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Addressing “the ones behind”: Public responses to technologies and the role of responsibility

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ABSTRACT

This paper advances a broadened understanding of technology acceptance by introducing the concept of the acceptance object responsible – the actors and institutions accountable for technological design, implementation, and governance. Traditional approaches have focused on the dyad of acceptance subject and object; we argue that social (non-)acceptance fundamentally targets actors behind technology decisions. Acceptance thus emerges as a relational and communicative process embedded in contexts of trust, fairness, and legitimacy. Building on a critical review of existing technology acceptance literature, we identify the neglect of responsibility as a crucial conceptual gap. To address this gap, we propose a triad comprising acceptance subject, object, and its responsibles. Technologies thereby function as proxies or mediating reference points through which broader evaluations of responsibility, accountability, and legitimacy are articulated. Public support or opposition is thus less a direct reaction to the intrinsic properties of a technology than an expression of confidence or distrust in the governance arrangements, communications, and decision-making of the actors (perceived as) responsible for making crucial decisions on development, implementation, and management. Thus, our main argument which we will lay out in this paper is the following: (non-)acceptance judgments address primarily technology related decisions of corresponding technology responsibles – that is of addressing “the ones behind”.

1. Introduction

Technologies raise controversies within societies potentially resulting in heated socio-political debates and conflicts. At the heart of technology debates lies the tension between technology-euphoric and technology-sceptical assessment and evaluation. While some promote technologies as an important solution to a given considerable problem, others see these technical options as exactly the very cause of the addressed or even other problems. Thus, different and opposing judgments of citizens and stakeholders are centre stage of the conflict. In addition, modern societies require and desire open and active social debate and approval as public support is of central importance in a pluralistic and democratic society [1]. Accordingly, socio-technological transformation processes cannot be assessed solely on the basis of technical and economic feasibility, they need societal approval as a key legitimacy source.

The relevance of legitimacy with regard to techno-scientific developments became particularly visible in Europe from the late 1980s onward, where several environmental and technological crises exposed the limitations of technocratic governance. The Chernobyl nuclear disaster in 1986 demonstrated how transboundary technological risks could undermine public trust in official expertise. The BSE (mad cow disease) crisis in the 1990s revealed major failures in the management and communication of scientific uncertainty [2]. Controversies surrounding genetically modified organisms (GMOs) further highlighted tensions between expert assessments of safety and public concerns about environmental and ethical risks [3]. These crises showed that decision-making practices that relied exclusively on technical expertise could lose legitimacy when they failed to address broader societal concerns. In response to these developments, European institutions increasingly institutionalized mechanisms designed to improve responsiveness in environmental decision-making. One of the most significant legal developments was the Aarhus Convention [4], which established rights for public access to environmental information, participation in environmental decision processes, and access to justice in environmental matters. The convention reflected a growing recognition that democratic legitimacy in environmental governance depends not only on scientific expertise but also on the inclusion of citizens and civil society

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organizations. Similarly, the European Commission's White Paper on European Governance [5] emphasized principles such as openness, participation, accountability, and effectiveness as central elements of legitimate policymaking in the European Union.

We refer to this shift from technocratic, expert-centred governance towards more participatory decision-making processes in environmental, risk, and technology decision-making as “responsiveness turn”. The theoretical foundations of this shift can be traced back to sociological analyses of risk society and late modernity by Ulrich Beck and Anthony Giddens who argued that advanced industrial societies are increasingly characterized by the production of manufactured risks [6–8]. Research in Science and Technology Studies (STS) also played an important role in explaining and justifying this shift. For example, Brian Wynne's work challenged the so-called deficit model, which assumed that public opposition to technological risks results primarily from a lack of scientific knowledge. Instead, Wynne demonstrated that conflicts often arise because institutions fail to recognize uncertainty, ignore local knowledge, or dismiss public concerns as irrational [9]. This insight contributed significantly to the growing emphasis on participation and responsiveness in technology governance.

In this paper, we argue, based on the observation of the “responsiveness turn”, that while technology acceptance research has acknowledged and addressed the growing relevance of decision-making practices and decision-makers for acceptance, this dimension has not yet been explicitly conceptualized or theorized. We therefore suggest that technology acceptance research should more explicitly focus on what we call the *technology object responsible* – that is, those actors and/or institutions (perceived as) responsible for technology decisions – in order to keep pace with the socio-political developments that have reshaped and are still reshaping technology governance. Technology (non-)acceptance in its various facets expressed by people in their role as consumers, citizens, employees, residents, stakeholders etc. refers at first glance to specific technology objects such as, for instance, energy technologies, nano technologies, digitization, artificial intelligence and so on – but *in nuce* it substantially addresses the ones behind, the ones holding responsibility for the technologies, the ones who are primarily *(perceived as) responsible for making crucial decisions on development, implementation, and management.* Thus, our main argument which we will lay out in this paper is the following: (non-)acceptance judgments address primarily technology related decisions of corresponding technology responsibles – that is of addressing “the ones behind”.

In the following, we outline our argument, primarily illustrated with examples from the field of energy technologies. Section 2 briefly reviews current conceptualizations of technology acceptance and identifies the dominant perspectives in the literature. Section 3 develops an understanding of technology acceptance as emerging from a triad of the accepting subject, the accepted object, and the responsible actors (i.e., those behind technological decisions). It also illustrates why accounting for the responsible is particularly important and discusses the key factors shaping acceptance across these three dimensions. Section 4 concludes with a summary of the main findings and highlights key implications for empirical research.

