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What is needed for citizen-centered urban energy transitions: Insights on attitudes towards decentralized energy storage

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ABSTRACT

This paper aims to fill a research gap in the area of consumer-citizen attitudes to business models for decentralized energy storage, at the level of households and buildings. The study focuses on the interaction of such attitudes and their underlying motivation factors with socio-cultural, contextual factors. Self-determination theory (SDT) is used as a theoretical framework, to connect interpersonal and contextual factors, addressing the question of how contexts influence the motivation to support energy storage. Drawing on SDT, this study examines the role of autarky (independence from the energy system), autonomy (control over energy management) and relatedness (degree of sharing required) in this regard, embedded and interpreted in the socio-cultural local context of two demonstration sites in Sweden and Portugal. A mixed method approach is used. Quantitative survey data provides information on local social and cultural dimensions, followed by stakeholder consultation workshops that elicit participants' views on different models of decentralized energy storage. The findings raise questions of how to improve autarky and autonomy for prosumers, while keeping the need for time investment low and provide flexibility regarding the required degree of interaction between prosumers. Implications for business models and policy support for citizen-centered sustainable urban energy systems are derived.

1. Introduction

Cities are dense and complex manifestations of all elements of the energy system, involving generation and distribution, provision of heating, cooling, lighting, mobility, communication, waste handling, supply of fresh water, and consumption of goods and services. They are also responsible for 60–80% of energy demand and generate an estimated 70–80% of human-induced greenhouse gas emissions contributing to climate change (UN-Habitat, 2011). As such, a transition to sustainable urban energy systems is recognized as the cornerstone for climate mitigation and transforming to a net zero emissions global economy (IEA, 2016; UN-Habitat, 2016).

The recent development of more decentralized energy systems could be seen as a step in this transition, as it challenges the current lock-in of energy systems (in developed countries) to centralization (Chmutina and Goodier, 2014). While existing centralized supply systems could in principle become climate-neutral by replacing existing power generation based on fossil fuel with large-scale renewable energy and/or nuclear power, this would leave cities in their current role, as "largely passive centres of demand" (Rutter and Keirstead, 2012, p. 78). At the same time, recent innovations such as smart grid technologies and energy storage, combined with increasing electricity demand, better affordability of renewable energy technologies, liberalization of energy markets, and work to improve energy security, all support decentralization of energy systems (Chmutina and Goodier, 2014). They have the potential to transform cities into sites for energy generation and distribution (Adil and Ko, 2016). Decentralized energy systems are often argued to be more climate and environment friendly, efficient, resilient, reliable, affordable, and accessible, as well as enabling higher energy security (Coaffee, 2008). Yet, decentralized energy systems also come with significant challenges, e.g. increased needs for demand management and storage (Mäkivierikko et al., 2019) and it remains to be seen whether they can live up to the high expectations.

Concerning preconditions for successful decentralized energy systems, energy storage is increasingly recognized as a key factor in delivering sustainable and more decentralized urban energy systems in the future, particularly for reasons of power balancing, i.e., matching supply and demand, but also in terms of avoiding curtailment of

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renewable energy supply (RES) at times of high renewable generation and low demand. Thus, decentralized energy storage can support more optimal use of installed RES capacity (EC, 2016) and reduce the need for (possibly non-renewable) baseload supply. Energy storage systems also offer the possibility for consumers in smart energy futures to produce energy, e.g., wind or solar power, for their own use, but also to store energy and potentially also sell this (Skjølsvold et al., 2015). Such storage can take various physical forms and scales of varying suitability for urban locations.

Here we focus on consumer-citizen issues that are most relevant to urban-scale storage (Sauter and Watson, 2007). We use the term consumer-citizen to acknowledge that consumers tend to be sensitized to governance issues in sustainability contexts, as well as to issues of consumer utility; given prevailing economic systems, this typically raises a wide range of questions and tensions between different human values (Johnston, 2008). Our focus here is on small-scale storage on the level of a shared apartment block – i.e. storage options supplying a small number of co-located residences. In particular, we study here consumer roles and the related prosumer versus consumer-debate concerning energy futures, which range from the current mostly passive use of energy by consumers to the active role that prosumers can play in energy production, consumption, and distribution. The latter usually characterizes visions for smart energy futures (Ballo, 2015). As Skjølsvold et al. (2015, p. 1) note: "While grids are primarily about energy transitions, smart grids are expected to change the relation between production and consumption."

Given this potential, the degree of consumer support and quite likely literal buy-in is likely to be a decisive factor for the different business models for city-level energy storage currently being discussed (Burlinson and Giulietti, 2018). In order to understand prospective domestic consumer-citizens in particular, specifically regarding perceptions of autonomy (control over energy management) as part of envisaged living experiences and motivations for engagement, here we examine the meanings and interpretations ascribed to decentralized energy system (DES) technologies on a local scale by small groups of citizens recruited in smart city demonstration sites in Sweden and Portugal. Both demonstration sites and also this study are part of the H2020 energy project Integrid (see https://integrid-h2020.eu/). Participants were informed that the broad context ranged from complete, actively chosen and self-managed independence from the power grid, to a passive, business-as-usual condition in which energy consumption is relatively invisible, managed by power companies or intermediaries, with other variants between these two extremes. The work is exploratory and the choice of two countries differing in culture and climate is intended to lay the foundation for larger-scale, comparative work that systematically explores prospective consumer-citizen perceptions across Europe.

Following previous work (Ecker et al., 2017), we use self-determination theory (SDT) (Pelletier, 2002) as an analytical frame. Self-determination theory addresses motivational aspects of human behavior. It focuses on intrinsic motivation, here referring especially to previous findings indicating the important role of autarky (independence from the energy system, with full autarky meaning that own energy resources cover the demand); and autonomy (control over energy management) for consumer-citizens' attitudes. Yet, self-determination theory also covers external influences on behavior. Here we are particularly interested in the effect of socio-cultural contextual factors. The study uses a mixed method approach. Qualitative data, namely storytelling-focused stakeholder consultation workshops, is used to study consumer-citizens' attitudes towards decentralized energy system technologies on a local scale in cities. Quantitative data from local surveys is added here to cover the local socio-cultural context and to interpret the findings from the consultation workshops in the same localities. Four main research questions are posed:

(i) What are consumer-citizens' attitudes towards decentralized energy storage, especially regarding their own roles in the new system (consumer versus prosumer)?
(ii) What motivates consumer-citizens' attitudes in general and how, in this context, do consumer-citizens view issues of autarky and autonomy, as well as relatedness (sharing)?
(iii) What role do socio-cultural local-context factors play in this regard?
(iv) What are the implications for decentralized energy system business models and policy support of sustainable urban energy systems?

The paper is structured as follows: Section 2 provides an overview of previous studies on consumer-citizens' attitudes towards decentralized energy storage on a local scale and, in particular, underlying motivational factors for these. Regarding the latter, it also introduces self-determination theory as the theoretical framework of the study in more detail. Section 3 describes the mixed method research design, which aims at studying the internal, intrinsic motivation embedded in its context, namely the local influences (e.g. experience with sharing). In the results section (Section 4) first described are socio-cultural contextual factors, particularly relating to community ties and sharing, based on the survey data. Thereafter, the qualitative findings for the two locations are presented, structured by case and theme. Section 5 discusses the results, structured by the research questions posed above. The findings raise questions of how energy solutions might look like that improve autarky and autonomy while keeping the need for (time) investment low and which would be flexible regarding the levels of interactions between involved prosumers to fit different local contexts. Finally, section 6 derives implications for business models and policy support for citizen-centered sustainable urban energy systems with decentralized energy storage on the household- or building-level in different local contexts.

