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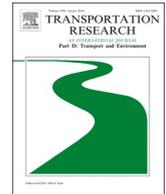
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Involving users and user roles in the transition to sustainable mobility systems: The case of light electric vehicle sharing in Sweden

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ABSTRACT

Low-carbon mobility alternatives, such as shared services integrating light electric vehicles, support transitions to sustainable transport systems. However, new products and services are not enough, as changes must also incorporate the practices of travelling, infrastructure, and mobility cultures in which users of mobility solutions are core stakeholders. This paper argues that user involvement is necessary in sustainable innovation processes but that the expected diversity of user roles and their involvement can also lead to contrasting outcomes for sustainable innovation transitions. Guided by theory in user involvement, this study investigated users and nonusers of light electric vehicles in a sharing mobility service system set up as living lab in two large workplaces in Sweden. Fifty-one interviews with employees at the workplaces were conducted during the implementation process and analysed combined with a questionnaire and data from system tracking through sensor technology. The paper finds that both users and non-users are co-creators in building momentum for sustainable mobility alternatives and provides a spectrum of user roles with defined characteristics. Four roles are distinguished within this spectrum: *vigilant users*, *passive collaborators*, *active decision makers* and *ambassadors*. We suggest that a *convergent activation strategy* is deployed for involving a full spectrum of users in order to capture their insights in ways that positively affect transition. Such a strategy addresses users and non-users as part of decision-making concerning alternatives and cultivates a culture of user collaboration, while also enabling a plurality of contributions in order to challenge existing regimes and established practices among individuals.

1. Introduction

Innovation in mobility, through electric vehicles and mobility sharing services, is one of the means of reaching a transition to sustainable transport systems (Kemp and Rotmans, 2004; Geels et al., 2018). Mobility, however, involves more than product service systems such as vehicles and sharing services. It also incorporates the practices of travelling, infrastructure, and mobility cultures (Verbeek and Mommaas, 2008). Changing mobility patterns is strongly linked to changes in user behaviour and practices (Mont, 2004; van Bree et al., 2010; Schot and Geels, 2008). The challenge for transitions to low-carbon mobility is thus to not only look for innovative design of vehicles and services (ibid.), but to also explore how innovative solutions enable users to change their travel practices (Liedtke et al., 2015). This requires the incorporation of consumer logics based on analysing travellers' lifestyles and

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routines into the design of mobility products and services, thus demanding a more involved user in the process (Spaargaren, 2003; Shove et al., 2012).

Users are involved in design processes in order to enhance the quality of design, fit the needs of the user, and make products more user-friendly (Gulari et al., 2011; Björgvinsson et al., 2010). In innovation processes, user involvement is also critical to accelerate the rate of innovative solutions penetrating the market and thus increase opportunities for firms to explore new markets (Lettl, 2007; von Hippel, 1988). Although user involvement is important for the success of design and innovation in numerous ways (Bano and Zowghi, 2015), it can emphasise an opportunistic view of innovations and maintain a growth-normative approach, focusing on the economic profit of industrial organisations (Gales and Mansour-Cole, 1995). On the other hand, the social impacts and possible trajectories that innovations could take when users are heavily involved, with a more central role in innovation processes, have been less explored. A more broadened user perspective is assumed by the socio-technical transitions approach, which recognises users as change agents, who can either stabilise existing regimes of practices or steer innovation trajectories towards more sustainable socio-technical systems (Schot et al., 2016). Such an approach emphasises that users do not just contribute by demonstrating their needs or through elicitation of information to benefit innovation. Rather, they influence processes of technology development and implementation by demanding more sustainable alternatives, generating expectations and legitimacy, learning how to use new sustainable alternatives and adopting these alternatives to change their own behaviour (Schot et al., 2016; Rohracher, 2003; Seyfang and Haxeltine, 2012; Hoogma and Schot, 2001). In contrast, users can also challenge expectations of providers by resisting to be controlled or to change their behaviour in response to new ideas, or by hacking the design for their own purpose (Oudshoorn and Pinch, 2003; Scott et al., 2012).

