ISSN 2385-2755
DiSSE Working papers
[online]

SAPIENZA
UNIVERSITÀ DI ROMA

WORKING PAPERS SERIES
DIPARTIMENTO DI SCIENZE SOCIALI ED ECONOMICHE

Public Acceptance of Energy Transition Technologies: Theoretical Perspectives

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N. 13/2023

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CF80209930587 – P.IVA 02133771002

Public Acceptance of Energy Transition Technologies: Theoretical Perspectives

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May 14, 2023
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Abstract

The public acceptance of technologies for the energy transition is a topic that has been debated, especially in recent years, from the second decade of the 2000s until today. The reasons for this interest lie in the need for innovation in the energy supply sector due to the climate and environmental crisis that has become increasingly serious and bursting in the public and political debate. The literature explored relates to social studies, which first deal with the macro-theme of the energy and ecological transitions and then move on to the exploration in the literature of the meaning of the concept of public acceptance, which has been much debated and at the same time little clarified. Also of interest is the association between technological acceptance and risk acceptance, an aspect on which sociology has been questioning itself for a long time: we refer to Beck, Giddens and Luhmann's studies on risk, which are decidedly central to the discipline, but also to the STS strand that has focused heavily on energy technologies. Most of the proposed literature questions the usefulness of public participation processes as a tool for a more transparent acceptance by civil society and as a co-adjuvant instrument of social justice. In conclusion, implementing these practices could be an alternative regarding awareness, collaboration, information, democratisation, and empowerment. However, there needs to be a more precise reference to models that can be used on a large scale in different contexts.

JEL codes: Q55; Q56; Q4; O33
Keywords: energy transition, public acceptance, technologies, public participation

Introduction

The proposed paper is the first part of a research that intends to focus on public acceptance of new technologies for the energy transition. In order to carry out the research, it was necessary to review the literature on "public acceptance" and how it could be made more easily realisable. Public participation is an excellent tool for conveying these changes, informing, and

consulting the public, especially those most interested in values and geographical context. The public acceptance of energy technologies has been debated in the literature for quite some time. However, most of the articles and studies on the subject are relatively recent, and this is because it is in recent years that there has been a change in political orientation concerning environmental issues and, consequently, energy supply.
The 2015 Paris Agreement and the UN 2030 Agenda for Sustainable Development, followed by the Next Generation EU financial plan and all respective national programs, and the 2021 Climate Change Conference are among the main drivers of change at the political level.
A transition, which by its nature is a long and complex process, in energy terms must, however, be shared with the public, which has the important task in the future of adapting to these changes in the least traumatic way possible. The emergence of new technological infrastructures in one's territory can cause confrontation and discontent, especially if the resident population does not know the new installations' fundamental objectives and possible benefits.
Therefore, public acceptance should not only be seen as an institutional solution to avoid conflict but is also a process of knowledge, empowerment, democratisation and sharing of possible costs and benefits of change. Information campaigns are useful for this purpose, but more is needed to achieve all these goals.
The literature considered analyses in different ways and fields of the usefulness of practices that put the citizen himself at the centre of the acceptance process. An initial overview of the ecological and energy transition was necessary to reconstruct the theoretical framework best, then the scientific definition of public acceptance. This concept is only sometimes clear. Finally, those studies that combine the elements of energy technologies with those of participation were taken into consideration, highlighting how good practices such as energy democracy, energy communities and citizen science are quite valuable for achieving active and conscious acceptance but how at the same time the inherent criticalities of participatory models remain.

1. Methodology

This article proposes a semi-structured literature review of the concepts of public acceptance and public participation in the energy field.
The aim is to propose an overview in which it is, or is not, shown how much and how these two critical concepts in the energy transition process are related not only in research but also in practice and whether, as hypothesised, it emerges that the involvement of citizenship is virtuous for the public acceptance of particular technological apparatuses.
The search for academic articles was carried out using the search engines "Scopus", "Google Scholar", and "Web of Science", searching for keywords: "public acceptance", "social acceptance", and "energy transition" and then adding "public participation". The initial review of this literature then led to widening the field of investigation to other concepts referred to in many of the first texts consulted: "energy democracy", "citizen science", and "energy

citizenship", but it was also useful to go and see which strands of the social sciences refer to these themes, so there was a search on the terms "STS", "risk society", "diffusion of innovation". Searches were conducted in English and Italian, excluding results in other languages. The results were filtered based on the field of research, limiting them to the categories of "sociology", "social sciences", and "social policy". Finally, previously known texts were also included in the literature.