2. Theoretical framework

2.1. Literature review on consumer-citizens' role in decentralized energy storage

Decentralized energy systems in general and decentralized energy storage at a household- and building-level are both already in operation (see e.g.Müller et al., 2011 for an overview of cases, e.g. in a community energy context**).** Yet the role of consumer-citizens in such systems has been relatively little-studied. In their business model for city-level energy storage, Burlinson and Giulietti (2018) categorize business models and respective roles of consumer-citizens in terms of three layers. The first layer consists of traditional business models for the purchase and storage of electricity, which reflect the extent to which a consumer is connected to the grid (i.e., on-grid, off-grid, or private wire). The second layer consists of the 'core' business models that provide innovative city-level solutions to local customers (e.g., those that support prosumers, third party aggregators, community groups, and municipal suppliers). The third layer comprises business models that augment the core layer by delivering specialized ancillary services (Bale et al., 2018; Burlinson and Giulietti, 2018). Consumer perceptions and behavior will be critical as to which model will prevail in the long run. As Burlinson and Giulietti (2018) conclude: "it is essential to identify the target customers in energy storage business models (e.g., generators, network operators, households, etc.) and evaluate whether the business model can deliver something that is valued by such customers (e.g., flexibility, aggregation, affordability)".

Moreover, to date, decentralized energy system in which consumer-citizens take an active, prosumer role are still relatively niche. Recently, Wirth et al. (2018) conducted a series of interviews in decentralized energy system (including energy storage) implementation sites in Europe (Germany and Switzerland) and concluded: "findings from our

series of interviews do not indicate such a shift occurring from consumer to prosumer in the decentralized energy system domain". In line with others, the authors highlight the need for an more in-depth understanding of consumer-citizens' attitudes towards decentralized energy system, to inform supply development from a niche level and to encourage consumers towards more active roles (Ecker et al., 2018; Wirth et al., 2018).

Yet, despite the importance of consumer and citizen attitudes to decentralized energy storage, there is still surprisingly little available information on how people view decentralized energy storage in their roles as either consumers or citizens. For example, a literature review on smart grid development by Bigerna et al. (2016) found that few studies address energy storage or prosumer issues. In line with this, studies of public acceptance of decentralized energy system mostly still see consumer-citizens in a passive role and thus study the passive acceptance of new energy technologies which are assumed to be built and managed by large, incumbent energy companies (Wirth et al., 2018). Following from this, particularly little is known about our study object of decentralized energy storage on a household or neighborhood level (Ecker et al., 2018; Wirth et al., 2018).

Exceptions include a study by Abe et al. (2015) on consumer perceptions of solar photovoltaic panels (PV) in relation to energy storage in a Japanese context; Romanach et al. (2013) present the results of a survey addressing various issues relating to batteries at household level and highlight the paucity of knowledge. A recent study in the UK (Ambrosio-Albalá et al., 2019) also used focus groups to examine consumer-citizens' attitudes to decentralized energy storage. The authors show how a variety of elements such as forms of energy consumption; costs; expectations of family members; previous experiences; perceptions of government and the municipal authority; and expectations about the technologies shaped actual and prospective views of battery storage at the household and community level.

Yet, there remains a gap on understanding the motivational factors underlying consumer-citizen attitudes towards decentralized energy system. This corresponds with a general gap on motivational aspects of human behavior in sustainability transitions (Svensson and Nikoleris, 2018). Where motivation is studied within an explicitly sociotechnical transition frame, this is usually done in relation to consumption per se (Bögel and Upham, 2018). With the active role of consumers assumed for decentralized energy system, however, the lines between prosumers and consumers blur and most likely, the acceptance patterns of these two types of actors and related motivational aspects are creating new, heterogeneous patterns of acceptance and underlying motivational structures (see also Wirth et al., 2018). Further studies are needed to understand consumer-citizens' attitudes towards their (potential) new role as prosumers and the underlying motivational factors.

Recently, a promising stream of research has emerged that studies this aspect from the perspective of self-determination theory. In the following section, we summarize the theory and related studies on consumer-citizens' role in decentralized energy storage in a household-/building level based on the theory. Particular focus is given to insights relating to (i) the motivational aspects underlying changes associated with consumers becoming prosumers; and (ii) the relationship of motivation with contextual factors, here primarily considered in terms of the socio-cultural local context, both of which the theory opens up.

2.2. Theoretical background: self-determination theory

Self-determination theory (Deci and Ryan, 2002) seeks to resolve a long-standing psychological controversy regarding the extent to which people, on the one hand, have an innate tendency to strive towards personal growth and integration, and, on the other hand, theoretical perspectives such as behaviorism, which assign a greater role to external stimuli as behavioral drivers. Self-determination theory shares the assumption of an innate tendency towards personal growth, but states that activation of this tendency depends upon social-contextual factors. In other words, self-determination theory posits that people have a drive to become what they may, but that this drive can be frustrated. Self-determination theory is thus a theory of motivation and hence applies to contexts in which questions of motivation are important, or considered important, i.e., why people are motivated, what motivates them, how this influences their behavior, as well as the question how this is influenced by external, socio-cultural local context factors.

Self-determination theory is also referred to as the "theory of intrinsic motivation and self-determination" (Pelletier, 2002, p. 206). It can also be characterized as a needs-based approach: self-determination theorists posit that three basic psychological needs must be fulfilled to enable self-determined, intrinsically motivated behavior:

(1) The need to feel competent: a feeling of efficacy and confidence in one's action, i.e., that one can fulfil a particular task.
(2) The need to feel related or connected: the feeling of belonging and of being taken care of, through a secure and motivating learning environment, home life, or some other context.
(3) The need for autonomy: the feeling that one has an adequate degree of free choice or is "the perceived origin or source of one's own behavior" (Deci and Ryan, 2002, p. 8).

Self-determination theory has been applied in a variety of contexts, but particularly in education (Deci and Ryan, 2002), health (Hancox et al., 2015), sport and leisure, occupational contexts, and psychotherapeutic contexts, and has obtained much empirical support in these areas (Pelletier, 2002). Yet the focus of the theory on the quality of motivation (extrinsic or intrinsic) and its insights into achieving self-determined motivation for behavior (change) (Hancox et al., 2015) also make it relevant for the study of technology adoption and pro-environmental behavior (Ecker et al., 2017; Pelletier, 2002).

2.3. Self-determination theory and attitudes towards decentralized energy storage on a household or building level

Drawing on self-determination theory, Ecker et al. (2017) explore the role of autarky as a possible psychological co-benefit of more decentralized energy systems. Autarky is here defined as the level of self-sufficiency of the energy system, meaning that full autarky implies that one's own supply and demand are at least equal (see also Ecker et al., 2018; Müller et al., 2011). The authors conclude from an empirical study of consumer perceptions of different future energy scenarios that: "enabling the people to self-determine, control, and secure their energy provision even in complex organizational settings in such a manner is likely to increase their acceptance (…)" (ibid., p. 1). The findings are in line with another recently published qualitative study on decentralized energy storage, which also finds that increased autarky is perceived as a key benefit of decentralized energy storage (Ambrosio-Albalá et al., 2019).

In a follow-up empirical study Ecker et al. (2018) differentiate further between autarky as the independence of supply and a second concept related to control, namely autonomy. Autonomy is defined as the level of control over the energy management, namely "the ability to determine one's energy provision" (Ecker et al., 2018, p. 215; see also Müller et al., 2011 using the same definition in their work in energy autarkic regions). Applied to the context of decentralized energy storage, a low level of autonomy would imply that homeowners are (still) not able to control and intervene in the energy management processes but rather the control units are operated by an external grid operator, optimizing the process of electricity production and storage at any time. The way in which decentralized energy system has been deployed to date seems in this latter mode of grid operator control over decentralized energy system development and most likely management (see e.g. Wirth et al., 2018). The study by Ecker et al. (2018) used an experimental setting to compare the effect of levels of autarky and levels of autonomy on willingness to pay. The study found that both are perceived as

desirable by participants, but energy autarky had a stronger, positive influence on willingness-to-pay than increased autonomy.