2. Background: technology acceptance literature review

Technology acceptance research reflects and analyses people's positive, negative, and ambivalent attitudes and actions in its different shades and expressions towards technologies [10,11]. Historically, the public has associated existing and emerging technologies with concerns, protests, and controversies ever since – from weavers' uprising in the early 19th century, to nuclear energy from the late 1960s onwards to even renewable energies as of today. Hence, it is of no surprise that social sciences and related fields substantially researched what (technology) acceptance is, how acceptance manifests, and which factors, processes, and dynamics determine and build up acceptance. Thus, the major strands of acceptance research focus, first, on conceptualizing and theorizing acceptance and, second, on empirically examining its underlying factors, processes, and dynamics. In the following, we briefly summarize the current state of the art in acceptance research and, based on this, identify existing research gaps. Building on these insights, we argue that acceptance research needs to place a more explicit focus on those responsible for the development and deployment of technology.

With regard to the *conceptualization and theorization of acceptance*, it can first of all be stated that acceptance is a fuzzy concept that is applied with diverse meanings and connotations, often without being clearly defined [12–14]. For Upham et al. [15,p. 103] acceptance is: “a favourable or positive response (including attitude, intention, behaviour, and – where appropriate – use) relating to a proposed or in situ technology or socio-technical system, by members of a given social unit (country or region, community or town and household, organization)”. Definitions of acceptance hence often include two different dimensions: an attitudinal respectively evaluative as well as an action-based dimension [13,15–20]. Acceptance therefore can be conceptualized as a positive attitude towards an object that is accompanied either by a positive behavioural response to the given object or by the absence of negative behavioural responses. Schweizer-Ries et al. [20] further elaborate the concept of acceptance by systematically combining the evaluative as well as the behavioural dynamics: acceptance can either stand for approval (positive attitude plus no behavioural response) or support (positive attitude plus supportive behavioural response), whereas non-acceptance encompasses refusal (negative attitude plus no behavioural response) or resistance (negative attitude plus unfavourable behavioural response).

Further conceptual work focuses on the demarcation of acceptance dimensions in order to identify crucial reference points for empirical research. As a basic analytical framework the categories of acceptance subject, acceptance object, and acceptance context have been introduced [18,21]. Acceptance is bound to the attitudes and behavioural dispositions of potential acceptance subjects. Furthermore, acceptance includes an object the acceptance subject refers to. The category of acceptance objects covers a broad diversity of topics such as material artefacts (consumer goods, technologies etc.), opinions, values, lifestyles, arguments, behaviour patterns, policies, institutions, organizations, persons, social groups and so on [18]. Both acceptance subject and object are embedded in a socio-cultural context which serves as a frame of reference as well as enabling or constraining factor.

With regard to research on acceptance of energy systems and technologies, Upham et al. [15] further sub-differentiate acceptance objects into technology, infrastructure, and application. Furthermore, they propose three separate societal levels, on which acceptance can be contested: the general level, local level and the household-organisational-end-user level. Similarly, Wüstenhagen et al. [14] specify energy technology acceptance as a phenomenon that is relevant in the following contexts: socio-political acceptance (general acceptance of a technology and associated policies), community acceptance (local level acceptance of specific energy projects) and market acceptance (consumption respectively adoption of a given technology and/or associated services by investors, households and companies). Based on subject and object differentiation, several research focusses on actor perspectives and characterisation, for instance, with tracing actor constellations and mapping of stakeholder groups [22], or identification of stakeholders including those beyond citizens [23]. In addition, further analytical work aims at clarifying differences between closely related concepts and categories such as between acceptance and acceptability [12,24,25], legitimacy [26,27], justice [28], transformation [29,30], technologies as social experiments [30], and technology domestication [31].

With regard to *acceptance factors, processes, and dynamics,* major emphasis is on identifying crucial drivers which individually and collectively determine (non-)acceptance judgments. Based on empirical work (e.g., opinion polls, social psychological experiments, case studies) and respective theories and concepts (e.g., planned behaviour, norm activation, elaboration likelihood, social representation), relevant factors are identified and put into a cause-impact chain sequence. A prominent set of cause-impacts refer to psychological factors influencing sustainable energy technology acceptance. The well-known approach of Huijts et al. [32] identified trust, fairness, knowledge, and experience as crucial psychological determinants, and sets up a comprehensive acceptance framework putting the variables in causal order. Besides this, other types of factors refer to socio-demographic factors such as age, gender, social class, education [33–35], individual traits as marked by values and worldviews [36–38] as well as situational and object-related factors such as site-selection and place attachment, media coverage, or general economic development [39–44]. Furthermore, so-called community response research investigates how local communities react and respond to specific technology planning and implementation [45–47]. Several key learnings from community response research have been summarized by Boudet et al. [48]: e.g., the significance of local message framing and power hierarchies; a focus on contextual factors such as proximity to protected, locally meaningful, and culturally important places; the residents' levels of attachment to such places; and perceptions of how the facility will affect these places. Moreover, there is also a research area that focusses on interventionist and policy related impact research. The key question here is to identify useful interventions that are able to encourage and stimulate technology acceptance. Common areas are, for instance, research on nudging [49,50] or compensation schemes [51].

As stated above, the “responsiveness turn” has transformed technology governance from a predominantly technocratic mode into a legitimacy-centred enterprise in which public justification, participation, and accountability have become central conditions of decision-making. However, while existing acceptance research empirically acknowledge the importance of factors such as trust, fairness, and participation, acceptance research continues to conceptualize acceptance primarily as a relationship between acceptance subjects and objects. In doing so, objects or technologies are conceptually treated as the primary targets of evaluation, while relegating the actors and institutions shaping these technologies to the background. However, under conditions of the responsiveness turn, acceptance judgments cannot be adequately understood as object-centred evaluations. Rather, they fundamentally address those actors and institutions that are perceived as responsible for technological decision-making. Technologies thereby function as proxies or mediating reference points through which broader evaluations of responsibility, accountability, and legitimacy are articulated. Public support or opposition is thus less a direct reaction to the intrinsic properties of a technology than an expression of confidence or distrust in the governance arrangements, communications, and decision-making of the actors “behind” it. To adequately capture this transformation, we propose in the following an expanded acceptance research framework that explicitly integrates the “technology responsible” as a central analytical category. Building on the established dyad of acceptance subject and acceptance object, we introduce a triad including a third, distinct dimension: the technology responsible as key addressee of technology acceptance. Thus, in our view technology acceptance judgments arise with references to subject, object and its responsible – addressing essentially the latter.