2. The Context: Energy Transition and Energy Justice

2.1. Plural Transition

Before asking what public acceptance means, it is necessary to delimit the space in which we are moving.

What the political lines of action are pushing towards is referred to as 'energy transition', but this mutation, in turn, must be placed within the framework of ecological and sustainable transition. The latter takes on a multitude of nuances and calls for objectives that are also very different from each other, including aspects of climate neutrality and environmental protection and objectives of social sustainability.

The energy transition, therefore, encompasses several lines of transformation that accompany the multiple areas of energy production and consumption, leading first to change in individual compartments and then to transition in the overall system.

Elzen, Geels and Green (2004) illustrate how we speak of 'system innovations' in the energy field, not 'mere' technological revolutions. This means that it is the entire socio-technical system that supports and encompasses a given type of energy infrastructure and technology that is changing and must change as a whole: the authors emphasise the importance of changing markets and the formation of new, new usage practices, regulations, and cultural meanings. These aspects accompany the technological revolution, making it a transition and allowing a structural shift from one previous condition to another, drawing attention to how the systems and actors involved in the transition are multiple and that it is precisely this multiplicity that co-constructs a complex new scenario.

It is important to remember that the energy transition towards a sustainable zero-emission approach is a constantly moving process; thus, we speak of a continuous transition aiming at a future stage of stability in the new socio-technical framework. The '*transition pathway' is,* in fact, one of the essential aspects of the multilevel perspective (Sovacool & Hess, 2017) and describes the levels of interaction from the micro to the macro and how this takes place in ways that are not necessarily linear, but often simultaneous and overlapping. Pathways and interactions are also key points in Latour's Actor-Network theory. Technology and its changes occur through a complex network of human and non-human actors interconnected by relationships of agreement or conflict. According to Latour's approach, the translation of needs and the problematisation of these is the key to triggering a change process and, thus, transition.

This brief theoretical framework is useful to delineate and highlight the arena in which these new energy technologies must be accepted: a field of constant innovation that must aim for a change in the production of almost total energy consumption by 2050.

2.2. A Declination of Social Justice: Energy Justice

Within the framework of ecological and energy transitions is the concept of justice. Social, ecological, and environmental justice are all aspects that outline and strengthen the conceptual tool of energy justice, to which the UN 2030 Agenda for Sustainable Development also refers.

Energy is also now a primary commodity, and therefore the social and environmental costs and benefits of this should be distributed fairly, as should the costs of the transition.

Sovacool and Dworkin (2015) emphasise that all aspects that constitute social justice, from energy efficiency and externalities to the distribution of resources, are not only technological and economic issues but, above all, social and political ones and, as such, must be governed.

"Justice represents not only a moral obligation but can enhance the legitimacy and acceptance of a rapid push towards global decarbonisation" (Sovacool et al., 2023, p. 1), and precisely for this reason, this conceptual and analytical aspect must be taken into account when reconstructing the concept of public acceptance of technologies for the energy transition: the latter should be able to compensate for the intersectional inequities that consumption, energy exploitation and climate change have reiterated as a structurally systemic element of our societies (Dwarkasing, 2023).

3. The Fuzzy Concept of "Public Acceptance"

In the literature, it takes work to identify a precise definition of public acceptance. In the majority of cases, this is described as a preference for a new technological condition over the initial one (Van Rijnsoever et al., 2015), but also as an additional process between the speed at which technologies are updated, the desirability of the technological/scientific novelty, the consumer's desire to purchase, the perception of risk linked to the lack of knowledge of the subject and the trust felt in experts and, finally, the involvement of the citizens themselves. Indeed, public acceptance is framed as a phenomenon that moves on multiple dimensions, such as the individual, the collective, and a combination of the first two (Corrias & Felici, 2019). The dimension of the individual (i.e., the micro-level) concerns the individual's attitudes, values, and daily life; the dimension of the collective (the macro-level) reflects the outcomes of policies and the conditions of the context to which individuals relate; the third dimension, on the other hand, is the meso-level in which these factors are brought together.