Another factor referred to in self-determination theory and that has been given research attention in decentralized energy system contexts is social relatedness. Early work on energy autarkic regions already suggested that an increase in interactions between people, e.g. within neighborhoods or regions, is perceived as desirable by consumer-citizens and could become a driver of decentralized energy system implementation (Müller et al., 2011). It is assumed here that "By interacting with one another during the process of implementing energy autarky, interpersonal relationships are created and reshaped. This can contribute to integration among the local population and can increase the social capital of residents." Recent work supports this line of argumentation (Ecker et al., 2018).

Overall, previous work relating to self-determination theory might be interpreted as favourable for prosumption, in that storage technology has the potential to improve social relatedness and reduce dependence on electricity supply companies. If people have a drive for self-realization and related autarky and autonomy as well as closer relatedness, then one might expect consumer-citizens to support decentralized energy system implementation at a local level; e.g. because they want to take more control over the role of energy supply in their lives. Yet this might also be a rather simplistic inference. To draw more nuanced conclusions, one would need to know more about who in particular sees a need to have more autarky and autonomy, from what or whom; who wants to be connected more, and to whom; and in what context or place. Self-determination theory itself adds to the case for investigating the role of relatedness and autonomy more carefully in the context of the energy prosumer. In fact, this is arguably one of the advantages of the theory relative to more individualistic theories of motivation: self-determination theory is not only internally focused (as e.g. rational choice models are often seen, limiting their possible use for informing sustainability transitions, see e.g. Shove, 2010), but inherently connects interpersonal and contextual factors. As such, it explicitly addresses the question of how contexts influence the motivation for self-realization (Pelletier, 2002). This role of context merits more attention in the case of energy prosumers.

In this regard, the present study echoes the (still limited) turn towards the use of integrated frameworks for the study of sustainability-related human behavior as contextually embedded (e.g. Southerton et al., 2011; Stephenson, 2018). While there is psychological work on integrative frameworks in the specific context of energy technology acceptance (e.g. Perlaviciute and Steg, 2014), the psychological literature to date has little examined interactions with wider socio-cultural factors. We aim to contribute to here by adding to research gaps on: (i) the underlying motivational aspects of decentralized energy system; (ii) the influence of different scenarios as contextual factors; (iii) the interrelation of both decentralized energy system and alternative deployment scenarios with socio-cultural local contexts. More specifically, we focus on the influences on acceptance of perceived levels of sharing; autarky and autonomy; and social relatedness implicit in different decentralized energy system designs.

3. Methods

The study uses a mixed method design (Johnson et al., 2007) including quantitative and qualitative methods to elicit an in-depth understanding of consumer attitudes to business models in energy storage. First, surveys were conducted in two contrasting locations (in Sweden and Portugal, see section 3.1 on the case study selection below). This quantitative data provided information on local social and cultural dimensions relevant to self-determination theory and to decentralized energy storage. Second, stakeholder consultation workshops were held in the two locations. These workshops used a storytelling-based, focus groups method to engage and elicit participants' views on different decentralized energy storage scenarios (see Fig. 1). As with most case study work, no claims to representativeness with respect to wider populations are made; rather the research design allows in-depth probing of particular processes (Yin, 2003). These are both of inherent value and provide a basis for further work.

Approach	Method	Goal	
Quantitative	Survey	Study the local socio-cultural context	Examine the influence of (i) socio-psychological factors (self-determination theory); and (ii) local socio-cultural factors (e.g. community ties) in relation to different energy scenarios in an integrated framework
Qualitative	Stakeholder consultation workshop	Engage and elicit participants' views on different decentralized energy storage scenarios	

Fig. 1. Methodological design applied in the two case studies.

3.1. Case study selection

As mentioned above, the case studies were part of the large EU energy project InteGrid, including smart city demonstration sites for testing new renewable energy technologies. In part, therefore, as including EU countries advancing renewable energy supply, the case study selection was based on criteria beyond the research questions of this particular paper. Sweden and Portugal are both ranked as well-developed with regard to taking up renewable energy technologies, as measured in indices such as the Climate Change Performance Index. Both countries are described as part of the country group that demonstrates "a pronounced tendency to mainly rely on renewable energy sources, particularly the European Union countries, which set targets for increasing renewable energy sources within the scope of sustainable growth" (Caglar 2020, 2). It is these characteristics that led to the original selection as part of the broader project aim to develop concepts for decentralized urban energy systems. For this purpose, the vision of the project is to bridge the gap between citizens and technology/solution providers such as utilities, aggregators, manufacturers and all other agents providing energy services, hence expanding from DSOs distribution and access services to active market facilitation and system optimisation services while ensuring sustainability, security and quality of supply.

With regard to the study's purpose of examining consumer-citizens' attitudes towards decentralized energy storage in general (RQ1/RQ2) and the influence of the local context-specific differences (RQ3) in particular, the case study locations offer specific social and cultural contexts of value for the research questions. While the locations are similar in some relevant respects, they also offer relevant differences with regard to their local contexts. To explore that premise for our purposes before the start of our study, we use established frameworks on cultural differences, namely Hofstede's work on intercultural differences. The cultural dimensions proposed by Hofstede (2001) are the most frequently consulted framework in the study of cultural differences (see e.g., Katz et al., 2001). Hofstede's typology consists of six (previously four) dimensions according to which a particular culture can be categorized: (1) Individualism-Collectivism; (2) Uncertainty avoidance; (3) Power distance; (4) Masculinity-Femininity; (5) Long-term versus short-term orientation; and (6) Indulgence-Restraint. The six categories have been measured in a worldwide survey, each on a scale from 0 to 100. Results are publicly available to use for studies interested in cross-cultural contexts and differences. [1]

While there is some debate regarding the validity of scales of national cultural characteristics in general and of Hofstede's findings in

[1] For more information see: https://geerthofstede.com/culture-geert-hofstede-gert-jan-hofstede/6d-model-of-national-culture/.

particular (see e.g., Jones and Hofstede, 2007; Minkov and Hofstede, 2011), such scales can still provide relevant insights according to e.g., Jones and Hofstede (2007) and Quigley et al. (2012). Thus, while we are aware of the limitations of Hofstede's typology - e.g. local differences within countries - we nonetheless agree with the authors above that the typology can theoretically underpin relevant contextual data. In addition, our assumption that the case studies differ regarding the specific socio-cultural context was backed up by further research on the case study characteristics (presented below in section 3.1.2). In the next section, we present results from our mixed method study, which confirmed differences in the local socio-cultural contexts of the two locations.

3.2. Survey & case study characteristics

3.2.1. Survey

A survey with questions on energy behavior and influencing factors, with a particular focus on socio-psychological factors and local socio-cultural factors, was conducted as part of the EU energy project InteGrid. In Sweden, the survey was conducted in Stockholm Royal Seaport (SRS), one of InteGrid pilot neighbourhoods, during April and May 2018. The data collection was done using phone interviews by the marketing research company Novus. Novus conducted 300 phone interviews with SRS residents. Conditions for recruitment included that participants were inhabitants of the city district examined and that the sample should be demographically representative of the locations. Of the 300 recruited participants, 142 (47.3%) were female and 158 (52.7%) male, all aged between 18 and 81 years (M = 49.55, SD = 16.71). The majority of the Swedish sample were born (91.0%) and/or raised (95.0%) in Sweden and had a university degree (82%), 17.0% had finished secondary school and 1.0% had a primary school education. Most participants were either employees (56.0%), retired (23.7%) or self-employed (9.0%).