Thus, users' involvement and their role in sustainable innovation becomes critical from idea generation to post-adoption improvements (Heiskanen et al., 2005), as well as in shaping new routines and enacting system changes (Schot et al., 2016). It is well known in innovation and technology studies that engaging users leads to commitment and action (Hoffmann, 2007). The social shaping of technology tradition, for example, has indicated that users are usually present in one way or another when technologies are invented or put into use (Bijker et al., 1987). However, user representations drawn from technology development are often problematic and incoherent (Heiskanen et al., 2005) since they are implicit, and making user representations converge is a challenge for any product or service development process (Akrich, 1995). In addition, given that motivations and preferences of individuals are non-homogeneous, not all users act and contribute to the same extent. In innovation literature, a number of critical aspects of user involvement can be distinguished that highlight the importance of involving users, the challenges of this and the practical implications thereof, all of which will be discussed further in this paper. User roles are of the utmost importance, particularly for late-stage implementation of sustainable innovation when a critical mass is necessary to give momentum to new alternatives, as well as when innovation challenges users' practices. It is not until the use phase begins that users can really reveal their behaviour and fully relate to their own practices, something which further emphasises why users' involvement in this phase of innovation needs further attention in sustainability transitions.

Between 2015 and 2017, a new mobility service system integrating light electric vehicles in a sharing service was prototyped in two large workplaces in Sweden with inspiration from a living lab approach (Følstad, 2008; Keyson et al., 2017), in which users could try the service in the context of their daily work. Living labs are an approach to innovation design and development, enabling the involvement of users in their real environments, where new applications can be tried and studied in users' everyday lives and practices (Van Timmeren and Keyson, 2016; Liedtke et al., 2015, 2012). The project was a multi-stakeholder initiative implemented and run in one-year consecutive periods at each workplace serving as a testbed for the solution. Users were the employees at the workplaces, but also citizens of the communities where these workplaces were located; as such they were end-users or end-consumers, herein referred to as the users of the mobility system. Decision making for upscaling and further implementation of the initiative was heavily influenced by user input and learning during the process, with users and non-users playing distinctive roles in the trajectory of the designed alternative. Consequently, the two large workplaces did not further implement the system, though the service operator decided to modify the concept significantly and continue testing in several other workplaces.

Hence, this paper investigates users' involvement during implementation of a mobility service system using data from 51 interviews with both users and non-users. The purpose of the paper is to define user roles by identifying the characteristics of these roles and their implications as observed in the implementation stage of a sustainable innovation project in which users are core stakeholders. We argue that user involvement is necessary, but that the expected diversity of user roles can also lead to contrasting outcomes for sustainable innovation, requiring strategic approaches to how users are engaged and activated in the process of sustainability transitions; in this case, towards sustainable low-carbon mobility systems. The main contribution of the paper is therefore to provide a spectrum of user roles with defined characteristics which can be used by practitioners devising involvement strategies when developing sustainable innovation in co-creation with users, such as in living labs or innovation experiments.

2. Theoretical foundations

2.1. Users in design, innovation, and transitions

Industry and professionals in product design identified several decades ago that technology development could no longer happen in isolation from users (e.g. Bjerknæs et al., 1987). Designers were then sent out to observe actual users and their behaviour during product tests and in real-world scenarios (Gasson, 2003; Gould and Lewis, 1985). Users were involved as informers to the process while still maintaining their roles as consumers. Participatory design took user involvement one step further by addressing co-design to obtain greater benefits for both producers and consumers (Gulari et al., 2011). Within human-centred design, involving users