3. The technology acceptance triad: subject, object – and its responsible

As illustrated above, literature primarily differentiates acceptance analytically into a subject and an object component. In addition, several acceptance models postulate a contextual environment as an independent area of decisive acceptance impact. Acceptance subject refers to an individual person or collective actors since only human beings are individually or collectively able to decide on and express their acceptance judgement. Thus, acceptance is always related to individual and/or collective-institutional actors who decide actively on acceptance matters based on a (more or less elaborate) opinion forming process. As such, acceptance is inevitably embedded in a social world and setting. Furthermore, acceptance decisions and manifestations are an act of communication in its various forms (e.g., linguistic statement, specific forms of action and behaviour).

An acceptance object, in contrast, is the reference point on what the acceptance decision is made. While the acceptance subject is tightly bound to people or collective actors, this is not the case for the acceptance object. An acceptance object can be both actor-related (e.g., behaviour, role or attitude of a person) or tangible-object related (e.g., technology, infrastructure or product). The object is the primary source and first reference point of acceptance decisions. When no object is in reach, no acceptance judgement is made. Thus, acceptance decisions are based first of all on the acceptance object as primary reference points.

However, not all objects stimulate likewise acceptance judgments, decisions, and manifestations. What is needed is the fact that a person is in one way or another affected by a referenced object. A person, for instance, may (not) accept a planned construction of a chemical plant or coal plant in close neighbourhood or a particular behaviour of a close friend. However, it is highly unlikely that this person would make acceptance decisions about the construction of a chemical plant or another person's behaviour on the other side of the world where hardly any or even no social relations exist. Perceived factual spatial or socially constructed proximity leading to affection are crucial for acceptance decision processes. Affection dimensions are complex and do not relate only to spatial proximity, but also to social norms and values, perceived and experienced risk, damages and benefits etc. On a very generic level, one may differentiate between self-experienced and communicated technology affection. Self-experienced affection refers to one's own usage of a technology and thus acceptance judgments are strongly nourished by one's own direct technology experience with, for instance, everyday product and work life technologies. But technology affection can also be mediated by communication in case a technology is not directly accessible for personal use, and other actors publicly communicate on existing or forthcoming benefits and/or drawbacks of a technology. In this case, technologies may also serve as symbolic scapegoats attributed as stigmatized risk source [52]. This may be the case for so-called external or large-scale technologies such as energy technologies (e.g., nuclear, coal and natural gas plants, power-to-X plant) or energy infrastructures (e.g., power transmission lines).

While most concepts of acceptance end here, we find it necessary to add a further element to better understand the social process of acceptance opinion-forming and decision-making: that is what we call the acceptance receiver, technology object holder and responsible – in short, the technology responsible. Acceptance decisions are communication acts embedded in interpersonal and institutional social settings. They are first and foremost targeted towards other people and their decisions, namely the ones who are perceived as being responsible for the acceptance related technology object. When a person states acceptance or non-acceptance having a technology object in mind, for instance, a coal plant, wind farm, or hydrogen facilities and infrastructures, the acceptance statement is not directed towards the technological artefact itself. Why is this the case? Simply put, a technological artefact would not respond to or engage with such a message. The response would simply be silence – and the statement sender surely is aware of that. Instead, the message is intended to go beyond, to address “the ones behind”. The acceptance message is from the very beginning targeted towards the persons and/or institutions (perceived as) responsible for the decisions taken to develop, construct, and implement the coal plant, wind farm or hydrogen industry. What is crucial here is the fact, that acceptance decisions and manifestations are always targeting towards the ones holding responsible, that is developing, owning, licencing, implementing, managing and regulating the technology – as such affecting other people. Technology object and responsible build some kind of symbiosis. The responsibility for the acceptance objects is, besides the perceived technology impacts of the object itself, crucial for making acceptance judgments. Issues of the decision-making process such as perceived fairness, necessity, and credibility then also come into play. Thus, trust in the object responsible has been stressed as crucial factor influencing acceptance levels [45,53–55].

We synthesize our understanding of technology acceptance formation in Fig. 1 differentiating between acceptance subject, object, and responsible. In the following subsections, we will detail relevant aspects of the proposed acceptance model.

3.1. The acceptance object: the role of technology types

Modern societies are deeply interwoven with a great variety of technologies. People have easy access to, and are surrounded and affected by technologies [56]. That raises the concern of whether technologies have a positive or negative impact on individuals or the society as a whole. Technology conflicts in society, therefore, are reflections and manifestations of these concerns. Debates and controversies on technologies have become a structural element in modern life and politics [7] – irrespective of whether science is dealing with it or not. Thus, technology assessment and evaluation are a daily fact undertaken by citizens, lay people, scientists, politicians and so on. Technology attributes as perceived by the subjects play an important role in the evaluation process [57].

However, acceptance decisions are highly influenced by the type of technologies reflecting specific attributes. A useful distinction has been made to cluster technologies with respect to people's responses and acceptance judgments to technologies [58,59]. Classes emerge from the multitude of technologies forming fairly consistent patterns of perceptions (see Table 1), these are: (i) *household and leisure technology* as a consumer product where acceptance is part of the market system of purchase; (ii) *technology at work* as a tool for work or vocation where acceptance is part of the corporate decision-making process; and (iii) *external technology as a neighbour* where acceptance is part of a policy making process.