The second survey was conducted in Caldas da Rainha, Portugal from 19th March until 30th March 2018. The data collection was via intercept interviews by a team from EDP Distribuição. The format differed from the Swedish case in reflection of local circumstances, i.e. it was considered that a survey would elicit a low response rate. All in all, 65 interviews were conducted. Each interview took about 15–20 min. Of the 65 participants of this survey, 33.8% were female and 66.2% were male, all aged between 21 and 75 years (M = 40.97, SD = 13.77). 95.4% of the participants were born in Portugal and 98.5% grew up there. The majority (56.9%) had a university degree, 40.0% had secondary education and 1.5% each had finished middle school and primary school. Most of our participants were employees (80.0%), fewer were retired (7.7%), self-employed (6.2%), unemployed (4.6%) or students (1.5%). In Portugal, the questionnaire was a shortened and translated version of the Swedish survey described above.

While we focus selectively in this section on questions regarding the local socio-cultural context, namely community ties and sharing experience, a full description of the survey can be found in the project report (available at https://integrid-h2020.eu/uploads/public_deliverables/D1.4%20Consumers%20engagement%20strategies.pdf) and further findings are available regarding the role of identity for energy behaviour (see Mäkivierikko et al., 2019). To measure the social network of the participants, first, they were asked if they have a good social relationship with their family, relatives, friends, neighbors and peers, respectively (with a *yes/no/not applicable* scale). For the Portuguese sample, the items measuring social bonds were posed in the questions regarding social relationships with family, friends etc. The category "relatives" was excluded for translation reasons and the additional response option of "not presently" was added. Second, participants were asked how often they spend time socially with any of their neighbors (from 1=*daily* to 5=*never*). Third, participants were asked to rate the statement „Where I live we have insights on each others' life" a three-point scale (1 = *too much*/2 = *moderate*/3 = *too little*). Concerning sharing practices, the participants in the survey were asked if they had "borrowed from their neighbors/lent to their neighbors/used a pool or sharing system with their neighbors" regarding a number of different items (clothes, toys, tools, home appliances, computer/tablet/mobile phone, TV/video/DVD/-stereo equipment, bicycles, cars/other motor vehicles). As an (admittedly coarse) indicator for a potential sharing economy, all instances of sharing, borrowing, or lending/renting reported for any item on the list were added together.

3.2.2. Case study site characteristics

The Stockholm study location spans two eco-districts in Stockholm, Stockholm Royal Seaport and Hammarby Sjöstad. The city districts are both part of the InteGrid project. In Stockholm Royal Seaport education level and income are higher than on the city average (Sweco, 2016). Housing is more expensive than the Stockholm average as well (Sweco, 2016). Recent work therefore describes it as an "upper class enclave" (Dyall Silfverbrand, 2019). The survey Stockholm Royal Seaport performed for the present study showed that the majority of respondents perceived their current income to be sufficient for them to live comfortably (46.7%) or very comfortably (30.0%), while 19.0% reported just coping on the current income and 4% found it difficult or very difficult to live on their income at the time of the survey. Almost all participants (97.3%) in the sample lived in an apartment.

The workshop from which findings are reported in this paper took place in Hammarby Sjöstad, a large industrial and harbor area where transformation began in 1996 (for more information on its sustainability goals, see e.g., Pandis Iveroth, 2014; Pandis Iveroth et al., 2013). The original vision was to develop a city district that is "twice as good" as other city districts in Stockholm (and beyond). As part of this strategy, Hammarby Sjöstad is a demonstration site in the InteGrid project, and also in other projects aimed at creating a sustainable city district, including energy storage (see e.g., Pandis Iveroth, 2014; Pandis Iveroth et al., 2013). Like Stockholm Royal Seaport, in Hammarby Sjöstad the education level is higher than the city average of Stockholm. Likewise, the income is higher: In 2013, 21% already had twice as high or higher income than the median in Stockholm. The income level is growing and with a stronger rate than the city average (Jernberg et al., 2015).

In Portugal, the selected location in the Lisbon area, Caldas da Rainha, is one of three included in the InteGrid project. Caldas da Rainha was chosen as a study site because of its technological development (e.g., installation of smart meters) and its mixed demographic patterns compared to the two Swedish study sites. Caldas de Rainha is a mix of urban and rural areas. It has a mixed population as well, e.g. mixed age groups. Income in the district is on average lower than in the Stockholm city districts. Survey results for this district showed that the majority of residents perceived that they were just coping on their current income (50.8%), 29.2% were living comfortably, and 20.0% (compared with 4% in the Swedish sample) found it difficult or very difficult to live on their current income. About half the respondents in the Caldas da Rainha sample lived in a house (50.8%), while the remainder lived in an apartment (41.7%) or a semi-detached house (7.7%).

3.3. Stakeholder consultation workshops

3.3.1. Participants

The stakeholder consultation workshop on decentralized energy storage was conducted as part of a larger workshop on consumer-citizens' perceptions of new energy technologies in the H2020 energy project InteGrid (findings from the second part of the workshop with a focus on demand side management are published in Mäkivierikko et al., 2019). The overall workshop lasted about 3 h and was intended to be of interest for all citizens in the city districts (e.g. an evening event in Sweden to improve inclusivity of participation). Workshop participants were recruited by the local project teams. Conditions for recruitment were that participants were inhabitants of the examined city districts and should be demographically representative, e.g. regarding age and gender. The workshop was advertised through various local initiatives and snowball sampling was used. Participants were not compensated financially but drinks and snacks were provided for the event.

In Sweden, 18 (potential) consumers participated in the workshop. Ten of these were residents of Hammarby Sjöstad, the Stockholm city district and demonstration site of the InteGrid project. Hammarby Sjöstad intends to install energy storage systems, including bi-directional charging with electric vehicles, in newly built apartments. The remaining eight participants came from other city districts in Stockholm, mostly located close to Hammarby Sjöstad. Eight of the 18 participants were female and the age range was wide. In Portugal, 46 participants from a demonstration site for new energy solutions in Caldas da Rainha engaged in the workshop. Of these, 19 were female and, as in Sweden, the age of participants covered a broad range, here 25–98 years.

In both countries, participants were split into four different focus groups for discussions, resulting overall in eight focus groups. The sample size was considered sufficient for the exploratory nature of the study, following McCracken's (1988) guidelines that a sufficient sample size for qualitative research will "gain access to the cultural categories and assumptions according to which one culture construes the world", a criterion also applied in similar studies to ours (see e.g. Axsen et al., 2018), but also many others.

3.3.2. Design

Our part of the stakeholder consultation workshop uses a storytelling design. More attention has been given recently to storytelling as a means of: (1) engaging publics as consumers and citizens with topics of future socio-technical interest; and (2) understanding consumer-citizen perceptions of the new technological solutions (Moezzi et al., 2017). The richness of the approach supports a deeper understanding of likely conditionalities. Here we were interested particularly in the influence of the socio-cultural local context on attitudes towards decentralized energy storage on household-/building level.

The workshop using the storytelling approach consisted of "three acts". The main storyline used was to ask participants to imagine that they had just recently bought a new apartment – still under construction – that uses innovative energy solutions and that their input is needed on their preferences during the construction phase. In Part 1 of the workshop, they were asked to specify their individual preferences for the energy storage system in their new apartment buildings (configuration of energy system). To facilitate this task, a morphological table with five criteria was used (Pereverza et al., 2017). The criteria were presented one at a time, with two options for each that participants were asked to choose between: (1) Location of battery: common battery in cellar *or* individual battery in apartment; (2) financing of battery: buy *or* rent; (3) management of battery: local energy supplier *or* self-management; (4) electric vehicles (EVs): bi-directional charging *or* no EVs in the storage system; and (5) sharing: sharing energy *or* using individual production/storage. A short summary of advantages and disadvantages of the two options was given, to provide participants with relevant information while trying to keep the information balanced, e.g. regarding (2) Financing of batteries (buy vs rent), the following aspects were named for renting: no initial costs (+); higher costs in the long run (−); and for buying: cheaper in the long-run (+); major investment at the beginning, pay back isn't sure (-).[2] After the criteria had been presented, participants were given a few minutes to reflect on their choices and change their answers now that they knew all the options.

