A conceptual framework for understanding the social acceptance of energy infrastructure: Insights from energy storage

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Abstract

Although social acceptance research has blossomed over the last decade, interdisciplinary studies combining market, socio-political and community aspects are scarce. We propose a novel integration of social science theory in which the belief systems or social representations held by key actors play a crucial role in fostering acceptance of novel technologies, and where a polycentric perspective places particular emphasis on ways that middle actors mediate processes of change between scales. We advance a methodological approach that combines qualitative and quantitative research methods and exemplify the framework by focusing on acceptance of renewable energy storage solutions to accommodate high levels of renewable energy deployment. A research agenda for the social acceptance of energy storage is proposed that sets out key research questions relating international, national and local levels. The outcome of such studies would not only lead to enhanced understanding of processes of social acceptance, but deliver important insights for policy and practice.

Keywords: social acceptance; energy storage; renewable energy.

1. Introduction

Social acceptance has been a prominent topic of research by energy social scientists for at least the past decade [1-5]. In this article we propose a novel, interdisciplinary conceptual approach to explain why changes to energy systems are accepted or resisted in different ways in different geographical contexts. We elaborate the methodological requirements needed to develop this approach empirically, and trace a pathway for research to address a novel and hitherto neglected topic: the social acceptance of renewable energy storage.

We adopt a critical approach to social acceptance, mindful of how energy social science research has been skewed towards understanding resistance to technology implementation by the 'NIMBY' concept (Not In My Back Yard) [3], with the result that research into support has been neglected by comparison, associated with a focus on public responses to the detriment of policies, institutions and other stakeholders [6]. For example, it has already been demonstrated how different epistemological and methodological frameworks lead to different policy conclusions (e.g. [6], [7]). These indicate how positivist, quantitative, and individualist frameworks produce partial pictures of the social acceptance of energy technologies, failing to consider the role of different actors, their expectations and interactions, and the diverse materialization of technologies at different scales.

In contrast, our approach aims to provide a first step in understanding the full gamut of societal beliefs about, and responses to technological change, including objections and resistance, support and adoption, apathy, disinterest and disengagement [8], and by different actors (e.g. companies including smaller enterprises and incumbents;

policy makers and regulatory bodies; nongovernmental organizations and other members of civil society, the media and local residents).

A highly cited framework proposes three dimensions to social acceptance: markets, socio-political and community [2], with a revised version separating the political from the societal/community aspects [4]. Whilst the framework is useful for distinguishing contrasting aspects of acceptance, each involving different actors, it is weakened by a lack of emphasis upon how each dimension inter-relates across different geographical scales (from macro to micro; international, national and local). Moreover, we observe that few empirical studies have encompassed more than one of the three aspects in their respective analytical frames.

Our interdisciplinary approach to social acceptance integrates theoretical ideas from social psychology (social representations theory, [9,10]), governance (polycentric governance and the role of middle actors), [11]) and human geography (micro to macro scales, [12]). It is therefore similar to theories of social practice, but still different in that we go beyond materials, competences, and meanings [13] and extend our analysis beyond the unit of a practice or circuit of practice.

Social representations theory (SRT, see [9,10]) explains how social knowledge changes over time. Specifically, it elaborates the socio-psychological processes through which actors make sense of change, or what happens when a new idea or technology (e.g. renewable energy storage) becomes more widely known, talked about and understood in society. The process of understanding is theorised as operating simultaneously at *both* individual and societal levels. Communication is central to the theory, as it is the basis of constructing knowledge and our understanding of the objects around us, and is shaped by power asymmetries between actors.

Communication is often studied by analysis of public talk during focus group discussions and by analysis of media reporting, as the media are considered within the theory as one of the most important actors in circulating and shaping public representations of social and potentially controversial issues. Social representation processes are also present and revealed by communications amongst actors within economic and political systems and by institutional arrangements that will influence how belief systems change and develop over time (e.g. [14]). This is why the theory of social representations is suitable for research on social acceptance that integrates policy, market and civil society actors. In turn, social representations theory can also be articulated with insights from other important theories regarding people's relations with technologies, such as theories of practice (see [6] for an extended discussion) that are useful to examine social acceptance at the local level.