The three areas of technologies can be categorized according to their main allocation field, acceptance test, and dominating conflict areas. Examples of everyday technologies are, for instance, mobile phones, cars, and household appliances – the acceptance test here refers to active purchases of these products within the allocation procedure of a market. Technologies at work refer, for instance, to computers, machine tools, or production facilities – the acceptance test manifests in active usage of these products by employees in their work life. External technologies, in contrast, are large-scale technologies such as a chemical plant, infrastructures, or genetic modified organisms where people in general do not have direct knowledge and experience. Implementations of external technologies are largely decided by policy decisions and are beyond direct control and personal experience of the affected people. The acceptance test in this area is twofold: conventionally, people decide within formal political decision-making procedures (i.e., elections,

Table 1
Types and attributes of technologies.

Attributes of technology	Type of technology: Household & leisure technology	Technology at work	External technology
Allocation	• market	• corporate decision making	• interface of economy, politics, civil society
Test for acceptance	• purchase	• active utilization	• conventional: voting • unconventional: protest
Conflict areas	• liability, quality, external effects	• rationalization, stress, co-determination	• equity, legitimacy, vision of the future
Technology access	• voluntary experience	• involuntary experience	• communication, involuntary experience
Risk-benefit focus	• benefits	• benefits	• risks
Risk avoidance option	• easy exit	• difficult exit	• no exit
Risk-related qualities	• weak	• modest	• strong

Source: adapted from Renn [59,p. 32] with own revisions and supplements.

voting, planning processes) whether or not to support these technologies (pushed by “the ones behind”), or in an unconventional way, people raise their voice for or against these external technologies via street protests, social media expressions etc.

Identified types of technologies also differentiate between technology accesses, the risk-benefit focus, and risk avoiding options. Household and leisure technologies when purchased by consumers are under their own control and own supervision. People buy consumer products generally for their own or peer group usage. Thus, people experience benefits and risks of these products voluntarily through their daily use. Technology affection here is mediated by experience through personal usage. Purchase of products yields to enjoy their benefits (e.g., reduced workload, entertainment, and reputation) while accepting corresponding disadvantages. Thus, the focus is on benefits rather than on risks. In addition, there are easy risk exit options by no further using or re-selling the product. Technology at work likewise affects employees by own experience with using these technologies for work albeit usage is often involuntarily ordered or at least highly recommended by the company. Thus, exit strategies are more difficult to undertake. Unwillingness to use these products due to perceived higher risks than benefits can also rely on collective power of workers' representation and dealt within negotiations of co-determination. Thus, the risk avoidance option is rather difficult but not impossible. The introduction of technologies at

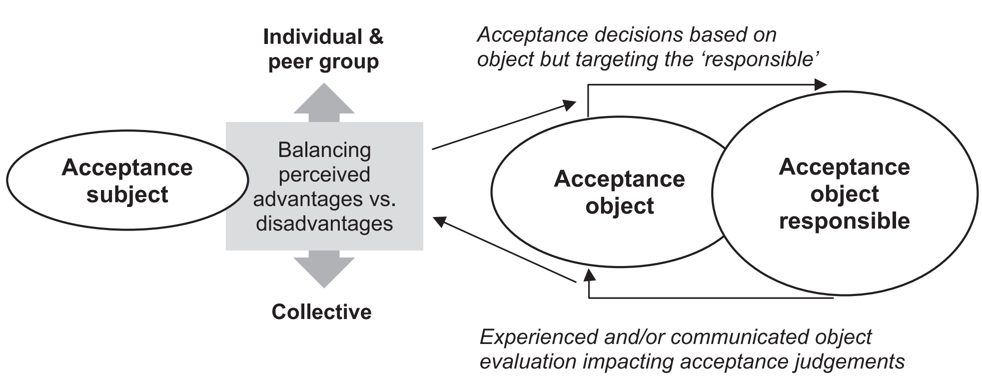

Fig. 1. Acceptance model differentiating subject, object, and responsible
Source: own elaboration.

work also focusses on the belief in additional benefits. However, risk-benefit judgments may fall apart between decision-makers and affected workers. While business leadership may favour the introduction of new work technologies for company and business reasons (e.g., cost savings, rationalization, competitive advantage, supporting the management structures), the workforce may suffer from higher risks (e.g. new routinization needs) with actually applying new technologies. In the field of external technologies, affection is in general mediated by communicating corresponding risks and benefits. The public discourse, expert statements from science, politics and business, and peer group communication debate risks and benefits of external technologies. In general, these debates are characterized by opposing views, dissent, and controversies on risk and benefit evaluation. The acceptance subject, hence, relies on a social construction of the technology's significance and its communication. Direct but involuntary experience is only given in case of implemented technologies in spatial proximity of affected residents. External technologies are much more discussed from a risk than a benefit perspective, and no individual risk exit option by the affected public is available in case the technology is implemented.

From a risk perspective, people's attitudes and preferences towards technologies have been studied primarily within the so-called psychometric risk perception approach [57]. This approach quantitatively describes the cognitive and evaluative structure of risks and their determinants, and uses risk as a subjective concept, completely distinct from the idea of risk as an objective entity. Field studies in risk perception research reveal a set of both risk-related, and situation-related characteristics [60]. The risk-related patterns are based on the perceived properties of the source of risk – in our case the technologies. Thus, risk perception among lay people is influenced by perceived technology attributes. Literature identified several influencing qualitative factors in this area, for instance, dread with regard to possible consequences, familiarity with a risk source, the magnitude of potential damage, the nature of risk (human or natural), and the reversibility of risk consequences [57,60–62]. As a generic conclusion, we assume risk-related qualities are weak in the area of household and leisure technology, modest for technologies at the workplace, and strong in the field of external technologies where people are confronted with uncertainties regarding negative side effects.