Part 2 of the workshop was a focus group discussion regarding criteria choices. To facilitate discussion, participants were first asked to "move" into one of two houses representing opposing combinations of the five criteria. *House 1* represented a *Prosumer-Sharing* solution including (1) a common battery, (2) renting the battery, (3) self-management, (4) EVs not included, and (5) sharing energy. House 2 represented a *Comfort-Independence* option, including (1) a private battery in each apartment, (2) buying the battery, (3) local energy company managing the system, (4) EVs as part of the system, and (5) no energy sharing. For each option, two groups were then formed and participants were asked to discuss their choices on given questions, including an elaboration on which aspects were important for them and for which criteria they would be willing to compromise on. These focus group discussions lasted about 10 min.

Part 3 of the workshop differed between the two locations, either deepening the storytelling approach (Sweden) or continuing with the storytelling-based focus group format (Portugal). In Sweden, participants were asked to imagine that one month after moving into their apartment, a lifestyle magazine wanted to publish an article about their life with the new energy solutions in their smart home. To facilitate the writing process, participants were asked to interview one another based on a given list of questions and then to complete a newspaper article with some pre-prepared text, either as a resident or as an interviewer. The pre-prepared text included gaps for listing: (1) positive and (2) negative experiences, and (3) arguments on the importance of change. This allowed the production of stories in some 10–15 min. In Portugal, storytelling was used for scenario creation (Part 1 and Part 2), where the participants were also presented with the scenario but asked to simply list (1) perceived advantages and (2) disadvantages of living in the smart house, and (3) perceived importance of smart grid solutions. Overall, the story-based design was intended to encourage both informed and emotionally engaged evaluation of technological systems that the participants were not familiar with in practice.

3.3.3. Data analysis

Focus group discussions and stories were transcribed and translated. Qualitative content analysis software (MaxQda) was used for analysis of the focus group transcripts. Concerning the storytelling/narrative approach of the workshops, contrasting methods are suggested in the literature. Some researchers argue that the analysis of stories requires "a focus on the whole story rather than the coded fragments provided in social science data sorting" (Palmer, 2016), while others take the view that using the coding process in qualitative content analysis is equally valuable for the analysis of stories (e.g. Pentland, 1999). In this study, we used a combination of both approaches.

First, all data were coded using several core categories based on the theoretical framework and with sub-categories added inductively. These categories were: (i) the three main variables of self-determination theory, namely autonomy (including subcategories in which consumers

[2] For more detailed information regarding the methodology see the «removed for review». As one of the key goals of the study was to foster comparative studies in Europe in order to examine the effect of the local socio-cultural context the workshop's moderator also recorded an audio-version of the presentation. This can be used as a basis for own moderation or as stand-alone tool for a workshop. We have tested the latter several times in seminars and found that it is also a very good way of engaging participants with the energy transitions. For a link to the audio presentation, please send an email to the corresponding author.

may want to gain independence or control); relatedness and community, and competence; (ii) perceived benefits (subcategories: comfort, energy savings, economic benefits, ecological benefits, well-being) and risks (numerous sub-categories, e.g., system failure, data security, and investment costs not paying off) of the new energy storage systems; (iii) positive visions in relation to the benefits of the systems (sub-categories: moving forward as a society, contribution to sustainable development); (iv) level of activity in the role consumers envisage for themselves in the new energy system (sub-categories: active, passive); (v) sharing, and (vi) emotions, as it emerged during the process of coding that the frequency of reference to emotional and rational arguments differed between locations and methods used in the study.

For overarching analysis of the story, the results from qualitative content analysis were considered and enriched with Pentland's (1999) approach to analyzing structural features in narrative data based on narrative theory. Pentland's technique aims at theory development and includes questions on the following aspects of the data: (1) the context of the story, based on information taken from the story, but also from other sources (see above for more details on the two case locations); (2) narrative voice (e.g. How is the story told? Who emphasized which part of the story?); (3) process/event structure; (4) character, role, and social structure (e.g., Who is the focal actor? How are actors related?). The analysis of characters and their relations is given particular emphasis in Pentland's (1999) approach. As Pentland remarks regarding organization studies: "Increasingly decentralized processes, and the increased prevalence of processes that include significant components performed by suppliers or customers, make it particularly important to understand who is doing what." (ibid, p. 714). This relates closely to our study topic of new and innovative changes from centralized to decentralized energy systems and was thus considered a key aspect in the data analysis, especially regarding the role consumers ascribe to themselves and other actors. Results from this overarching analysis are presented in form of "stories from stories", namely visions from all consumers summarized in one vision per location (in part using quotes from the data). These summaries of the overall analysis are presented below and then illustrated further, regarding also the results of the coding process (this includes also follow-up explanations of quotes used for the vision formulation).

4. Results

We begin with further information regarding the local context. More precisely, the descriptive results on the city districts and its income structures as presented above as part of the sample description are followed below by a description of the survey results in relation to socio-cultural local context, namely community ties and sharing experience. Based on this comprehensive information on the local context, we accordingly structure the results from the workshops by country and theme. For each, we start with the overarching vision. This is then illustrated using results from qualitative content analysis and Pentland's (1999) set of questions, applied with the self-determination theory theme of autarky and autonomy as well as relatedness in mind. We use italics for example quotations from participants. The selection criterion for quotations is not numerical representativeness, but inclusiveness: to convey the breadth and variety of views expressed (hence a form of purposeful sampling, also used for case study selection per se) (Marshall, 1996).

4.1. Local context: community ties and sharing experience

The aim of the survey conducted within the InteGrid project was to determine the status quo locally on attitudes and behaviour relating to social and ecological sustainability (survey methods and findings are available in an EU report: https://integrid-h2020.eu/uploads/public_deliverables/D1.4%20Consumers%20engagement%20strategies.pdf). The results revealed relevant insights into the socio-cultural context of the two locations, namely with regard to relatedness (one of the variables considered in self-determination theory) and practices of sharing. Concerning the perceived level of relatedness in their location, participants were asked whether they think they have a good relationship with different social groups (e.g., family, friend, neighbors), i.e., people belonging to their social network (with a yes/no/not applicable response). In the Swedish sample, only 56% reported having a good relationship with their neighbors, and a further 33% reported never having met their neighbors in a social context.

In comparison, a higher proportion of the Portuguese participants reported meeting their neighbors in a social context. A particularly noteworthy finding regarding further collective action approaches (in energy projects or beyond) is that Swedish participants would like stronger social bonds with their neighbors: 25% of participants reported having too little insight into each other's life (66% moderate insight, 5% too much). In contrast, in the Portuguese sample only 16.9% considered their social bonds with neighbors to be too weak, while 38.5% reported having too much insight into each other's life. These findings indicate that different local communities may have different needs regarding development of collective actions (in energy projects and beyond) and is important to keep in mind in the context of the present study.

