, production systems and consumption patterns, energy communities can determine different models of territorial development.

5. Discussion

The analysis proposed in the previous pages highlights that the theme of the energy transition has acquired an important centrality in the scientific debate, welcoming the interest of various disciplines around it. However, on the one hand, it can be argued that it is extensively covered from the technological and engineering point of view, on the other hand, it is safe to argue that the sociological debate has just begun.
This can be considered as a paradox, especially because the energy question can be defined as a total social fact since it involves multiple aspects of society.
In addition, the reading of the papers and the consequent hermeneutic analysis that followed the data mining operations made it possible to identify other critical issues.

The first and most obvious one is that even if a young generation of sociologists has begun to take an interest in the theme of the energy transition, especially in Europe, scholars have focused only on some aspects. This does not mean that the topics that have been covered in the published papers are not of great importance. On the contrary, they have the merit of enriching knowledge on this subject, but there are also many other aspects that should be deepened.
More specifically, most of the analyzed literature on socio-technical transitions proposes a de-politicized view of innovation, assuming a managerial and collaborative perspective. Thus, sociological analyzes published in recent years paid little attention to the conflicting aspects and to the possible challenges that the energy transition can bring to the current socio-economic system.
For example, as the energy transition facilitates the shift to more efficient and low-carbon energy resources, some of the literature on the subject agrees that new job opportunities in related sectors will rise (e.g., Wei, Patadia and Kammen, 2010; Lehr, Lutz and Edler, 2012; Carley et al., 2018; Ram, Aghahosseini and Breyer, 2020). Sociology should verify which subjects are to be incorporated into the new green economy and which ones are more vulnerable and at risk of exclusion, to plan targeted interventions capable of favoring their full inclusion in the future social configurations.
In order to do this, they could rely on several approaches (e.g., using the gender lens, conducting generational analyzes or positioning within the paradigm of intersectionality theory), useful to provide new insights for example on technological illiterates, people with a low level of education or women's role in renewable energy employment and decision-making globally. Except for very few contributions, similar studies approaches are currently almost entirely absent in the sociological scientific panorama.
Other reflections concern the lack of robust comparative investigations. This depends by the fact that most of the case studies are based on qualitative methodologies, which partially allow that the obtained results could be compared with other territorial contexts.
For this purpose, whenever possible, sociologists should use both a qualitative and quantitative methodology, with particular attention to environmental accountability methods. This strategy would allow for the development of broader perspectives than case studies, generating research on global phenomena, albeit declined in their territorial specificities.

Conclusion

Even if the shift to another paradigm is already underway, the current analysis has highlighted that sociology on the theme of energy transition is only partially using its tools to fully grasp the new social demands, potential conflicts, possible governance systems, and, above all, the challenges that society must face up to ensure that the new models do not reproduce social inequalities.
In this sense, the effort that sociology is called upon to make is to increase its attention to issues related to energy transition. The current analysis on scientific debate on this theme highlights not only the need to deepen in a more critical manner some of the issues that have currently caught the attention of sociologists, but also the need to look at other social phenomena.
In light of the above, it is safe to argue that possible (but not exhaustive) analytical tracks to follow could be: the consequences of the consumption of land, raw materials, energy and water; the impact of technologies and plants on bio-diversity and on local communities identities; the cultural consequences of environmental changes on the life of societies; the global and local transfer of goods that feeds the inequalities among different socio-economic systems, territories, countries, continents; the environmental and social effectiveness of the policies implemented in the context of the ecological transition; the connections between ecological crisis and naturalization of differences at the global and local level; the relationships among consumption, ways of life and transformation of territories; old and new form of mobility and tourism.
Furthermore, in terms of empirical research, sociology must identify other methodologies and approaches capable of grasping and analyzing the complexity of the phenomenon, if necessary also

in collaboration with researchers from other disciplines, in order to contribute profitably to the growth of scientific knowledge on energy transition. In this regard, the contribution of sociology that deals with territories and the environment must enrich the vision and the perception of reality, distinguishing itself from other disciplines above all for its ability to predict future scenarios.
The progress and the contributions of sociology in the field of energy transition could be monitored by periodically replicating the analysis proposed here over time, in order to verify from a quantitative point of view if the sociological debate is growing, and from the content point of view which other issues and research methodologies begin to be taken into consideration in the scientific production.
Furthermore, in order to be able to evaluate the contribution of each country within the sociological debate on this topic, a further possibility could be to conduct territorially circumscribed literature analyzes, even considering local languages and other scientific libraries.

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