For Grade and Rowlands (2018), acceptance is a favourable response by social community members to implementing a new technology or socio-technical system.

Wolsink (2018 and 2019) points out that the definition is full of confusing concepts, first and foremost the distinction, almost never emphasised in the studies on the subject, between 'public acceptance' and 'social acceptance': the former represents the aggregate acceptance of individual citizens (based on cultural, value-based, local processes), while the latter is directly related to the usefulness and social implications of the technology.
Rijinsoever and colleagues (2015), however, prefer to identify three dimensions of public acceptance:

1. Socio-political acceptance: It encompasses the role of citizens and the aggregate attitudes of citizens and is manifested by support for new technology and innovative policies. Not only citizens are involved, but also the stakeholders are equally involved in the acceptance process.
2. Market acceptance: Scholars distinguish between adopting consumers (those involved in the technological application even at a preliminary stage) and user consumers (those who use the end product and touch upon its future consequences). When speaking of market acceptance, we refer to the role of adopting consumers and adopting companies, who are the first to engage in (even 'experimental') support of the new technology.
3. Community acceptance refers to the final consumers (the users) of a technology who may be aware of it. We speak of community acceptance when many actors are involved (at the level of citizenship, companies, and public institutions).

Scholars argue the importance of these community processes of acceptance because technologies need legitimacy.
Other interesting theoretical references to acceptance come from psychology; in particular, reference is made to the Technology Acceptance Model (TAM), a model built on the perceived usefulness, ease of use and attitude toward using the technologies themselves (Davis, 1986). Thus, in the conceptual and analytical model of the TAM, the individual user's motivation justifies or does not justify the acceptance response to the technological implementation.
In psychology, a further distinction is also offered between acceptability and acceptance: acceptance is related to behaviour towards technologies, whereas acceptability is an attitude concerning the behaviour that the technologies themselves might trigger, and acceptance is a reflection, therefore, of the behaviour that allows for the promotion or not of the technology (Hujits et al., 2011).
Flynn and Bellaby (2007), on the other hand, argue the importance of working on public acceptance because citizens are also consumers - unlike in other studies analysed, but even in policies, they should not be considered as separate entities - and the continuous implementation of technologies with a high impact on everyday life should not involve the limited involvement of an elite of professionals, to the exclusion of an 'undifferentiated' public, also because it is the experts themselves who are often socially 'challenged'.
What is often overlooked in studies on public acceptance is the problematisation of this as a type of diffusion model. Public acceptance is not just a conceptual category that may or may not explain and highlight the favourable opinion of citizens towards the implementation of technological infrastructure or novelty.

The theory of the diffusion of innovations was proposed in 1965 by Everett Rogers, who theorised how the time cycle of the diffusion of a technology depends on different actors and factors, as opposed to the previously described TAM (which places users as central figures): on the innovators, the characteristics of the innovation itself and contextual variables.
Despite the significant amount of criticism, it has received, the theory offers some interesting insights that link it well with public acceptance as if it were a model in which the characteristics, and the relative power, of the innovators, are so incisive as to establish a communicative model that leads to (early or late) acceptance by society.

