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Mapping concept use in energy technologies research

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Perspective

Making sense of acceptance and acceptability: Mapping concept use in energy technologies research

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ABSTRACT

With the increasing reliance on technological advancements, it becomes imperative to critically examine and evaluate their implications on society and the environment. The concepts of *acceptance* and *acceptability* have gained prominence among researchers shaping technology implementation strategies. However, the lack of precise definitions for these concepts leads to diverse interpretations, compromising their usefulness in technology development and impeding further progress in research endeavours. This paper illustrates how these important concepts have been used in the energy technology discourse and develops a schematic overview highlighting the varied overarching interpretations of these concepts: the funnel of acceptance and acceptability. It underscores how different research levels – institutional, societal, and individual – affect the relevant understanding of these concepts. The funnel metaphor emphasises the interconnectedness of these interpretations and underlines the importance of addressing all research levels to ensure technology implementation processes advance in a desirable and responsible manner.

1. Acceptance & acceptability – A source of misunderstandings

As societies grapple with the challenges of transitioning to more environmentally friendly and socially responsible technologies, the concepts of acceptance and acceptability have gained increasing importance. Yet, there is no unequivocal understanding of these concepts. Instead, research often utilises either of the concepts without defining them [1] or uses them interchangeably together with the concept of adoption [2,3].

Terms like acceptance and acceptability have been subjected to significant variations in interpretation based in part on the research field and objectives. Consequently, misinterpretations and ambiguity concerning research outcomes persist. This lack of consistent and clear definitions may hamper effective communication, impede the comparison of research findings across different studies, and complicate the development of cohesive strategies for technology implementation and societal integration. As such, clarity should be pursued when using the fundamental concepts of acceptance and acceptability in the interdisciplinary context of technology implementation strategies.

In support of this pursuit, we will provide an overview of the dominant interpretations of acceptance and acceptability that have arisen in social studies, ethics of technology, and innovation studies in the last decade, where especially research on energy transitions has contributed to concept development. With this overarching picture, we developed a scheme – the funnel of acceptance and acceptability – to illustrate that different understandings address different research perspectives and levels of abstraction. The funnel aims to help differentiate the various meanings of acceptance and acceptability more independently of the research fields, emphasising the interconnectedness and complementary nature of all definition types. Moreover, it prompts scholars to clarify their intent with these concepts, facilitating effective communication and fostering interdisciplinary dialogue within and across research areas.

2. Methodology

Before diving into the different understandings of acceptance and acceptability, a note on this perspective's methodology is needed: This theoretical synthesis attempts to integrate the different conceptualisations of acceptance and acceptability in energy technologies in a structuring framework. The need to do so emerged from another study of ours, which aimed at understanding narratives surrounding acceptance in another large-scale infrastructure context [4]. We found that the fields of social studies, ethics of technology and innovation sciences

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contributed most to the debate. As ethics of technology scholars, we see these fields often come together when researching the societal impacts of implementing technology into society, making it difficult to make watertight distinctions between them.

To determine which understandings of the concepts of acceptance and acceptability dominate the current debates, we sought out widely cited papers that deal with these concepts, recognising their significant contributions to contemporary debates. We conducted a loose narrative review with the following title-abstract-keywords queries in the Web of Science database:

- (energy AND acceptance AND (social OR societal))
- (energy AND acceptability AND (social OR societal))
- (energy AND acceptance AND (ethic* OR normative*))
- (energy AND acceptability AND (ethic* OR normative*))
- (energy AND acceptance AND (adopti* OR innovati*) AND (user OR consumer OR market))
- (energy AND acceptability AND (adopti* OR innovati*) AND (user OR consumer OR market))

We deliberately separated the queries of acceptance and acceptability because their number of citations is appreciably different. The importance of acceptance in energy technologies has increased dramatically in the last two decades, leading to a range of highly cited literature debating this notion. The idea of acceptability, though emerging as early as the 1990s, seems much less developed, leaving ambiguity about which conceptualisation dominates the field. Although some papers seem increasingly impactful, it remains uncertain which definition will ultimately become dominant. Therefore, instead of setting a threshold, we decided to look at the ten most cited papers per query, excluding those not focusing on energy technologies or adequately discussing these concepts.

The identified literature comprised conceptual and empirical papers, where social studies have contributed most notably to the development of acceptance and acceptability conceptualisations. In the other domains, these seem to be mostly lacking. Instead, empirical evidence that emphasises the conflation of different terms was dominant. To obtain additional conceptualisations in these domains, our own expertise and the snowballing effect from identified literature facilitated finding conceptual papers that go deeper into the meaning of these concepts in their respective field.