3.2. The acceptance subject: and its scope of (non-)acceptance

Acceptance subjects as individuals and/or collective actors are the providers and senders of (non-)acceptance referencing an acceptance object but addressing the decisions of the responsible. A closer examination of acceptance subjects raises key questions: What constitutes acceptance, and how does the process of its articulation and provision unfold? Semantic roots reveal acceptance is related to a person's assent, approval and affirmation towards someone or something. It is a positive statement based on the willingness to agree with the 'raison d'être' of the acceptance object. Willingness refers to free will decisions where acceptance is understood as a conscious attitude and active decision to acknowledge reality as it is or is perceived including difficult situations, thoughts, and feelings. As a consequence, technology acceptance cannot be manufactured by others. In that sense, acceptance provides legitimacy towards the object for the right to exist – thus, it justifies its existence. In case the 'raison d'être' of an object is disputable in society, acceptance subjects might advocate, defend or even fight for the right of existence – and vice versa, that is acceptance subjects (actively) oppose the right of existence.

In this regard acceptance has several facets that we will differentiate further. Acceptance requires an individual's voluntary decision based on a process of balancing several pro and con arguments (explicitly or intuitively) making finally a decision towards acceptance or non-acceptance. However, there is room for gradual interpretations of (non-)acceptance, since it can be weak or strong. We propose here an acceptance scale model as displayed in Fig. 2 which comprises knowledge from existing literature.

Acceptance decisions can either result in a specific attitude towards the acceptance object without any related behavioural reactions or in a specific attitude that even translates in a behavioural response towards the acceptance object. In the first case, a passive (and potentially unstable) tolerant or intolerant position prevails. Passive positions might be due to the fact that the level of affection is not adequate to stimulate distinct behavioural responses. In case of strong (non-)acceptance, in contrast, a clear-cut decision in favour or against the object is made that translates into respective behaviours as either active support or active opposition. As a consequence, one might differentiate between strong and weak (non-)acceptance regarding the 'raison d'être' of an acceptance object. As such, strong (non-)acceptance tends to manifest in strong active support or opposition while in-between forms decrease towards passive attitudes subsequently (i.e., in refusal/approval, conditional (non-) acceptance, and indifference/tolerance). While passive attitudes might turn into active support or opposition one day, it is rather unlikely that active support or opposition falls back into the area of passiveness. (Non-)acceptance decisions resulting in related behaviours tend to be more stable, whereas passive attitudes may be both

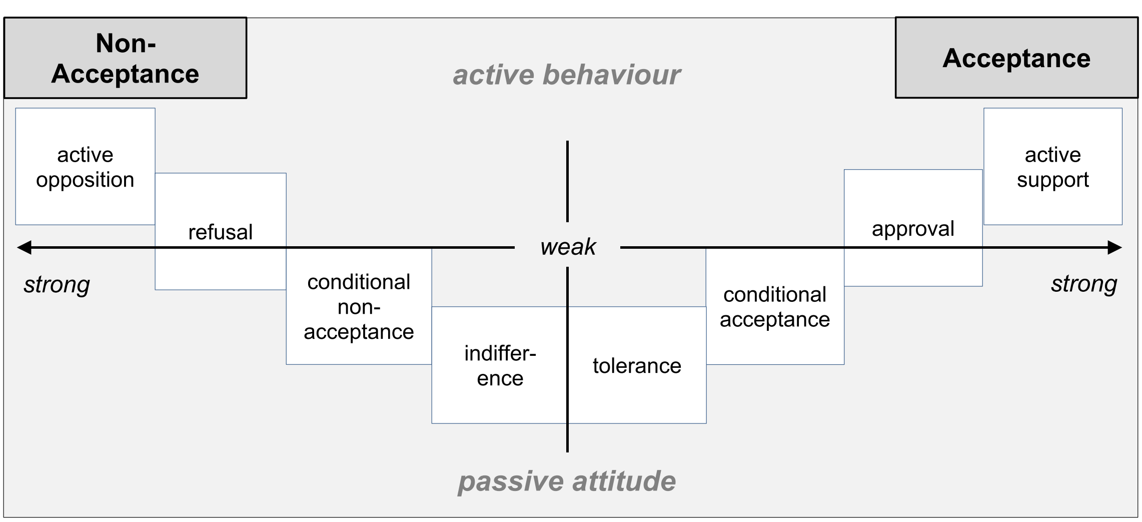

Fig. 2. The scope of acceptance decision manifestations
Source: own elaboration based on conceptions by Sauer et al. [63].

stable and unstable.

Another facet of (non-)acceptance is to look deeper into the mechanisms of the opinion-forming and decision-making process. On a general level, people evaluate technologies by balancing their benefits and threats and costs respectively. A positive balance with benefits outweighing the costs results in technology acceptance, while a negative balance with higher perception of risks and negative outcomes leads to technology rejection and non-acceptance. The situation is more complicated, however, as people evaluate benefits and threats of a technology object from both a personal or peer group and a collective perspective. Acceptance relies on the one hand, on the belief that a technology has considerable benefits for one's self or for people close by (individual evaluation); on the other hand, acceptance may also refer to society as a whole (collective evaluation). Thus, people accept technologies when they serve the common and individual good. Technology acceptance is given, when both personal or peer group and collective balancing is positive; non-acceptance of a technology is given, when the balancing is negative.