3.1. Public Acceptance and Technological Innovations for the Energy Transition

These kinds of statements are all valid when studying the public acceptance of various technological innovations. However, they are even more valid when focusing on new or semi-new energy technologies.
The energy sector is increasingly at the centre of specific policy measures aimed at reducing emissions (as energy is one of the factors most responsible for them): the United Nations' Agenda 2030 inserts the need for clean, sustainable, usable, but also cheap energy in Goal 7. Meeting these goals by 2030 means modernising and re-proposing already known renewable technologies (such as wind and photovoltaics) but also focusing on research and innovation by bringing new technologies that enable production to fruition of clean energy with zero environmental impact.
Based on international agreements, individual governments are in the process of implementing policies aimed at the energy transition. This has major repercussions for citizens and, for this reason, as argued by Spandagos et al. (2022), it is crucial to focus on factors that can be adjuvant to public acceptance, such as the possibility of technological diffusion and economic factors (which considering the current geopolitical condition are of paramount importance). More than technology is needed, it needs the support and approval of citizens, which is crucial in introducing the infrastructure into everyday activities.
Several studies deal with this subject, and considering the changing environmental and political framework, various theories from the social sciences and social psychology have been somewhat adapted to the energy sector. The latter approach focuses on how individual citizens' opinions about energy technologies are formed and affirmed; some of the factors impacting the formation of opinions regarding an energy technology infrastructure are the design of the technology, the place of implementation, the distribution of costs and benefits, but also the actors involved in the implementation (Hujits et al., 2011).
For Grade and Rowlands (2018), studies on the social acceptance of energy technologies and innovations (the two authors do not offer a distinction between 'public acceptance' and 'social acceptance') can be placed somewhere between those concerning the processes of innovation and diffusion of new technologies and those that focus on the social study of the role of energy and the political trajectories in this regard.

Studies on technological acceptance (particularly of energy technologies) cannot be divorced from the issues of conflict that appear inherent in these transitional mechanisms.
Scotti (2014) argues, as do other scholars, that conflicts related to these aspects are the result of an unequal distribution of costs (or instead risks) and benefits of the technologies themselves, but also that conflict episodes can be the driving force behind new proposals, community-based initiatives, and a more central role for civil society.
The prerequisite for technological acceptance, however, is that the public protagonist of these dynamics is involved and well-informed about the transition (O'Connor et al., 2021) so that they can put proposals on the table that oppose the predetermined options envisaged at the institutional level.
The so-called nimbyism ('not in my backyard'), the type of local protest that insists on the environmental impacts of energy technologies on one's home areas, is usually the conceptualisation that is most frequently highlighted by studies as a model for measuring levels of acceptance (without focusing too much on why there is an indirect proportionality between the proximity of the technological plant and the protest, *ibid.*). Protests of this kind have taken place at the time of installation of technological plants for wind energy production, CO2 capture and storage, and for various issues related to nuclear power plants (both nuclear fission and magnetic fusion). Nimbyism, however, is considered in the most recent literature as a simple concept but also as a movement used to simplify the complicated issues related to the energy transition, often with a selfish and self-interested motion, without a real collaborative spirit. On the other hand, however, there are movements that are interested in these changes and are used to offering alternative solutions to the problems related to fossil fuels and the emission of greenhouse gases, primarily proposing a totalitarian use of renewable energies, including wind power, which in the case of the nymbi movements is widely questioned due to problems perceived by local citizens: aesthetic concerns, noise, dangers (even if not supported by empirical data) and possible inefficiencies that could be created in energy use.
The concept of acceptance of technology, however, cannot be superimposed on that of support since, in the latter case, it is a kind of resignation to the implementation of what is imposed, since there is no real knowledge of possible alternatives, whereas full acceptance presupposes a well-informed and aware public, which is also exposed to these as consumers and users (o' Connor et al., 2021); furthermore, there may be a dimension of conditional acceptance also depending on the indecision of the public concerned in the territories. The process of acceptance, in any case, is not immutable: Hitzeroth et al. (2013) define this as 'acceptance reversal' and occurs in *itinere* to the planning or implementation process.

3.2. Public Acceptance and Risk Acceptance

In the literature, public (or simplistically 'social') acceptance of energy transition technologies is related to the concept of risk acceptance.
Citizens are led, and sometimes persuaded, to accept situations they are unfamiliar with and the risks that might ensue by having to rely somewhat blindly on the judgements of experts but also on the politically oriented information and communications offered (Flynn & Bellaby, 2007).

The topic in question is undoubtedly one of the key concepts in contemporary sociological theories, starting with the studies of Beck, Giddens and Luhmann. However, it is also widely addressed in the STS (science, technology, and society) perspective.