In theories of energy system change, actors are typically positioned at either national/regime or local/niche levels (e.g. [15]). The Wüstenhagen et al. [2] framework exemplifies this by reference to (national) socio-political and (local) community dimensions. Although important, this neglects the role that 'middle-actors' play in driving (or obstructing) system change, and in diffusing innovative technologies and practices. Middle actors refer to those who work from the 'middle out' with the agency and capacity to influence transitions by making change upstream (to top actors), downstream (to bottom actors) and sideways (to other middle agents) [11].

Accordingly, we take a polycentric perspective [16] on the process of social acceptance of energy system change. This involves investigating actors that are working independently of each other at macro, meso and micro levels within the same energy system, thus transcending both conventional 'top-down' *and* 'bottom-up' understandings to investigate the complex dynamics between technological solutions and actors over time. This requires analysis of multiple societal groups [17], remaining

cognizant of the potential implementation of novel technologies at different levels/scales, with a particular interest in the dynamics *between* several levels of decision-making and intertwined policy areas that encompasses both public and non-governmental strategies and actors [18]. At the same time, we recognise that incumbents may find current processes and accompanying changes as a challenge to conventional belief systems and ways of working. Path dependence may create a form of lock-in [19] or inertia to change – even if change is politically approved and socially acknowledged. This has already been documented by studies of renewable energy policy implementation in Europe [20].

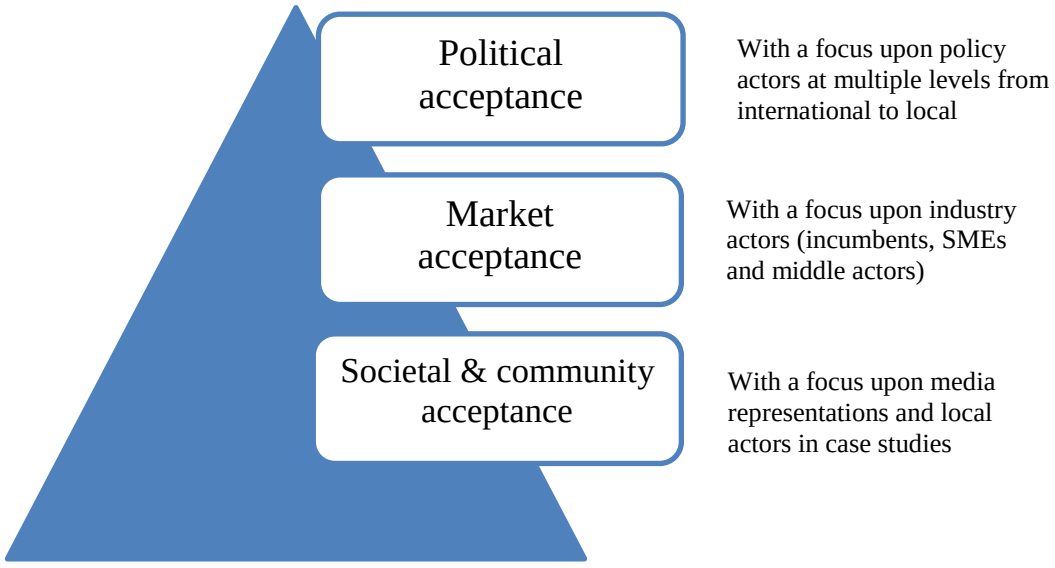

Figure 1. Holistic approach to social acceptance (following [2])

At its core, our integrative framework focuses upon the role of belief systems held by diverse social actors (e.g. policy makers, journalists, community leaders), based on the assumption that these are crucial to social acceptance within each of the three dimensions proposed by Wüstenhagen et al. [2], and cannot be understood without also taking existing political, economic, socio-cultural and geographical factors into

account. Hence, the scope of our approach is holistic and interdisciplinary. Cross-cutting these levels, we use the geographical concept of scaling as an analytical lens, mindful that the scale at which energy systems generally, and energy storage in particular, are deployed is not preordained [21].