became an obvious means to design the best products, and design processes have been evolving towards co-creation or co-design in which users take the role of designers (Sanders and Stappers, 2008) and are viewed as concept generators (Gulari et al., 2011). In a parallel vein, innovation literature has evolved to emphasise user involvement as a key success factor for new products. However, if product design, in a somewhat simplified way, can be said to involve users in specifically improving the products, involving users in innovation is also aimed at reaching faster product adoption, seen from an innovation diffusion perspective (Gales and Mansour-Cole, 1995; Alam, 2002), while using users as sources of knowledge and competence who are contributing with ideas (Chesbrough, 2003). The co-creation perspective has also been emphasised by e.g. von Hippel (1988, 2005), who argued, addressing the concept of democratising innovation, that by actively involving users in decision making, products and services that are right for the users can be produced. Von Hippel and colleagues defined specific user roles that contributed directly to innovation implementation and diffusion, such as user innovators and lead users (Urban and von Hippel, 1988; Herstatt and von Hippel, 1992). By early adoption of innovations that might not even be top performing when launched, such users strongly affect the market and mass customisation of certain products. The division of actors into roles such as user-providers or consumer-producers has thus been blurred as end-users are considered co-creators of value (Vines et al., 2013; Gulari et al., 2011; Voorberg et al., 2015; Davis and Andrew, 2017). While users were once viewed as having a passive role, they are now regarded as active participants, shaping and influencing the outcomes of design and innovation processes (Piller et al., 2010). In practice, however, even if users are actively engaged, they do not necessarily have an influence in the process or always see gains towards having their own interests met, as noted by Sanders and Stappers (2008) and Vines et al. (2013), although products may become more user friendly and reach markets faster. In comparison to product design and innovation, the area of sustainability transitions conceptualises slightly different user roles and involvement. Sustainability transitions entail wide-ranging and long-lasting reconfiguration processes from one socio-technical system to another (Geels, 2002; Geels and Schot, 2007), such as transition to low-carbon mobility. These systems are comprised of networks of artefacts, actors, and institutions which gain stability and path-dependence as particular 'socio-technical regimes' (Smith et al., 2010). Transition scholars take a broader perspective on innovation beyond isolated products, processes or technologies, additionally including supply chains and infrastructure, as well as patterns of use and consumption. Between these elements there are dependencies that affect desired transitions, and routines among users which need to be destabilised with the creation of new ones in order for transitions to take place (Smith et al., 2010). Therefore, the involvement and role of users, in both individual and collective capacities, are seen as crucial in initiating, accelerating, and stabilising transitions (Schot et al., 2016; Smith, 2007; Seyfang and Smith, 2007). Users in sustainability transitions are change agents, both through their adjustments in behaviour and through their participation in innovation processes. They contribute to diffuse innovative niche ideas and practices, encourage regime actors to seek new solutions from niches, use lobbying to unsettle the regime, and represent cultural trends (Seyfang et al., 2010; Fischer and Newig, 2016). Users play a large role as activists (Penna and Geels, 2015) by becoming co-developers of new routines through engaging in the innovation process and implementation: learning how to use new technology and gradually altering their routines (Schot et al., 2016).

2.2. User involvement

Sustainability transitions further expand the view of users described above. However, more empirical research is needed as the theory is still rather conceptual and abstract to practitioners. Research needs to further elaborate on user roles, specifically in sustainable innovation where more systemic changes are required in, for example, user behaviours and asking for a more actively involved user. The literature on *user involvement* brings forward a number of important aspects with regard to how users are involved in innovation processes such as user motivation, involvement intensity and involvement effect. These critical aspects are further elaborated below to conceptualise the framework for this study.

2.2.1. User motivation

Users are involved when they consider a system to be both important and personally relevant (Barki and Hartwick, 1989, p. 53). Their roles are strongly related to their psychologically motivated affective state and the user's own willingness to contribute with their energy and knowledge (Barki and Hartwick, 1989; Iddagoda et al., 2016). According to Vines et al. (2013), there are three core goals that motivate user participation: to share control beyond the designer, to elicit and share human expertise, and to motivate change. First, control is an explicit motivating factor for user participation, since through participation users can express ambitions to share information and destabilise power structures in technologies, where various groups are not often represented. Second, users can contribute with knowledge, values, and opinions that can be shared and exchanged. For users this is motivating as they can actually shape products according to their needs (Hoffmann, 2007). And third, motivating user participation can inspire some form of change, as exposure to innovation processes enables users to reflect on current practices as well as articulate possible futures (Ehn, 1988; Rohracher, 2003). Agrawal and Rahman (2015), on the other hand, state that reputation, self-development and altruism are motivating factors to contribute in value co-creation processes. Hars and Ou (2002) argue that external factors such as human capital, self-marketing and personal factors are more important than internal ones such as joy of co-creating and identifying with community. In sustainability innovation initiatives, studies have shown that involvement is also motivated by users' ethical concerns such as environmental protection, energy saving, regional development or health issues (Ornetzeder and Rohracher, 2006). Talsma and Molenbroek (2012) showed that a sense of being responsible motivates people to put effort into improving services. However, people need to clearly feel it as their responsibility and they also need to be aware of how and what they can influence.