3. Different concept interpretations per research field

This section provides an overview of dominant definitions of acceptance and acceptability encountered within the research fields of social studies, ethics of technology, and innovation studies.

3.1. Social studies

Social studies have played a prominent role in acceptance and acceptability research, where scholars from the renewable energy domain, particularly Wüstenhagen et al. (2007), have greatly influenced the conceptualisation of acceptance beyond their research field. Social acceptance is commonly understood as "the positive response to, or tolerance of a technical or socio-technical transition project by members of a given social unit" [5], critical for technology implementation success. Public opposition, on the other hand, is seen as a barrier that needs to be understood and overcome, which is predominantly done by unpacking and delineating impacting factors [e.g., [6,7]]. While being a dominant interpretation of public opposition, it is also increasingly criticised for its uncritical underpinnings [8], such as its "unreflective positivist research frame" [9].

In response, a shift in the understanding of the concept has occurred in recent years, moving from an outcome-oriented to a process-oriented perspective where social acceptance is defined as "complex, multi-level and polycentric processes of escaping our institutionally locked-in energy systems" [10]. Rather than aiming for securing acceptance, this more recent 'third social acceptance wave' assesses energy technologies more critically and questions whether overcoming public opposition is a desirable pathway [11].

In addition to different understandings of acceptance, there is also an increasing uptake of the concept of acceptability, increasing conceptual ambiguity even further. Fournis and Fortin [12] define acceptability as "the collective process of evaluation of a socio-technical project" (p. 15), which seems to overlap with the third wave of social acceptance. However, Huijts, et al. [13] propose a different account and define acceptability on the individual level as "an attitude […] towards new technologies and attitude towards possible behaviours in response to the technology" (p. 526). This type of understanding seems to be driven by a relatively small but highly influential cluster of scholars who attempt to delineate factors influencing public attitudes and behaviour [see [14,15,16]].

While some scholars treat acceptance and acceptability as separate entities, as seen above, others use them interchangeably, albeit with a preference for one over the other [17,18]. The diversity of these concept interpretations highlights the need for more clarity in their use. Yet, the third wave of acceptance and the introduction of acceptability as a stand-alone concept especially indicate a general paradigm change towards becoming more process-oriented. To a certain extent, this development produces a 'systemic' approach to questions about acceptance and acceptability in which the successful implementation of a new technology results from the interplay between decisions being taken within different institutional settings and the responses of societal groups. However, earlier definitions of the concepts continue to be used, contributing to ambiguity and confusion.

3.2. Ethics of technology

Ethics of technology is a research field addressing ethical concerns arising from technology development. A prominent goal of this field is judging the moral desirability of particular technologies and their implementation. The use and discussion of acceptance and acceptability concepts are relatively recent.

The concept of acceptance is often seen as an empirical matter, describing a "state-of-affairs" [19] or a factual situation referring to "the fact that a new technology is accepted – or merely tolerated – by a community" [20]. Here, considerable importance is placed on moral values and their impacts on acceptance [see, e.g., [21]]. For example, Oosterlaken [22] found that distributive justice and sustainability are critical for increasing acceptance of wind park projects. In the Groningen gas controversy, Mouter, et al. [23] identified the procedural justice-related values of trust and honesty as critical and noted that these remain under-addressed. Overall, the value of justice seems to be increasingly prominent for many energy technologies [also see [24,25]].

Also the concept of acceptance itself is subject to criticism. For example, Milchram, et al. [3] criticise that most research on acceptance considers many contributing factors but neglects the importance of moral values. Moreover, Batel, et al. [2] cautioned against the uncritical use of the term acceptance and pointed to the risk of conflating two distinct stances towards technology: acceptance and support. Cowell, et al. [25], on the other hand, highlight that *ex-post* acceptance should not be confused with *ex-ante* acceptability as "people accept all sorts of unwanted outcomes" (p. 553) once the technology has been implemented.

Instead, institutions and technology should be designed for values such as justice a priori technology implementation to ensure acceptability [also see [22]]. As such, ethical acceptability is a morally evaluative term, judging how something ought to be. Although the evaluative standard could range from moral or public values, a code of ethics, or adherence to moral standards found in the law [19], moral value judgements seem to be dominant for energy technologies. For

example, Künneke, et al. [26] define social acceptability as a reflection of "moral and societal values that are shared by all members of society" (p. 118–119) and Taebi, et al. [27] connect acceptability with distributive justice in nuclear power considerations.