Ulrich Beck sees risk as the essence of modern society, as the so-called scientification of society is complete. This process has led to scientific doubt about the external consequences of innovation. In Beck's writings, it is still being determined whether this is due to an increased public awareness of the risks induced by technologies. However, he points out that this does not necessarily point to hostility towards scientific progress but rather to a more unfriendly trust. However, for Beck, denouncing the risk is still a conscious way of introducing actions for change and alternatives to be considered. On the other hand, Beck divides scientific rationality from social rationality, which is influenced by factors such as political ideology, geographical context, and countless social and cultural inclinations (Hess & Sovacool, 2020) rather than by empirical evidence alone. In fact, for Beck, risk arises from the mixture of empirical, measurable, and calculable reality and social and individual perception. Despite the importance of the individual sphere in the perception of risk, the public should be addressed. However, it should be given the opportunity, including through an information campaign that can build or deconstruct fear of technology, to choose which risks are potentially worth taking.

Conversely, Giddens noted that new technologies increasingly 'penetrate' the heart of everyday life. However, simultaneously, in a society of risk, the prospects of technological and scientific progress are shifted further and further ahead. For this reason, in a society in which personal knowledge is becoming more and more detailed when there is more incredible difficulty in understanding, trust in techno-scientific expertise is also diminished, and the doubt of being exposed to a risk creep in more. Some technologies, on the other hand, as Flynn (2001) argues, are already stigmatised in the collective imagination. Therefore, the fear of being exposed to risk is too strong to be completely shaken off.

According to Luhmann, risk in modern society is normalised within everyday life and is inextricably linked to progress: faced with a constant increase in technological development, individuals find themselves in the position of constantly making new choices, the implications of which they cannot always know, so the risks are always high. Moreover, external decision-makers often take decisions, so there is an increasingly averse attitude towards the risks imposed. The response is, therefore, a search for personal security, which is also the cause of risk exposure. For Luhmann, modernity and technological progress lead to constant coexistence with risk.

For Borrelli and Guzzo (2011), perceptions concerning technological risk are derived from the intersection of polarised expert opinions in strong disagreement with political agendas and internally discordant scientific opinions; thus, the public finds itself having to navigate a complex system that provides little empirical certainty.

In the more contemporary STS perspective, on the other hand, the public's perception of risk is the result of a negotiation process that brings together political demands and scientific evidence, but also the individual and collective

factors that guide society's doubts. There are several studies that affirm that, in any case, risk perception is closer to reality when trust in scientists is solid and that the public is more inclined to take the risk that technology may inherently cause when the implementation process is guided and supported by the experts themselves (Armstrong, 2021).

4. Public Acceptance and Public Participation

The issue of participation is debated and exploited differently in political contexts. With regard to scientific and, above all, energy progression, there have been several attempts in different European areas, such as in Great Britain and the Netherlands.

More generally, the involvement of the public, at a theoretical and strategic level, is considered a good tool for advancing both research and project development in support of the energy transition, not least because the results obtained may be far more in line with the expectations of the citizens concerned, as they have a say in key issues that could change their daily lives. The role of the public must be evaluated and then reflected in the energy projects and policies implemented (Armstrong, 2021).

The involvement of stakeholders, by which we also mean the users who are supposed to be users of a given innovation, is also part of the issues that policy should take into account in order to ensure a fair process that enables the consolidation and guarantee of first social and then energy justice (Sovacool & Dworkin, 2015).

Pellizzoni (2006) argues that deliberation and public participation in the field of technology are part of what could be defined as new models of governance and which could still be discussed today. According to Pellizzoni, this type of deliberative consultation has some peculiarities compared to participatory models on other issues: the extremely technical nature of the issues being debated leads to a narrowing of the deliberative path as the position of experts and non-experts can powerfully manipulate discourses and decisions; however, even non-expert citizens can be able to understand technological issues and perspectives.

Renn (1999) argues that the use of 'analytical-deliberative' methods, i.e. hybrid models of citizen participation, is useful to create a framework within which the public's reference values can be placed in order to understand what their criteria of judgement are by connecting them with experts who can assess the possible function of the options proposed by the public and then be able to discuss them together with an unspecified number of interlocutors, including the various stakeholders, in order to arrive at a solution that is as widely accepted and successful as possible in terms of its wide-scale acceptance.