In Sweden, the mean value obtained for the sharing economy was 0.87 instances of sharing behavior per person ($SD = 1.40$), with 58.3% of participants not participating in any sharing behavior. In Portugal, the mean value for this sample was 1.34 instances of sharing behavior per person (SD = 1.83), with 44.6% of participants not participating in any sharing behavior. These characteristics suggest that sharing practices are more common in Portugal than in Sweden. Yet, it is important to note that in residential buildings and lifestyles in Sweden, shared solutions (at least in apartment buildings) are very common. Apartment owners within a building are often self-organized into a housing cooperative (*Bostadsrättsförening* – own translation from Swedish), in which some costs are shared and decisions are member-based. The cooperative often also manages shared facilities such as laundry rooms, often following clear guidelines, e.g. a booking system and rules for use.

4.2. Results from the stakeholder consultation workshop on consumer-citizens' attitudes

Based on narrative theory, we use Pentland's (1999) approach in the following to summarize the findings from our case studies, here in form of (short) "stories from stories". These short statements in form of visions summarize the insights from the qualitative study in light of the quantitative findings on local cultural background (for more details see section 3.2.3). They are presented in the box below. Afterwards, these short summaries are illustrated in more detail using results from the qualitative content analysis of the workshop data for the two study site locations.

4.2.1. Case study 1: Stockholm Royal Seaport & Hammarby Sjöstad, Stockholm, Sweden

Vision: Teething troubles have been overcome. I feel I can contribute to sustainable development, actually making a difference, with the help of a 'self-playing piano' (energy storage system) and a great and growing community. I feel in control and happy.

In the configuration of the energy system by consumers in the beginning of the workshop (Part 1), using the morphological table and its five criteria ((1) Location of battery: common battery in cellar *or* individual battery in apartment; (2) financing of battery: buy *or* rent; (3) management of battery: local energy supplier *or* self-management; (4) electric vehicles (EVs): bi-directional charging *or* no EVs in the storage system; and (5) sharing: sharing energy *or* using individual production/storage), it was assumed that consumers would be interested in taking on an active prosumer role in the new, decentralized energy systems. This assumption was justified, with 72% in the survey of the Swedish site opting for self-management by phone app rather than control through a third party.

However, the comments from the focus groups revealed limited interest in actually taking an active role. The stories offered further insights into how consumers imagine their own role in the decentralized system: Their decision for self-management via an app was based on the assumption of complete automation of the process. The full quote concerning the "self-playing piano" referenced in the vision above illustrates this:

> *It is like a self-playing piano in a way where I do not have to get that involved, which is important for me as I have a great many other things to do*.

The results also provide insights into factors preventing people from taking more active roles, namely a (perceived or real) lack of competence *("you are an amateur after all")* and lack of time to engage in managing energy supply, as the quote above also illustrates.

Yet, while consumers wanted to remain rather passive in their roles, they nonetheless envisaged gaining control, with the app as the functioning intermediary. The present study here differentiates three different drives for gaining autonomy:

(1) *Independence from energy suppliers:* Here the main goal is to gain independence from current energy suppliers, in particular, large companies. Advantages referred to included, for example, that one could decide oneself how to split-up and use energy rather than a company making these decisions ("*then we won't have Eon that you buy electricity from saying 'during these times you will have this and that much'")*. Joint solutions in form of community energy are seen as way to bundle forces to achieve this goal in the Swedish sample.
(2) *Gaining control in order to reach societal goals*: Here community energy is also used to gain autonomy, but the goal of this is not focused on own improvements in energy management but rather community energy is seen as way to achieve societal goals, e.g. improve working conditions, as the following quotation illustrates:

> *Then there is also this major issue with electricity and the humanitarian aspect, how it is produced, who are struggling down in Africa. We know the working conditions aren't that great, child slavery, in order to find cobalt. (…)*/Question: from another participant: *You mean you have better control on that using your mobile app?* Following answer: *I can only see that there is a problem here that is not really evident and one which I think is important. And it is easier to talk about it if you share things.*

(3) *Control of own use and independence from neighbors*: While the first two points focus on gaining independence from large companies through energy community and more power in decision-making, another motivation regarding control and independence is to reduce dependence on neighbors. A key reason referred to is that it is assumed that neighbors might not handle energy responsibly, e.g. not cutting down consumption in case of a power failure, as well as anticipated differences in energy needs and, thus, production needs (and related costs for this).

At the Swedish study site, the motivation of gaining independence from neighbors was less pronounced. In fact, 83% of survey respondents opted to have a common battery for the house and 65% opted for shared access to resources (even if this included equal splitting of costs, as most participants assumed). Some consumers mentioned the risks of a shared system and the related benefits of full control in an individual-level solution. Yet, participants also mentioned that clear rules on use and costs, to which they are already accustomed with regard to other shared facilities in apartment housing, such as shared laundry rooms, could help to overcome these problems. In addition, solidarity was perceived as an important factor. Overall, the Swedish consumers appreciated shared solutions, the related gain in control over suppliers and achieving concomitant societal goals.

In fact, a key benefit perceived by consumers at the Swedish study site concerned social relations. While the consumers perceived the current level of social relatedness to be low, they considered the new decentralized energy system to be a way of increasing this, as the following quotation shows:

> *Creating a natural way of interacting with and getting to know your neighbors (…)*
>
> *Shared resources, for instance electricity, gives happier neighbors*.

Overall, the visions of the Swedish consumers were characterized by very low risk perception. Very few risks were mentioned in general and those mentioned were perceived to be overcome quickly (stories in Part 3 took place only one month after moving in the new house) and easily, as the mention of risks as *"teething troubles"* illustrates. In addition to the low level of risks, several benefits of the new system were mentioned, with the key benefit being to contribute to sustainable development.

4.2.2. Case study 2: Caldas da Rainha, Lisbon area, Portugal

Vision: I gain control with the individual-level system, used simply by clicking a button. It can increase my comfort and help me to save money and time, but it also includes several risks like system failure and dependence on technology, ending in near catastrophe.

For participants at the Portuguese study site, the question of the role of consumers in the new decentralized energy system was connected closely to the topic of autonomy and control, with "control" being the overall topic that seemed to influence the views of all participants.

Concerning the level of active management by the user, the findings were quite similar to those for the Swedish consumers: 74% of Portuguese consumers opted for self-management via an app rather than management through a third-party provider, and described this as a key criterion when deciding between House 1 (*Prosumer-Sharing*) and House 2 (*Comfort-Independence*) in Part 2 of the workshop. As in Sweden, most Portuguese consumers, however, indicated that they would prefer an easy-to-handle system that could be managed with low effort ("*with just a click*"), as the following quotation illustrates:

> *You would buy the house and already there would be that service and that's it. It's like you have a house with a pool. (Focus group, House 2)*

Yet, among the Portuguese participants, the discrepancy between preferences for a low-effort solution and the desire to gain autonomy (the most frequently mentioned perceived benefit of the new system) was stronger and more radical than in Sweden. Portuguese participants preferred an individual-level solution. The majority (59%) of Portuguese consumers preferred an individual battery in their flat over a shared battery and 87% preferred individual access over shared access. In fact, 32 participants (out of 46) opted for House 2, the *Individual-Comfort* solution, and for 22 of these 32 participants the individual solution was the main decision criterion, including willingness to compromise on other matters. A key reason for this preference for individual-level rather than shared community solutions was (mis-)trust in other people and in institutions. While the Swedish consumers considered wrong (or thoughtless) behavior in shared facilities "the extreme" or at least rarely occurring, the Portuguese consumers considered this to be "the norm". The following quotation (one of many) illustrate the group's perceptions of shared facilities:

> *An example of this. A boiler or a cylinder has X liters of water. And in this house there are 10 people. One would shower in hot water. The second will shower with hot water. The third will shower with lukewarm water. The fourth will shower with lukewarm water. The fifth will no longer have hot water and the others … well, cannot shower.*

It is particularly noteworthy that they also considered that rules on sharing would not be of help in this regard, as no one would obey these, e.g.:

> *The rules were well-defined in wording and all that. From one day to another, everything changes. (…) / And well, these rules have no value.*

These findings indicate that negative experiences of shared solutions could be one reason for the very pessimistic view. This is supported within the data by several examples referring to negative personal experiences of sharing, e.g., a garden, a boiler (the hot water example above) and especially the shared bike system in Caldas da Rainha, which participants perceived as a huge failure because users did not take care of the bicycles and did not follow the rules.