Even with some definitions in place, ambiguity persists within technology ethics, as both acceptance and acceptability are frequently defined in terms of values relevant to technology and institutional frameworks. Yet, there seems to be a consensus that moral values must be incorporated better to ensure the desirability of technology implementation, brought out by the acceptance and acceptability concerns.

3.3. Innovation studies

Innovation studies encompass various research fields, including innovation, economy, and market studies. This extensive domain primarily revolves around facilitating successful tool adoption and has long recognised the critical nature of acceptance. A cornerstone of this domain is the incorporation of marketing strategies and innovation diffusion theory, explaining how consumers adopt new products through interactions between individual adopters and their environment [1].

One of the earlier and most impactful contributions to this debate is the Technology Acceptance Model (TAM) [28], which centres on the user with the objective of augmenting tool adoption by influencing specific criteria. Over time, this model has evolved to address new challenges, incorporate advancements in knowledge, and assess diverse technologies, including electric vehicles [29,30]. More recent models, such as extended TAM or the Unified Theory of Acceptance and Use of Technology (UTAUT), have emerged, encompassing the user environment and social influences [31].

Innovation studies often concentrate on the individual's behaviour and attitudes, where acceptance can be defined as an individual's tangible, measurable technology use or technology adoption [32,33]. Ruiz-Mercado, et al. [34] make a more fine-grained distinction where tool adoption does not equal acceptance. Instead, *initial* acceptance refers to the choice to purchase, which is one phase of the adoption process.

Acceptability, on the other hand, refers to the extent to which these innovations are perceived as appropriate and desirable by stakeholders, such as end-users, consumers, businesses, or policymakers [33]. Hence, acceptability differs from acceptance as acceptance relates to the individual's actual use of the technology, while acceptability is the anticipated willingness or "a positive attitude toward adoption" [35].

Nevertheless, the use of the two concepts is not always explicitly maintained throughout the innovation studies. A large number of influential empirical researchers use the terms acceptance and acceptability interchangeably, often paired with a lack of definition of the concept [e.g., [36,37]]. Moreover, both concepts are often described through criteria deemed relevant for tool adoption. For example, [38] claims that the social acceptability of biomass systems is ensured "when the benefits of using biomass [are] recognised as outweighing any negative social impacts" (p. 6076). In the case of new energy vehicles in China, Du, et al. [39] claim that the acceptability of government policy can be determined by awareness and knowledge about these policies.

Consequently, although some clear definitions of acceptance and acceptability exist, they are not always used distinctively in practice and are often defined through criteria or factors to be met. Nevertheless, there is common ground between the studies: the overall aim of acceptance and acceptability studies is to understand which design criteria are most impactful for consumers to buy or (be willing to) use a particular technology.

4. Overview of concept interpretations and categorisation

The diverse interpretations of acceptability and acceptance across research fields have arisen from each field's unique demands and research needs. Consequently, no single understanding can be deemed superior to the others. Instead, these perspectives are all crucial and complementary, serving distinct purposes within their respective fields. Fig. 1 shows an overview of the different understandings. Together, they offer valuable insights into the multifaceted nature of acceptance in the context of technology implementation.

Nevertheless, it is a valuable endeavour to construct an overview of the diverse interpretations of acceptability and acceptance. Establishing a framework can help researchers from different domains engage in discussions and exchange insights more effectively while at the same time reducing miscommunications. Here, we propose that the various understandings of acceptance and acceptability can be visualised as a funnel, where the chosen research level – systemic, societal, or individual – dictates the relevant interpretation of these concepts (see Fig. 2).

At the *systemic level*, acceptance and acceptability provide a general perspective on technology desirability within a socio-technical system. Acceptance is the desired outcome of technology implementation encompassing the interactions between institutions of state and market, as well as societal groups, including the consideration of ethical, legal, political, and market aspects to ensure effective integration within the institution. The concept of acceptance is traditionally emphasised, whereas acceptability only emerges on the systemic level. It is referred to as the desirability of the technology implementation process, encompassing all steps and considerations involved in successfully introducing the technology within society. The contributions of Batel [11], Wolsink [10] and Fournis and Fortin [12] can be seen as representatives for the systemic level.