In both the Netherlands and the United Kingdom (Jellema & Mulder, 2016), in the projects concerned, the public was involved together with experts and different stakeholders. Underlying this was the desire to involve citizenship on four levels:

1. Research design and policy making
2. Designing interventions

3. Development
4. Implementation

Getting very close to the highest level of involvement, i.e. letting the citizens themselves make the final decision, building their own knowledge in a collective and communal manner.

Jellema and Mulder (2016) also offer an interesting overview of what are the key steps for collective knowledge to come to life: top-down information, involvement, consultation, and collaboration to ultimate empowerment, which is also most likely to lead to an affirmation of the credibility of techno-scientific actors and the consequent public trust in them, leading to the meeting of the differences between public and expertise.

From the STS perspective, for instance, the study of the nexus between society and energy technology has been a central issue since the 1990s, assuming already the interest in the engaged role of the public and the need for public understanding. Hess and Sovacool (2020) argue that it is crucial for energy science to focus on raising public awareness in order to avoid social rejection. Also, following the Actor-Network Theory (ANT) perspective, it can be seen that the systems under consideration (the political, the techno-scientific and the societal) are interconnected and mutually constructed and not simply in an exogenous relationship. The public must be consulted so that we can move beyond the communicative model that envisages the pattern of decision-making, information and defence of technology in a manner imposed from above by the institution. Arnaldi (2020) argues that the two fundamental principles of public participation in technology policy-making must be inclusion and deliberation, and "science, technology and innovation are seen as means to just ends" (ibid., p.87), which are more valuable when pursued in a collaborative spirit. However, Arrobbio and Sciullo (2020) emphasise that public engagement is not precisely superimposable in the achievement of acceptance and that, indeed, participatory processes are put in place precisely to mitigate the controversies related to the energy transition; in addition, the two authors focus on the differentiation inherent in the words, as participation refers to an active approach of the public, while acceptance, in their view, is a receptive but passive process.

Further critical studies on participation (Moini, 2012) highlight the contradiction linked to the increasing diffusion of these practices that, at the same time, fail to have the expected and hoped-for major impacts. Once again, in fact, these types of practices may be introduced not with the aim of helping the process of political decision-making but with that of guiding the passive judgement of citizens.

When it comes to deliberative processes on technological issues, moreover, if the role of scientific experts is considered to have been deprioritised in favour of decision-makers instead, one can assume the hypothesis that the success of these same processes is somehow called into question and rendered less effective because confidence in scientific emancipation has waned (Latour,2000; Pellizzoni, 2006).

It is also necessary to specify how public engagement is a concept that encompasses various actions such as communication, the public's desire to be active, moments of sharing and consultation, deliberation, and only as a final step, participatory processes and practices.

Participation models are diverse and exploited according to contexts; however, some more than others are considered useful in order to achieve an increasingly informed mobilised public fully involved in energy transition processes.
So-called energy democracy and citizen science turn out to be quite useful conceptualisations and practices in the context of the energy paradigm shift.