However, people do not always arrive at a clear assessment in which either harm or benefit is collectively and individually uniquely determined. Of particular interest for technology acceptance research is the assessment in which individual and collective judgments diverge, i.e., high benefits are perceived individually, but high costs are perceived collectively (or vice versa). On the one hand, there is evidence that people pursue selfish goals despite a perceived social benefit. On the other hand, there is also human behaviour that consciously foregoes personal advantages in order to benefit the common good. Research shows that people are very willing to do without personal benefits when they are convinced that the technology serves the common good and overall social preferences [64,65]. Social preferences refer to the fact that people care about certain “social” goals, such as the well-being of other individuals, or a “fair” allocation of risks and benefits among members in society. In the case of energy technologies, this refers to perceived forms of energy ethics or energy justice [66]. However, what can also be observed is the contrary, namely the fact that people act selfishly even though they know that their behaviour disadvantages others or the common good in general (e.g., non-acceptance of renewables in spatial proximity though the common good of them is on general level acknowledged). It needs to be stressed that the substance of costs and benefits are not limited to pure direct economic and monetary units. Cost and benefit considerations address wider contexts in technology acceptance judgments. They refer to economic considerations (e.g., personal or societal monetary costs for technology provision), ecological and health considerations (e.g., technology impacts on the environment and humankind), socio-cultural considerations such as cultural identity and normative conceptions of a ‘Good Life’, loss of trust in policy-makers and business leaders, and their way of communication and opaque decision-making processes which leads to transferring their bad reputation on technology judgments.

To summarize, strong (non-)acceptance manifests in behavioural responses towards the acceptance object: people buy, use, vote, or protest expressing their decision on (non-)acceptance of technologies. Only when people are strongly in favour or against technologies they act – in case the acceptance judgement is weak and lies in the area of passive attitudes they do not. With regard to the types of technology acceptance and behavioural manifestations differ. In the area of everyday and work technologies behavioural manifestations only refer to strong acceptance with people buying and using technologies while non-acceptance is not immediately apparent and is only indirectly present with non-purchases. People not using or buying distinct technologies is not a standalone indicator for non-acceptance but may relate to a great variety of reasons (e.g., no interest, no resources, lack of user skills etc.). This is different for the field of external technologies. Taking the conventional procedure of acceptance test as indicated in Table 1, all types are visible. Strong acceptance manifests in voting pro technologies or engaging in their implementation (e.g., by becoming a member of an energy cooperative). Strong non-acceptance, in contrast, manifests in voting contra technologies or protesting against technology projects in the street. Interestingly, it is particularly strong non-acceptance which manifests in protest behaviour. People, in general, take the streets for protesting against technologies while strong pro technology protests are rare. Thus, for external technologies acceptance manifests rather in conventional forms such as voting while non-acceptance rather chooses unconventional forms with street protests.

3.3. *The responsible: why it matters to focus on responsibility*

With the analytical category of the responsible actor, we introduce an additional dimension into acceptance research, referring to those actors perceived as accountable for the design, implementation, and governance of technologies. While elements of this dimension – such as trust or procedural justice – are already common constructs in acceptance research, our aim here is to provide conceptual simplification and clarification. In our view, the responsible actor constitutes a third crucial analytical category, alongside the acceptance object and the acceptance subject.

Our central argument is that acceptance judgments are not merely evaluations of technological artefacts but communicative acts *directed towards the actors behind them* – particularly in the context of the above introduced “responsiveness turn”. When individuals express support for or opposition to a technology, their reactions implicitly address those responsible for making decisions about that technology. The necessity of introducing this analytical category becomes particularly evident when examining acceptance dynamics across different domains of the contemporary energy transition, such as renewable electricity projects (solar and wind) and hydrogen infrastructure development. In the following, we briefly examine these cases in order to highlight the relevance of the responsible actor category. This brief case application also reveals distinct ways in which the evaluation of responsible actor shapes acceptance.

In many debates surrounding solar and wind projects, the focus of public concern shifts from the technology itself to the actors responsible for planning and implementation. While renewable energy technologies are often broadly supported at the societal level because of their role in addressing climate change and enabling the energy transition, local conflicts frequently emerge once specific projects are proposed. In these situations, public discussion often moves away from the abstract benefits of renewable energy and towards the intentions, credibility, and behaviour of those responsible for implementing the project. This shift occurs because renewable energy infrastructures are embedded in social and institutional contexts. Decisions about where projects are located, how they are designed, and how their impacts are managed are not determined by technology alone but by planning authorities, developers, investors, and political institutions. In this context, local controversies frequently revolve around questions such as [67–75]:

- who develops and owns the project,
- whether local communities were involved in planning processes,
- how financial benefits are distributed,
- whether decision-making procedures are perceived as fair.

These questions point to a broader shift in the object of evaluation. Rather than assessing renewable energy technologies purely on the basis of their environmental performance or technical characteristics, communities frequently evaluate the institutional and social arrangements through which such technologies are implemented. In other words, acceptance debates often center on governance structures, responsibilities, and relationships between project developers, authorities, and local residents – i.e., the technology responsibles are addressed. Thus, acceptance judgments are strongly shaped by evaluations of governance arrangements and governance actors [27,76]. A solar park developed by a locally embedded cooperative may be perceived as legitimate and beneficial for the community, while a similar project implemented by an external developer can provoke resistance because the responsible actors are seen as lacking local accountability [72]. In the first case, local ownership structures can create a sense of shared responsibility and collective benefit, which can enhance perceptions of legitimacy. In the second case, the project may be perceived as externally imposed, particularly if residents feel excluded from decision-making or believe that profits will primarily flow to actors outside the region. The same dynamic can be observed in wind energy development. Residents often emphasize that they support renewable energy in general but oppose a particular project because they distrust the developers or perceive the planning process as unfair [45]. Such statements illustrate that opposition does not necessarily reflect a rejection of the technology itself, but rather dissatisfaction with the actors and procedures involved in its implementation. In such situations, the technological artefact – the wind turbine or solar installation – serves primarily as a focal point for debates that actually concern the legitimacy of responsible actors. The visible infrastructure becomes a symbol through which broader concerns about power, control, and fairness, shaped by those responsible for the technology, are articulated. Residents may question whether project developers are acting in the public interest, whether local authorities adequately represent community concerns, or whether economic benefits are distributed in ways that reflect principles of fairness and reciprocity [77]. Thus, in renewable electricity projects, acceptance is closely linked to governance legitimacy [27]. Communities evaluate whether those responsible for technological implementation are trustworthy, responsive, accountable and act in a fair manner. From this perspective, references to trust, procedural justice, and distributive justice all ultimately address those behind the technology.