2. From theory to application – assessing the social acceptance of renewable energy storage

High levels of renewable energy deployment (e.g. wind and solar) are a fundamental element of policies for the low carbon transition and for responding effectively to the threat of climate change (e.g. [22]). However, there are significant challenges involved with balancing supply and demand in a system with high levels of variable or intermittent energy sources [23], challenges that have been a longstanding concern of system experts (e.g. [24]). The curtailment of renewable energy generation is already a widespread global phenomenon [25], leading to loss of revenues, threats to the satisfaction of basic needs and delay in progressing climate change mitigation.

Energy storage is one of a number of measures proposed to deliver system flexibility, and is an area of rapidly developing technological and economic activity [26]. Storage solutions, like many energy technologies, can be deployed at a range of scales, involving many forms of 'hardware' and 'software' (cf. [27]). Storage hardwares encompass systems at the micro level that might be installed in domestic settings (or taking advantage of the batteries already installed in electric vehicles), at the meso level, for example larger scale solutions that might be attached to a particular renewable energy project such as a ground-mounted solar farm or a community energy facility, and macro level, grid-scale solutions – each of which involve varying storage time, voltage levels, ramp rates, response times and costs. These aspects are

necessarily intertwined with diverse softwares, for example procedures of governance, market and business models, and public roles and expectations.

Despite its emerging significance, social acceptance of renewable energy storage has been overlooked to date by energy social scientists. This is problematic as it provides a deficient evidence base to inform policy making and practice, and may lead to resistance towards technical solutions, implemented at micro, meso or macro scales, which are based upon flawed assumptions about user expectations. Research has already documented the prevalence of 'information deficit' [28] and 'NIMBY' (Not In My Back Yard, [29]) ways of imagining publics and critiqued their consequences in relation to strategies of public and community engagement (e.g. [30]). Research is needed to investigate the ways that these representations shape technological trajectories and siting strategies for energy storage, for example leading to grid-scale solutions that are driven by, in part, assumptions of domestic apathy or resistance. In consequence, it is important to examine multiple technological proposals at different scales of deployment and to fully reveal the representations of publics, and social acceptance, that underlie these.

To address the lack of social science research on social acceptance of energy storage to date, we propose that research should adopt an interdisciplinary focus on three themes – governance and regulation, markets and innovation, socio-cultural and public acceptance aspects - each of which are conceived to shape social acceptance [2]. For each theme, we identify key social science research issues of significance in relation to the future deployment of energy storage solutions; pose research questions for future studies to address; and set out the theoretical and methodological challenges involved in researching social acceptance of storage at multiple levels.

3. Outlining a programme of research for the social acceptance of renewable energy

storage

3a. Governance and regulation

Since storage solutions are emerging at different scales of deployment, governance at various scales needs to be understood in a comprehensive manner and we suggest to apply a polycentric approach [14]. The stringency of policy objectives and targets set at different decision-making levels need to be analysed, as well as how they are followed up during policy implementation and execution [31]. It is important to acknowledge the distinction between policy outputs and policy outcomes [32]. While the former can generally be considered results of the decision-making process and the formal products of policy formulation [33], the latter can be understood as the actual effects and impacts of the policy within the field of action being governed [34]. Methodologically, studies of governance should combine document studies, as well as the study of the belief systems held by policymakers and key stakeholders, using qualitative and quantitative methods. Cross-national studies are useful to gain a broader perspective on governance (e.g. [35], [36]). A range of research issues addressing governance at different scales can be identified:

- *At an international level:* Is the current growth in new storage solutions a way towards strengthening cooperation across national borders for secure, climate neutral energy systems? Are international regulations and guidelines [37] accounting for the opportunities in storage and to what extent are international bodies promoting new, more complex and sustainable energy pathways? Here, content analyses of existing or proposed regulations would be useful in addition to research applying concepts from the “policy mixes” literature [38, 39]. International organizations and bodies projecting future energy mixes and regulations can map this evolution, such as the International

Energy Agency (IEA), Intergovernmental Panel on Climate Change (IPCC), and more regional bodies like National Association of Regulatory Commissioners (NARUC)[40].