4.1 Energy Democracy, Energy Citizenship

The Clear Energy Package (CEP) is the programme promoted by the European Union to promote the transition to clean energy within the broader horizon of the European and International Agendas, in which the active role of the citizen in the democratic process leads to the final implementation of new forms of energy is emphasised.
Armstrong (2021) defines energy democracy, first and foremost, as a concept. This is increasingly popular in politics when dealing with issues of climate change, decarbonisation and total transitions to renewables; those involved in this governance process claim it is a good practice to strengthen so-called 'social justice'. Energy democracy aims at equitable participation, even if - depending on who participates - it may, on the other hand, lead to inequities in the costs and benefits of interventions, as it is not self-evident that those who participate do not aim at selfishly oriented welfare.
The concept of energy democracy emerged through the efforts of social movements interested in environmental issues and took hold in the 1910s.
Van Valeen and Van Der Host (2018) emphasise the importance of the concept of governance underlying this mode of active civil society participation. This particular type of governance is referred to by the authors as 'energy governance', which envisages a tout court involvement of the citizenry through which it is possible to envisage the achievement of better results, making the opinions of individual citizens of possible solutions, decentralising part of the power from the institutions towards the citizenry. In this regard, however, it is necessary to recall how the public role of institutions in the energy field has also been reasserting itself in recent years, as it was for a long time frame as a process to be entrusted solely to techno-scientific competencies (excluding the integrated vision of these systems, as is instead in the tradition of the STS).
In Osti's (2017) study, energy democracy emerges as a concept economically oriented towards the sharing of the means of production, i.e. widespread ownership of energy sources, especially renewables, and is thus a process linked to the energy revolution that has put photovoltaics and wind power at the centre, partly bypassing the usual control of fossil resources by the state and a few energy companies.
Energy democracy is indeed a useful process when talking about renewable energies, while when dealing with discourses related to other types, first and foremost nuclear energy, there is a definite tendency to limit popular participation in favour of a de-democratisation of decision-making processes in favour of institutional intervention. However, the nuclear discourse has always been at the centre of a broad bottom-up debate, whereby citizenship itself has wanted to find its own space for discussion on higher levels, increasingly seeking that denied democratic space (Borrelli et al., 2013).

Citizenship plays the dual role of stakeholders, but also of the end consumer. It is from the same process of energy democracy that energy citizenship, involving citizens, can derive. Thus, energy democracy and energy citizenship go hand in hand and are often used as synonyms, despite their intrinsic differences. The democratisation of processes is undoubtedly an excellent tool so that, by gaining awareness of the power of the individual in the transition, citizenship itself assumes part of the responsibility in the implementation of new forms of energy, with particular reference to renewables.
Wahlund and Palm (2021) offer a detailed analysis of the differences between the two concepts. Although both democracy and energy citizenship envisage the active involvement of citizens in decision-making on a local scale, they are not overlapping. In fact, according to Wahlund and Palm, energy democracy is a concept that can be defined as 'political', born - as mentioned above - out of the engagement of social movements, whereas energy citizenship follows a more academic conceptualisation whereby a number of citizens engage in the practice of clean energy production and consumption through participation in collaborative cooperatives on local consumption.

4.2 Citizen Science

Citizen Science is a concept that expresses the possibility of opening up access to science to civil society. 'Open science' and 'open innovation' are among the definitions that appear to best express much of the deeper meaning of this practice, but it has been defined differently by different authors since 1995; Irwin, in particular, argues that citizen science is that process by which the goals of scientific research are defined collaboratively between experts and citizens, while more recently, in 2015, Holdren defines it as the voluntary intervention of citizens to participate in defining, but also solving issues that affect their own daily lives.
The European Community also defines citizen science: as scientific work that involves the public but never independently.
On the one hand, citizen science offers the possibility of enrichment, knowledge and literacy for the public, who have the opportunity to enter into the scientific mechanisms and be part of a more inclusive vision of something that has historically been elitist, but on the other hand, it is also a good practice of scientific improvement, as it is science itself that opens up to new (sometimes less rigorous) visions and perspectives so that scientific research can be more interdisciplinary, but also better responds to that demand for the trust that contemporary society continuously demands answers to. Robinson et al. (2018) argue that citizen science adopts a rather complex approach compared to experiential education in that scientific, educational, social, and political objectives are brought together, which of course, differ according to needs.
The authors maintain that in the last decade, there has been an important growth of these participatory processes, as it is civil society that has the need and curiosity to become part of the world of scientific research, feeling part of changes that are also essential to everyday life; this diffusion has taken place thanks to the use of mobile phones and computer facilities in general. From a scientific point of view, citizen science offers itself as a driving force for a methodological change in scientific research that never before has opened up