Moving to the *societal level*, the focus shifts to the groups and communities that form society and that are affected by technology

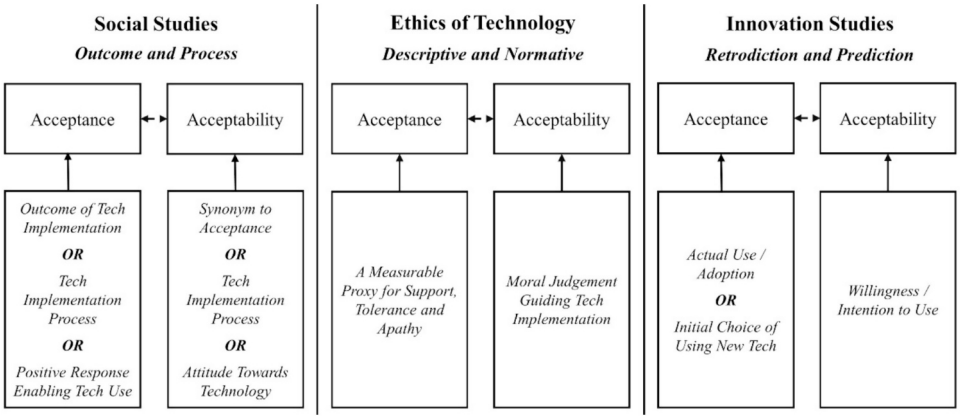

Fig. 1. Overview of Acceptance and Acceptability Interpretations by Research Field.

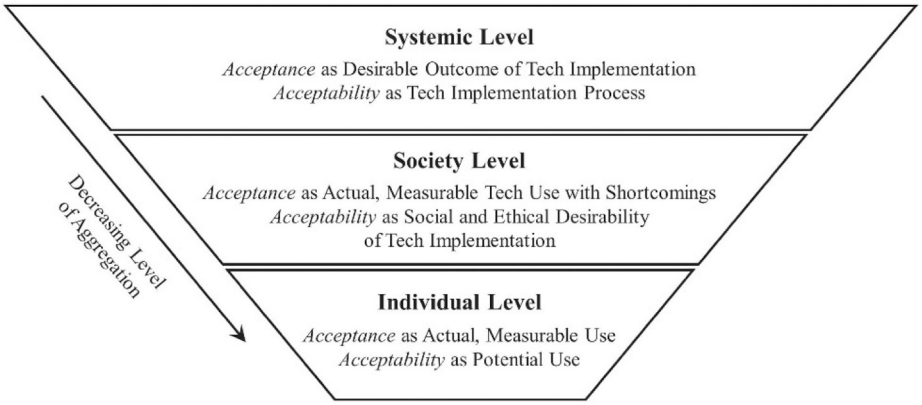

Fig. 2. Funnel of Acceptance and Acceptability – Concept Definitions Based on Abstraction Level.

implementation. Discussions here predominantly revolve around the ethical and social impacts of the technology. In this, acceptance often refers to a generally positive attitude towards technology and a desirable outcome of the implementation process, even though it may come with certain shortcomings or limitations. Typical representatives of this research level are Jobert, et al. [7] for the social focus and Milchram, et al. [3] for the ethical considerations on this research level. Acceptability, on the other hand, encompasses both the social and ethical desirability aspects of technology implementation, often operationalised through values, as found in the works of Künneke, et al. [26].

Lastly, the *individual level* considers acceptance and acceptability indicators of individual tool adoption. Acceptance is characterised as individuals' actual and measurable use of technology, reflecting their tangible engagement with technology in practice. Representatives for this research level can be found in innovation studies [e.g., [30]] but also in social studies which focus on the individual [e.g., [13]]. In contrast, acceptability indicates an individual's willingness and readiness to adopt and integrate technology into their daily lives, as represented by the works of Noppers, et al. [35] and Steg, et al. [15].

Starting from the institutional entanglements at the macro-level of society, the funnel contracts to the meso-level of groups to arrive at the micro-level of individuals. What can be observed is that within these different levels the question of what is being accepted pertains to the process of implementing a socio-technical system. Here, a broad spectrum of considerations play a role, ranging from political, technology, societal and individual factors, to the assessment of the desirability of a particular technology, to the use of a concrete tool, respectively. With that, the levels of the funnel present varying degrees of aggregation, with the scale and object of acceptance becoming more specific and less aggregated moving down the funnel. Hence, with increasing object specificity, the concepts of acceptance and acceptability become also more specific.