- *At the national level:* How do national energy regimes respond to new storage opportunities? The Spanish government introduced legislative proposals in 2015 to impose a system of fines upon those who failed to pay a new tax on solar energy storage [41]. The UK government has declared a willingness to remove existing regulations that are acting as a barrier to storage [42]. Research is needed to investigate which solutions will prevail under differing socio-political circumstances – put another way, to reveal the politics behind policies. A mixed methods approach of quantitative indices and qualitative case studies provides opportunity for comparisons between countries while offering localized narratives on technology innovation and policy approaches [43]. Researchers need to acknowledge disagreements and distributed actors [44].

- *At the local level:* The opportunities for local action given established national regulatory pathways and vested policy interests [45] should be assessed through assessment of policy implementation schemes, including the role of guidance and economic support directed towards this level [17].

- *The role of middle actors:* How middle actors work upstream as well as downstream towards the local level and across sectors should be investigated to achieve more effective and equitable policy outcomes [46]. Here, work on intermediaries or system builders could reveal how innovation and policy diffusion occurs from the "middle out." This category in the budding industry of energy storage is tightly connected with actors and policy processes within 'markets and innovation', due to firms, investors and reliance on government policies to assist with commercialization [47]. Middle actors resemble sectoral experts in a governance process, holding long-term views and

marshalling rules, regulations and systemic transformation to encourage the entrance of new technologies in cooperation or in conflict with energy utilities [48].

3b. Markets and innovation

In order for energy storage technology to meet climate mitigation goals and support economic and energy security objectives, it must fit into markets and spur investment into innovative designs. Storage systems must evolve with new business models - a term that refers to how firms create superior customer value (low-cost or differentiated products) and put themselves in a position to appropriate revenue. This includes providing services across a range of scales. Market segments need to include commoditization of storage. Storage costs require placing value on location, social and environmental impacts, system integration and time-of-day pricing. Likely adopters and non-adopters are classified according to distinct market segments. Critical questions include: How do socio-technical priorities influence normative business decision-making [49] and the acceptance or rejection of energy storage? How can markets be structured to price the cost and benefits of energy storage? What business and revenue models are acceptable to different users? Which companies in the value/supply chain of energy systems become winners and losers (see [50])? Theories explaining disruptor technologies are warranted and which are tightly tied to empirical studies that capture changes in centralized/decentralized systems [51].

- *At an international level:* Analysis can focus on the creation of new, more complex energy pathways, involving multinational corporate players, who represent the global scale of renewable energy technologies and technology supply lines, investigating how they interact with national and local energy policies, serving as markets and incubators for novel storage technologies [52]. Methodologically, the diversity of actors must be

addressed, and focus group interviews followed up to a wider number of actors in quantitative surveys is a suitable approach.

- *At a national level:* How do national industrial policies affect types of energy storage technologies? How do socio-political agreements influence business models? Research into renewable energy provides a starting point for answers to these questions. Research of this kind can further understanding of which solutions emerge and why. Document studies, followed up by in-depth interviews with policymakers and business representatives will shed light on the interplay between politicians, civil servants and business representatives [53].

- *At a local level:* Research can analyse the local impacts and alterations of different storage options, including how revenue models may be translated into jobs and different socio-environmental impacts [54].

- *The role of middle actors:* Innovation studies research often refers to middle actors as “intermediaries” or “system builders” who circulate knowledge and practices and also legitimate particular agendas. Future research can investigate how these middle actors facilitate change, and what new theoretical constructs might be needed to understand their behavior. This can be approached through participatory observations and in-depth interviews.

3c. Socio-cultural and public acceptance aspects

Understanding which socio-cultural aspects shape the public acceptance of storage technologies implies examining communication at different scales in terms of content and process. Focusing on content implies analyzing questions such as: what is being

said about storage? How is it being used? What is being associated with it? Which images are used to make sense of storage? Regarding process, it is crucial to take into account the political nature of meaning-making [6] and power differentials between groups, to better understanding why storage is re-presented in different ways by different groups. Important questions to answer are: who is saying what regarding storage? How? With what functions and consequences?