the whole of its long process, going beyond the mere publication and sharing of data and results obtained, strengthening precisely the path of innovation and scientific progress.
Environmental and ecological issues are among the fields in which citizen science is most widely used as an engagement practice; with regard to the energy sector in particular, this process is implemented especially when it comes to renewable energies, and according to the studies of Saurmann et al. (2020) this is done through three directives: outlining environmental sustainability issues, an increase on the side of involvement and informed communication, and linking the scientific and social aspects insisting on the energy transition.
These processes, in fact, respond very well to the public's demands for involvement in the energy transition, as this has an important spill-over into various spheres such as the economy, work, culture and politics.
Citizen science is a practice that goes further than public acceptance of technologies; it is not merely informed and informative participation but is also more demanding than the previously discussed processes of energy democracy: the public gets its hands dirty by practically participating in scientific research and innovation (Barbosa et al., 2022).
Wuebben et al. (2020) differentiate citizen science from energy communities and energy citizenship on the basis of power and democratisation: the former proposes the democratisation of knowledge and practice, while the latter categorisation aims to democratise power, making it shared at both institutional and public levels.

Conclusion

An analysis of the literature suggests that the concept of public acceptance needs to be problematised and questioned in order to clarify its boundaries and nature, which still appears confused; there is often a risk of assuming public acceptance as an attitude, a purpose (whereas it is a constantly changing process), a series of behaviours enacted to legitimise the arrival of new technology.
As set out in the previous paragraphs, the knowledge of the individual does not appear to be complete if the information is conveyed in an autonomous manner but better if it is conveyed by inclusive and collective processes, such as participatory processes. There are several authors who state that public acceptance becomes more widespread and public fear management easier when knowledge of the energy transition in general and of the technologies to be implemented in different territorial contexts has also increased.
Public participation, in any case, is not always a widespread and/or accessible practice as it entails costs, including in terms of time, energy and human resources employed. The methodology of involving the public concerned is also a complex practice since it is necessary to understand whether the citizenry involved should be a representative sample of the territory or not (this depends on the different types of practices).

When citizens' knowledge is supported by processes, they can become both an integral part of the process and support the transition themselves, e.g. through collaboration in energy communities or by taking part in the scientific research process through citizen science. The process of sharing not only the finished science but also the entire scientific process (from the formulation of the research question to the most exact methodology for constructing the object of analysis) appears to be a virtuous example of the democratisation of processes, which inspires awareness and empowerment constructions with respect to pressing energy issues, which can no longer be considered as factors external to the individual or civil society, but with respect to which the public must question itself and be guided in paths of paradigm change, also of a value and cultural nature, as well as merely economic and responding to new energy market logics. And it is for these reasons that the citizen cannot be framed only as an end consumer but also as an active player in the techno-scientific progress that is increasingly permeating everyday life.

Some scholars, however, are more doubtful about the real effectiveness of participatory processes. Sometimes these practices are implemented with the aim of bamboozling the public and guiding them in a more unconscious and passive way towards acceptance, creating in them the feeling of being part of a process that, however, appears to be already designed and that, any case, must be implemented in favour of political logics and ideologies, but also in response to specific market needs in agreement with stakeholders, with private actors as protagonists, such as energy companies.

Most of the literature reviewed in this paper expresses positive conclusions regarding the involvement of the public in decision-making processes concerning the energy transition and affirms how these practices are useful in public acceptance; this should not be an endorsement of technology, nor should it constitute a resignation to the only known alternative. The political process must be able, through the involvement of scientists and experts of various kinds, to give the public a range of possibilities to learn about and evaluate so that the technological infrastructure is not seen almost as an enemy in the territory (as happens in the manifestations of nimbyism), but becomes an integral part of a positive process aimed at improving wellbeing through a radical change in daily habits and in thinking about energy and energy consumption.

The geopolitical situation from 2022 somehow offers an opportunity to rethink the issue of energy supply in a shorter timeframe, even with respect to already established political trajectories, but it should also be a driving force for information campaigns and participatory practices that allow for collectively shared thinking with respect to the way forward in individual countries.

The prerequisite for future work on public participation as a virtuous tool to foster a conscious acceptance of energy technologies is to be able to analyse a network that connects institutions, stakeholders (understood as energy companies and, in particular, Eni SpA), scientists and citizens. Communication and collaborative work between these four spheres can be useful in achieving objectives that can be common and validly decisive but also innovative and proactive.

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