The Swedish consumers formed an overall very positive vision with regard to the new decentralized energy (storage) system. In contrast, the Portuguese consumers perceived more risks, e.g., data security was only mentioned in Caldas da Rainha, and more severe problems, e.g., regarding "*near catastrophe*", were mentioned more frequently. The most notable risks mentioned by consumers were: (1) technology dependence and the risk of system failure, and (2) the risk that others might take advantage of shared solutions.

4.3. Overview on findings from the mixed method approach

Having provided qualitative examples above of the themes prevalent in the groups sampled at both study sites, the findings from both countries are now summarized in Table 1. These are based on the results from both the quantitative and the qualitative parts of the study and are structured according to the research questions: Attitude towards decentralized energy storage (RQ 1), separately reported attitude towards shared solutions as a key topic emerging from the data; Underlying motivational aspects of attitudes based on needs and perceived benefits and risks (RQ 2); and the relevant local context factors that the study revealed (RQ 3). In the following, these are discussed in relation to each other and the current state of literature. Policy implications (RQ 4) are then derived.

Table 1
Consumer-citizens' attitudes towards (shared) decentralized energy storage embedded in the local context.

	Similarities between local case studies	Differences between local case studies
Attitude towards decentralized energy storage & prosumption (RQ 1)	• Interest in decentralized energy storage & presumption in both cases • Yet, both participants groups assume a rather passive role (app as intermediary for self-management)	• Swedish sample overall very positive; in contrast Portuguese sample is rather skeptical • Portuguese participants see more risks
Attitude towards shared solutions/ community energy	• Risks seen in both case studies, esp. mistrust in neighbors	• Preference for sharing (Swe. sample) versus individual solutions (Port. sample) • Use of rules to manage risks perceived differently: Low in Port. sample
Underlying motivational factors: Needs and perceived benefits (RQ 2)	• Interest in independence through decentralized, self-managed energy systems	• Participants in Sweden see closer relations with neighbors as one key benefit • Additional perceived benefits in Portuguese sample: comfort, money, time
Local context (RQ 3)	• City districts are all part of the Horizon 2020 energy project InteGrid; advanced energy infrastructure	• Closer relations between neighbors in Portuguese city district • Wish for more collective actions in Swed. city district • Different experience with sharing: more negative experiences in the Portuguese sample

5. Discussion

Decentralized energy storage on the household- and building-level is seen by many as a decisive factor for successful transition of energy systems; yet, one that remain a niche so far (Wirth et al., 2018). For the technology to grow from the niche, uptake by consumer-citizens will be key (Ecker et al., 2018). In the present study, we contribute to a gap in the literature relating to consumer-citizen attitudes towards different scenarios for decentralized energy storage at the household-/building level and related business models. In particular, we are concerned with the underlying motivational factors and their interaction with contextual factors, the latter including different scenarios and business models as well as local socio-cultural factors. The following discussion is structured according to the four research questions that guide the study, namely (RQ 1) consumer-citizens' attitudes towards different scenarios for decentralized energy storage, especially regarding their consumer vs. prosumer-role in the new system; (RQ 2) the underlying motivational factors (based on self-determination theory especially autarky/autonomy and relatedness); and (RQ 3) their interrelation with local context factors.

5.1. Attitude towards decentralized energy storage: consumers versus prosumers

The attitudes of consumer-citizens towards decentralized energy storage at the household-/building-level differ strongly between the two case studies. The Swedish sample saw many benefits overall, e.g. stronger bonds with neighbors and only a few risks perceived as manageable - resulting in an overall very positive attitude towards decentralized energy storage. By contrast, the Portuguese sample perceived the change to be much riskier and remained skeptical. A key benefit that participants in both case studies see is the (increased) autarky and autonomy through the new system. This finding is in in line with previous work (Ambrosio-Albalá et al., 2019; Ecker et al., 2017, 2018). Yet, our findings also provide ambivalent findings that counteract the previous assumptions on prosumer roles in decentralized energy system. Namely, the study shows that while asking for more autonomy, in fact, consumer-citizens still see themselves in a rather passive role: While consumers want to gain more autonomy, they perceive their competence level to be rather low, caused by a lack of knowledge and/or time, and they imagine that this shortcoming will be 'fixed' by automated solutions. Notably, besides that drive to stay passive, participants opted for increased autonomy through self-management via an app, despite the hypothetical alternative being a local energy supplier. This raises questions about local suppliers necessarily being trusted bodies, how trust might be engendered.

Another direction for further research that arises from recent studies is how much consumer-citizens will actually care about autonomy (control over energy management). While the findings on a desire for autarky (independence from the grid) are uncontested, recent work has found that while autonomy is also desired, it may not have such a strong influence on willingness-to-pay (Ecker et al., 2018). Yet, in contrast to this, our study found autonomy as a key decision criterion for participants, especially in the Portuguese sample. Further studies are needed on the importance of autonomy and how this may be achieved while keeping the effort for consumer-citizens low. Some first implications (RQ 4) in this regard are presented subsequently (section 6).

5.2. Underlying motivational factors: needs and benefits

Self-determination theory assumes three factors to be of relevance for adopting behavior, namely (i) the need to feel competent; (ii) the need to feel related or connected; and (iii) the need for autonomy. Our study confirms all three as relevant underlying motivational factors of consumer-citizens' attitudes towards decentralized energy storage on the household- or building-level. These findings are in line with previous work that identifies (i) a lack of competence, both regarding knowledge and time, as a barrier to energy transitions, (ii) improved community building and social relatedness as a driver (Mäkivierikko et al., 2019; Müller et al., 2011); as well as (iii) increased autarky and autonomy as a driver of positive perceptions of decentralized energy system (Ecker et al., 2017).

To date, most work on consumer-citizen attitudes towards decentralized energy system focus on autonomy and competence. Yet, our study particularly highlights the role of social relations and community identity building as a co-benefit of decentralized energy storage among neighbors. In work on mobility transitions, the role of identity is widely acknowledged (e.g. Gössling, 2017). In contrast, for energy transitions the role of identity has recently been given consideration. Yet, the few studies that have considered identity in relation to energy consumption suggest - in line with our findings - that this may play a key role (Bögel et al., 2019; Mäkivierikko et al., 2019; Pohlmann and Colell, 2017). Concerning the role of identity for household energy behavior, Mäkivierikko et al. (2019) examine the influence of social identity among neighbors on energy demand reduction. In addition, previous studies have recently started to discuss the role of identity for the development of social movements in general – either as a driver or barrier for social diffusion (Seyfang and Haxeltine, 2012) – and community energy in particular (e.g. Pohlmann and Colell, 2017). While our findings are in line with the recently highlighted role of social identity for energy transitions, the present study, however, shows that the role of particularly social identity seems to be context-dependent. The interaction between social relatedness as a socio-psychological, motivational factor and the local socio-cultural context is discussed in the following section in more detail.