Providing answers to these questions is challenging as we are examining re-presentations about storage in the making - a dynamic process that is being shaped by many different actors and contexts. It is therefore crucial to examine communication in different contexts and moments in time, and to bear in mind the interrelations between groups – e.g., how middle actors, who are important intermediaries in the translation of international and national level policies to citizens' practices [8], impact on the latter. The following empirical research might be helpful:

- *At an international level:* Comparing the ways that energy storage is communicated within different countries, using thematic analysis and discourse analysis [see 55 for an example] to analyse discourse and visual imagery in national and local media coverage; assessing to what extent rationales for implementing storage are based upon arguments about international benefits (e.g. at a Europe-wide system level) by comparison to benefits at national or local levels.

- *At a national level:* Conducting focus group discussions with members of communities engaging with or affected by storage at micro, meso and macro scales, and using thematic and discourse analysis to examine them;

- *At a local level:* Borrowing insights from theories of practice (see [6]) to examine everyday practices amongst householders with storage at the domestic level, for

instance through asking participants to write diaries that reveal how they engage with storage over time, revealing how storage becomes embedded within domestic routines [56];

- *The role of middle actors:* Examining the activities of organisations attempting to influence national policy and media discourse on the benefits or risks involved in energy storage, for example efforts to shift framings. These could be revealed by conducting in-depth interviews with representatives of middle-actor organisations and by using discourse analysis to analyze secondary data materials from those organisations, for example reports and guidance documents.

4. Conclusions and policy implications

Social acceptance has become an increasingly important topic for energy social science research over the past decade, focused on a range of technologies relevant for the transition towards low carbon energy sources. However, this literature has several weaknesses. Although a highly cited theoretical framework proposes three dimensions to social acceptance: markets, socio-political and community [2], few studies have encompassed more than one of the three aspects in their respective analytical frames. Second, the framework is weakened by a lack of emphasis upon how each dimension inter-relates across different geographical scales (from macro to micro; international, national and local). Here we propose a novel integration of theoretical ideas from across the social sciences, in which the belief systems or social representations [9,10] held by key actors working at different scales play a crucial role in fostering social acceptance of novel technologies, and where a polycentric perspective leads to particular interest in the role of middle actors [11] that mediate processes of change between scales (e.g. national and local).

Despite its significance, social acceptance of renewable energy storage has been neglected to date by energy social scientists in particular. This is problematic as it provides a deficient evidence base to inform policy making and practice, and may lead to resistance towards technical solutions, which are based upon flawed assumptions about user expectations. Research is needed to investigate the ways that these representations shape technological trajectories and siting strategies for energy storage. Given interdependencies between the three dimensions of social acceptance as they play out within and between scales of deployment, it is crucial that future research on applies the framework holistically by examining processes of social representation of energy storage as they travel between policy, market and community dimensions. Research can investigate how longstanding beliefs about the virtues of national scale, centralized infrastructures may shape policy makers' beliefs about potential technological trajectories of energy storage, perhaps favouring policies consistent with macro-scale deployments over meso and micro-solutions. The outcome of such studies would not only lead to enhanced understanding of processes of social acceptance, but findings that deliver important insights for policy and practice.

In terms of policy implications, we identify the following conclusions. First, policy makers could give higher priority to issues of social acceptance in funding calls for grant proposals. Energy research is already skewed away from the social sciences towards disciplines such as engineering and economics [57]. To address this, it is necessary for policy makers to understand that social acceptance is insufficiently covered by issues of technology design or pricing mechanisms. Second, policy makers can ensure that research calls are interdisciplinary as well as disciplinary in nature, organizing research platforms around societal challenges that require interdisciplinary input rather than monodisciplinary analysis. As noted in this paper, research on social acceptance rarely addresses the multiple dimensions identified a decade ago ([2]). Finally, government institutions such as energy ministries and statistical agencies can

collect data on social acceptance that goes beyond highly generalized opinion polling (see [58] for a critique). These measures would ensure that policy makers can draw upon a more robust and comprehensive evidence base in order to inform the low carbon transition.

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