While solar and wind technologies are already widely deployed, hydrogen systems – including large-scale production plants, pipelines, and storage facilities – are still emerging components of the energy transition. Consequently, public familiarity with hydrogen technologies is relatively limited [78–80]. Many individuals lack direct experience with hydrogen infrastructures, and their knowledge about potential risks and benefits is largely mediated through communication by experts, policymakers, and industry actors. This lack of experiential knowledge creates conditions of uncertainty in which the evaluation of technological attributes becomes more difficult for acceptance subjects.

Under conditions of uncertainty, acceptance judgments tend to rely more strongly on institutional trust [81,82]. Instead of evaluating the technical characteristics of hydrogen infrastructures themselves, individuals often focus on the actors responsible (sic!) for developing and regulating these technologies. Thus, public debates surrounding hydrogen projects frequently address questions such as [83–86]:

- whether industrial actors are pursuing hydrogen primarily for climate protection or economic gain,
- whether regulatory authorities are capable of ensuring safety,
- whether public subsidies for hydrogen projects are justified and transparent,
- whether risks and uncertainties are communicated openly.

These debates illustrate that acceptance in the hydrogen case is shaped by perceptions of institutional credibility and competence. Because technological attributes are difficult to evaluate directly, individuals rely on their trust in responsible actors as a heuristic for judging the technology [87]. Thus, while renewable electricity projects highlight the importance of governance legitimacy at the local level, hydrogen infrastructures emphasize the role of institutional trust under conditions of technological uncertainty.

Comparing the two cases suggests that acceptance processes in both contexts depend strongly on evaluations of responsible actors, but the mechanisms through which responsibility becomes relevant differ. In renewable electricity projects, technologies are relatively well known, and the main controversies emerge during the local implementation of concrete projects. Acceptance therefore depends largely on governance actors and the institutional arrangements they shape, including participation processes, ownership structures, and the distribution of costs and benefits. Communities evaluate whether those responsible for the project act in a transparent, fair, and accountable manner. In the case of hydrogen infrastructure, by contrast, technological uncertainty plays a more prominent role. Because most individuals lack direct experience with hydrogen technologies, they rely on trust in institutions to evaluate potential risks and benefits. Acceptance judgments therefore focus more strongly on the credibility and competence of regulators, policymakers, and industrial actors. Despite these differences, both cases demonstrate that acceptance judgments ultimately address the actors responsible for technological decisions rather than the technologies themselves. The technological artefact serves as the visible object of debate, but the underlying evaluation concerns the legitimacy, trustworthiness, accountability, and practices of "the ones behind" the technology.

3.4. Acceptance factors: contextualizing subject, object and its responsible

Integrating our considerations with regard to the state of research

Table 2
Acceptance factors contextualizing subject, object, and responsible.

Subject	Object	Responsible
Socio-demographic factors • age, gender, social class, education Sources: [33–35,88,89]	***Technology related factors*** • scale and type • Technology alternatives • Perceived risks, costs, benefits Sources: [90–93]	***Institutional factors*** • ownership structures • distribution of risks and benefits Sources: [24,70,94–98]:
Attitudes • Political and environmental belief • Place attachment • technologies in general Source: [37,39–41,99–103]	***Socio-technical factors*** • Public discourse on object • Organisational implementation • Assistance with technology implementation • Responses of others when implemented • Socially assigned object value Sources: [41–43,104,105]	***Procedural aspects*** • Perceived fairness • use of participatory approaches Sources: [45,93,106–110]
Values and worldviews • entrepreneurial, egalitarian, bureaucratic Sources: [36,38,111–113]	***Spatial factors*** • regional and local context • spatial proximity Sources: [44,103,114,115]	***Actor related factors*** • Credibility, reputation, identification, salient value similarity, trust Source: [45,93,116–119]
	Knowledge • Communicated knowledge: awareness and understanding • Experienced knowledge: prior experience with object Sources: [102,106,120–125]	

Source: own elaboration.

and the differentiation between acceptance subject, object, and responsible, in Table 2 we systematize acceptance impact factors mainly derived from existing literature in order to simplify and harmonize knowledge of acceptance factors with our proposed triadic framework.

Acceptance factors associated with *the subject* comprise (i) socio-demographic factors (e.g., age, gender, and education), (ii) general attitudes on political and environmental belief, technologies in general, and place attachment (i.e., positive emotional bonds between people and valued environments), and values and worldviews (i.e., entrepreneurial, egalitarian, bureaucratic) as pointed out in the cultural theory of risk [126] (for overviews of acceptance factors see: [33,34,127–133]). These factors do not determine in detail the acceptance decision regarding a specific object but rather serve as a primary channel and a fundamental guide towards the decision. These sociopsychological dispositions covering fundamental orientations are rather inactive provided no object affection is given. In case acceptance decisions are stimulated by object affection, one may assume that these dispositions work implicitly in the background in order to fundamentally channel the acceptance alignment by reducing complexity and implicitly provide a limited choice of decision options.