5.3. Influence of local influences

The findings suggest that the role of relatedness depends on the local socio-cultural context. At the Portuguese site, where people perceived their degree of community engagement to be already more than sufficient and where trust in sharing norms was lower, individual-level solutions were perceived as providing the necessary level of control. Concerning the role of trust in institutions, the Portuguese responses are similar to those of UK focus groups examined by Ambrosio-Albalá et al. (2019). In both there was a lack of trust that sharing norms would be respected, and hence a preference for either individual- or household-level control. In contrast to Portugal, the Swedish experience of more reliable sharing of resources between households in apartment blocks arguably led the participants to have more trust in the possibilities in this regard. These findings are similar to those in previous studies emphasizing the role of prior attitudes as an outcome of experience (Ambrosio-Albalá et al., 2019; Bale et al., 2018). Experience in the local socio-cultural context seems to be a key factor here, particularly experience with community ties and associated experience with sharing. The different socio-demographic background may have also had an influence here and further research is needed on the interaction of socio-psychological factors; (ii) different energy system scenarios as one context factor; and (iii) the local social and cultural dimension as another context factor. As mentioned, recent frameworks call for the integration of the first two factors (Perlaviciute and Steg, 2014) but, so far, to our knowledge, have not addressed the interaction of these with the local socio-cultural context. Yet, recent work in energy transitions calls for further emphasis on these spatially-related aspects (Köhler et al., 2019; Wirth et al., 2018). The present study reinforces this and in this respect connects to longstanding work on the role of place perceptions in the socio-psychology of public responses to energy infrastructure (Devine-Wright, 2009).

6. Limitations

In terms of limitations, the study is explorative and does not make claims to representativeness beyond the boundaries of the case study locations. Concerning the partly asymmetrical case study design, it should be noted that while the embeddedness of the study in an inter- and transdisciplinary EU demonstration project comes with benefits such as the ability to study attitudes of local consumer-citizens in real-world settings, it can also come with challenges for research design (see Lang et al. (2012) for a more detailed discussion on transdisciplinary research designs and their challenges).

Regarding case study selection, while this was suitable for the research questions, it was nonetheless restricted by the initial project design (for a more detailed discussion on such limitations for theory and practice see Späth and Knieling 2020). For our study design, full symmetry in terms of surveys and workshop design, as would be achieved in an experimental context, was not possible. The implementation was led by the local project teams consisting of partners from different sectors, leading to differences in the design of the workshops. With regard to a possible impact of this on the findings, we noted that in the Swedish case, the storytelling phase of the workshop elicited more nuanced and emotionally engaged responses and enabled new responses to be observed, including the view that decentralized energy storage might bolster a sense of community which was perceived to be very positive.

From this, it might be inferred that storytelling methods (e.g. Moezzi et et al. (2017) generally re energy and climate change research and engagement; and Gordon et al. (2018) re methods such as video narratives in energy related social marketing) – may lead to more open, imaginative, and possibility-revealing responses, freeing people to express their hopes and allowing the technology to be associated with those hopes.

Finally, it should be noted that only some scenarios have been covered and further work could extend in this regard, e.g. also study the effect of different storage options, e.g. short-term storage and seasonal storage and/or different levels of autarky, on possibilities for consumer-prosumer engagement in more detail.

7. Conclusions and policy implications

Energy storage has an important role to play in achieving the high-level goals of the European Commission (EC, 2020/2030 Climate & Energy Package and Energy Roadmap 2050). After initially limited policy responses (Store Project, 2014), the level of policy attention and awareness of the importance of storage have improved in recent years (e.g., EC, 2017). In 2016, the EC proposed policy principles (EC, 2016) that, inter alia, highlight the value of energy storage for energy security, decarbonisation, and avoiding costs in both RES curtailment and installing backup generation capacity. Consumer-citizens are assumed to play a key role in this scenario. Yet, energy social science research is just beginning to analyze the potential roles of consumer-citizens in more decentralized urban energy systems that include energy storage.

This empirical, mixed-method study adds to the literature by examining consumer-citizens' perceived roles and particularly the inherent prosumer versus consumer-debate concerning energy futures, an essential factor in the question of which energy storage business models will prevail in the long-term. The study supports (i) our understanding of consumer-citizens' attitudes towards new technological solutions and, in particular, their motivational backgrounds for these; as well (ii) as the interrelation of the socio-psychological motivational factors with two contextual factors, namely different scenarios for business models and local socio-cultural factors.

Our findings suggest that consumer-citizens perceived an increase in autarky and autonomy as key benefits of decentralized energy system and that this is highly motivating for their support of the technology. Yet, the study also shows that while autonomy is wished for, at the same time consumer-citizens expect to handle the new technology with close to no effort. This finding contrasts with prevailing assumptions of consumer-citizens playing a more active role in the new energy system. It raises new requirements for decentralized energy storage solutions on a household-/building level, with regard to offering (more) autonomy while being easy to manage.

Furthermore, the study shows that consumer-citizen attitudes towards different scenarios of decentralized energy storage (especially levels of sharing, namely household vs building) are positively influenced by an expected increased level of relatedness (with neighbors) as a socio-psychological factor. This adds nuance to previous findings by showing, in addition, that the effect depends on the local socio-cultural context: Increased relatedness through decentralized energy system seems to be only a driver if community ties are low, closer bonds wished for and previous experience with sharing - e.g. in housing associations - is positive. An implication is that support for business models that include shared storage facilities and cooperation with neighbors is likely to be conditional, and this conditionality is likely to reflect prior, relevant experience. This in turn may reflect prevailing socio-cultural norms. We thus derive very different preferences at our two study sites: in Sweden, shared systems on building or neighborhood-level; and in Portugal, individual household-level systems.

In terms of implications for business models and, and hence for the design of supportive policy, the findings suggest that programs on decentralized energy system development should support decentralized energy storage solutions on the household- or building level, as gains in autarky and autonomy are key motivators for consumer-citizens to support a sustainable energy transition. Yet, the findings also imply that while consumer-citizens want to gain more autonomy, they also still rather see themselves in passive roles: if these perceptions are widespread, new systems would need to assume very low effort from users as a condition for acceptance. In addition, the study implies that programs on decentralized energy system development should build on context-dependent strategies regarding matters of social relations and the question of what organisations users might want autonomy from. In areas with a low level of community ties and interest in developing closer bonds with neighbors, relatedness could be a driver for the development of decentralized energy storage, while areas with opposite characteristics may favour individual-, household-level solutions. Yet, the latter contrasts with the fact that shared approaches could help with gaining both more autarky and more autonomy with respect to suppliers.

Overall, the findings raise questions as to how new energy solutions might be offered such that they improve perceived autarky and autonomy, while keeping the need for (time) investment low and furthermore, are flexible regarding the levels of interactions between involved prosumers dependent on the local needs. While the current energy market and even recently established decentralized energy system are mainly led by established energy actors (Wirth et al., 2018), the need to satisfy the conditions that the present case suggests may open up the room for innovative solutions by energy start-ups, particularly digital platforms (Kloppenburg and Boekelo, 2019) that connect producers and consumers. These offer online marketplaces for energy on a peer-to-peer basis, typically allowing consumers to buy energy from other prosumers in their region or wider, sometimes including the possibility of site visits and thus improving relatedness and community building. Such firms may support households in establishing their own solar power generation systems, thus, increasing their prosumer market base. An additional innovation that may help to establish trust in this context is blockchain-based record-keeping, which should provide a clear account of quantities supplied and used and hence mitigate against rule-breaking relating to sharing, or at least provide an evidence base for subsequent sanctions. Resulting from this, e.g. a concept for a blockchain ecosystem presented in white paper of a Germany energy start-up states promises "actors and participants do not have to rely on each other, but, rather, on the integrity of the blockchain infrastructure" (enyway, 2019). The business models required to support these types of services – as well as associated policy, regulatory and financial support – are arguably still underdeveloped, but all have a potential role to play in strengthening a citizen-centered urban energy transition.

CRediT authorship contribution statement

Paula Maria Bögel: Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Paul Upham:** Conceptualization, Writing - original draft. **Hossein Shahrokni:** Funding acquisition, Investigation, Project administration. **Olga Kordas:** Funding acquisition, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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