As such, the funnel adds insight to the triangle of social acceptance by Wüstenhagen, et al. [1], by which it is inspired. Yet, the funnel of acceptance and acceptability not only reveals the varying interpretations of these concepts but also that the uptake of new technology in society is a phenomenon that has multiple dimensions. Researchers using these concepts could usefully be mindful of the level of analysis they are adopting, as reflected in the funnel diagram, and use this in their definitions of the concepts. Doing so may help social scientists, in particular, contribute to further developing our understanding of acceptance and acceptability, reducing confusion. With such additional clarity, other researchers can build on the findings more easily, avoid misinterpretations and facilitate collaborations. At the same time, acknowledging multiple layers allows for a more comprehensive understanding of the complex phenomena of acceptance and acceptability.

5. Discussion

It became evident that all research fields contribute to understanding the persisting challenges of technology implementation but are not addressed equally. Moreover, silo thinking seems to be a recurring issue in technology development and implementation, thereby prioritising one research level over the others.

Large-scale technologies such as energy technology infrastructures are often understood on the systemic level, thereby marginalising societal and individual considerations. For example, we can look at the development of photovoltaic panels (henceforth PV panels) as a decarbonised energy source. At the systemic level, this development pertains to various aspects, including establishing regulations, innovation policies, subsidies, and interconnections with the existing energy grid. The questions for acceptance and acceptability involve the interplay between all these aspects, including the societal responses to any of these. Yet, several studies show that the systemic levels are considered in isolation, ultimately lacking to provide a holistic view of acceptance. For instance, the commonly used systemic attempt to move towards renewable energy by incentivising PV panel adoption through tax benefits and subsidies has disproportionately favoured affluent neighbourhoods, leading to distributive injustice as all residents, including non-owners, bear the costs leading to limited adoption [40], consequently decreasing acceptance on the societal and individual level.

Yet, there is a wide range of studies on the social and individual level. At the social level, the question of acceptance and acceptability primarily concerns the desirability of PV panels themselves, particularly in contexts like large solar (and wind) parks, where local impacts are significant but often overlooked in regulatory processes [41,42]. At the individual level, attention goes to households and understanding what individual aspects impact the decision to purchase PV panels, which go beyond affordability and include altruism and socio-democratic factors such as gender and age [e.g., [43]].

These examples show that the isolation of the different levels fails to provide a holistic view of acceptance, potentially leading to technology implementation problems. For instance, we might not connect the decision of households to buy PV panels with broader discussions about compensation schemes nor with the justice implications of non-owners contributing to the well-being of PV panel owners. If we fail to see these regulatory issues as codetermining the ethical desirability of PV panels, we miss out on the whole picture.

5.1. Limitations & future research

Finally, we want to stress the importance of validity, considering both the comprehensiveness of this concept analysis and the generalizability of the resulting framework. We recognise that this investigation is not exhaustive, acknowledging that the notions of acceptance and

acceptability go beyond the boundaries of the specific research fields we discussed. Since this study has not been conducted as a systematic literature review, there is the possibility that other significant literature distinguishes between both concepts well. However, such a review remains essential given that we found many highly influential empirical studies that conflate different meanings. Moreover, the focus on acceptance conceptualisations in energy technologies might unintentionally limit its generalizability to other technologies. Yet, its leading role in addressing issues of acceptance and acceptability can still serve as a starting point for other areas of technology development, providing foundational knowledge and methods that can be adjusted for different sectors. Finally, we want to highlight the ontological challenges of the concepts of acceptance and acceptability. While our research focused on their current usage in the literature, it is crucial to gain deeper insights into the social concerns these concepts aim to draw out. Exploring these underlying issues could provide fresh perspectives for distinguishing between acceptance and acceptability and formulating clearer definitions.

6. Concluding remarks

Acceptance and acceptability are critical in shaping the discourse and understanding of technology implementation in several research fields. Yet, the interpretations of the concepts show significant differences. This research aimed to provide some structure in the diverse variations of acceptance and acceptability within social studies, ethics of technology, and innovation studies. It revealed disparities between and within the fields and frequent occurrences of silo thinking. To foster a more interdisciplinary dialogue, we propose the *funnel of acceptance and acceptability*. The funnel metaphor illustrates how distinct research levels impact the interpretation of these concepts and emphasises their interconnectedness. Moreover, it underscores the importance of moving away from silo thinking and towards simultaneously addressing the systemic, societal, and individual levels to move towards responsible technology implementation.

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CRediT authorship contribution statement

K. Moesker: Visualization, Conceptualization, Writing – original draft. **U. Pesch:** Supervision, Writing – review & editing. **N. Doorn:** Supervision, Writing – review & editing.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT 3.5 to improve readability and remove language mistakes. It has not been used for the interpretation and analysis of the data, nor has it been used to draw conclusions. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Data availability

No data was used for the research described in the article.

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