Among acceptance factors associated with *the object*, we differentiate between technical, socio-technical, spatial and knowledge factors. Technical issues relate to the scale and type of the technological artefact, the perceived technology impacts such as risks, costs, and benefits, and existing alternatives competing with the object in question. Socio-technical issues are at the interface between the object and the social environment. These factors relate to the public discourse in the media on the technology, the type of organisational implementation, assistance to help get familiar to the object when implemented (e.g., technologies at work), and social responses as perceived by the acceptance subjects (i.e., responses of others when the technology is implemented, socially assigned object value). Spatial factors relate to the regional and local context, and the spatial proximity of installed external technologies since direct experience with the object (e.g., noise, smell, visibility etc.) varies with distance. Spatial qualities are especially significant when landscapes of particular symbolic significance (e.g., natural monuments) are affected by a local energy project. The last factor relates to the level of knowledge based either on prior personal experience or the level of awareness and understanding. Regarding local energy projects prior positive experiences with the respective technology can have a positive influence on acceptance [121]. New wind turbines are perceived as more acceptable in communities, where wind turbines are already located. However, negative experiences, e.g., with poorly designed participation processes, have a diminishing effect on acceptance [43]. Historical experiences that are part of the collective memory of a specific social group can influence acceptance as well.

Acceptance factors associated with the *responsible* cover institutional, procedural, and actor-related issues. Institutional factors comprise ownership structure, the distribution of costs and benefits: the implementation of an acceptance object such as a wind farm can be structured in different ways. Thus, institutional factors vary from case to case. However, institutional factors such as ownership structure or distribution of costs and benefits shape acceptance as well. For example, a community-owned energy production facility is more likely to be accepted than one owned by a big energy company without any local ties [70]. Procedural aspects of decision-making regarding the acceptance object have also been proved an important acceptance factor. It is well known that the perceived fairness of decision-making processes influences the acceptance of its outcomes [131,134]. Therefore, the design of decision-making processes, especially public participation, is crucial for acceptance. Often local energy projects fail because of decision-making processes that are perceived as unfair. Finally, actor related factors such as trust, assigned credibility, reputation, and perceived value similarity also matter. Together, these factors position the technology responsible not just as a technical developer, but as a socially embedded actor whose legitimacy depends on fair structures, inclusive processes, and trustworthy relationships.

4. Conclusions

In this paper, we have argued for an understanding of technology acceptance that further transcends the traditional duality between the accepting subject and the accepted object. By introducing the concept of the responsible – the "ones behind" technology decisions – we emphasize that social (non-)acceptance does not pertain solely to artefacts or technical systems, but also and foremost to the actors and institutions accountable for their design, implementation, and governance. Acceptance thus emerges as a fundamentally *relational and communicative process* embedded in socio-cultural contexts of trust, fairness, and perceived legitimacy. Particularly in the context of the responsiveness turn, acceptance fundamentally targets those actors and institutions responsible for technological decision-making. While factors related to the accepting subject, the accepted object, and the responsible actors have been discussed above, we now elaborate on key implications for the design and advancement of empirical research arising from our focus on responsibility attribution.

First, empirical studies have begun to move beyond an object-centred operationalization of acceptance, but this shift should be further strengthened. Our framework requires systematically capturing how individuals attribute responsibility for technological decisions. This implies the need for measurement instruments that explicitly identify which actors are perceived as accountable and how responsibility is distributed across institutional constellations. Such an approach allows researchers to distinguish between evaluations of technologies and evaluations of those who govern them – an analytical separation that remains largely absent in the current state of the art.

Second, responsibility-centered variables such as trust should no longer be treated as core components of acceptance formation, particularly under conditions of uncertainty with regard to side-effects of the technology object. This requires multi-dimensional and actor-specific measurement of trust (e.g., towards public authorities, private firms, and scientific institutions), thereby moving beyond generalized trust constructs.

Third, incorporating perceived intentions and motivations of responsible actors opens a new empirical dimension that has so far been underexplored. In our opinion, acceptance research has largely neglected how individuals interpret the goals and interests driving technological development. Future studies should therefore include measures that capture whether actors are perceived as acting in the public interest or pursuing particularistic economic or political objectives. This extension enables a more nuanced understanding of legitimacy perceptions and their influence on acceptance.

Fourth, the inclusion of accountability and responsiveness introduces a dynamic perspective that extends existing acceptance models. Empirical research should therefore move towards longitudinal and process-oriented designs capable of capturing how acceptance evolves in response to institutional behaviour over time. Measuring perceived responsiveness – such as the extent to which actors react to public concerns or adapt policies – enables researchers to analyse feedback loops between governance practices and societal evaluations, a dimension that is largely missing in current acceptance research.

In terms of practical implications, we advocate for the institutionalization of accountability. Policymakers should establish clear and formalized lines of responsibility among public authorities, private firms, and research institutions concerning both technological decisions and objects. As previous research has shown, transparent attribution of responsibility can enhance legitimacy and public trust. From a governance perspective, technology policy frameworks should also be designed for iterative adaptation in response to emerging societal concerns. Mechanisms such as feedback loops connecting regulators, developers, and citizens can strengthen responsiveness. Correspondingly, clear, consistent, and evidence-based communication regarding technological risks, benefits, and trade-offs should be institutionalized. Against this background, policymakers and acceptance object responsibles should invest in trust-building communication that is dialogical rather than paternalistic.

Finally, future research should empirically examine the proposed model across diverse technological domains and societal contexts. In particular, investigating how responsibility and responsiveness are perceived and enacted may reveal new pathways towards more legitimate and socially robust technology governance. Ultimately, recognizing and addressing "the ones behind" technology decisions is essential for fostering sustainable and socially resilient socio-technical transformations.

CRediT authorship contribution statement

Dirk Scheer: Writing – review & editing, Writing – original draft, Conceptualization. **Marco Sonnberger:** Writing – review & editing, Writing – original draft.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dirk Scheer reports financial support was provided by Karlsruhe Institute of Technology. Dirk Scheer reports a relationship with Karlsruhe Institute of Technology that includes: employment. no other activities influenced the work If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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

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