2.2.2. Involvement intensity

The roles and influence of users in processes of innovation are strongly related to the type of participation and degree of

participation (Ives and Olson, 1984), that is, to their intensity of involvement (Alam, 2002). Three general modes of involvement are often referred to in the literature: (1) listen in on the user domain, (2) ask users about their needs and preferences, and (3) build, co-design or co-create with users (Kaulio, 1998; Kujala, 2003; Piller et al., 2010). Each mode permits some expression of users' ideas, potentially enabling users to influence the innovation (Barki and Hartwick, 1989). The degree of involvement, on the other hand, refers to the actual influence that users have (ibid.). Users can influence processes in ways that are witting, unwitting, spectator-like, as reflexive commentators or as creators that lead to participation of others as well (Vines et al., 2013). This is often influenced by the complexity of the innovation or designed solution (Hoffmann, 2007) and stages of the process, e.g. early idea stage up to implementation and diffusion, where user roles are changing throughout different phases of an innovation process (Bogers et al., 2010). Taking on roles that require high engagement intensity, as in co-creation, is more easily achieved if users perceive that they are critical to the process and also when expectations of them are clear (Hennig-Thurau et al., 2004). According to Bogers et al. (2010), user importance increases in the subsequent stages: invention, innovation and re-innovation. For example, Leonard-Barton (1988) and Rice and Rogers (1980) found that users play a quite important role even after a technology is implemented, i.e. post-implementation, although Bogers et al. (2010) assert that it remains relatively unexplored how a provider would take advantage of the post-implementation process.

2.2.3. Involvement effects

Involvement and participation can lead to numerous changes for participants, in society, or for organisations (Vines et al., 2013). Specifically, innovation studies show sufficient empirical evidence that user involvement has a positive influence on the process of design and innovation, including its outcomes and success (e.g. Baroudi et al., 1986). It supports the generation of R&D ideas (e.g. von Hippel, 2005), improves understanding of their requirements and needs (Bano and Zowghi, 2015), and improves quality of design decisions (Gulari et al., 2011). Numerous studies have shown that it also enables enhancing user-system satisfaction and acceptance and facilitating change through improving user attitudes towards the system and increasing their motivation and perception of the relevance of the system (Magnusson et al., 2003; Kujala, 2003; Lettl, 2007; Vines et al., 2013; Bano and Zowghi, 2015; Voorberg et al., 2015). Complementing the somewhat narrow views on improving products and services, sustainability transition sources also highlight effects on users as necessary preconditions for transition to more sustainable socio-technical systems (Schot et al., 2016). Involvement enables deep learning among users through the actual use of technologies: learning by using, learning by producing, and learning by interacting (Schot et al., 2016). It is generally argued that active involvement of users at all stages of innovation provides synergy for initiating a critical mass for using innovative solutions and accelerating diffusion and change.

2.3. User role categories

Users have been increasingly involved in innovation processes and play many roles in impacting both production and consumption practices. We interpret user *role* as a situation-specific way of acting and behaving enacted into positions in a network and as a product of actors' interpretations of situations (Callero, 1994; Anderson et al., 1998). Users are described as holding the roles of co-innovators, co-creators, co-producers, co-designers, co-developers and co-promoters (Hoffmann, 2007). Voorberg et al. (2015) have argued that citizens (end-users) take roles such as *co-implementers*: citizens rather than service providers are implementing activities; as *co-designers*: citizens are involved in the process of service delivery; and, as *initiators*: citizens take the initiative to formulate specific services. Or users can take roles in the active, creative and social collaboration with providers and other stakeholders, referred to as co-creation, directly influencing the process of innovation (Piller et al., 2010). As involved, users tend to take or be given numerous roles; however, *non-active users* also have interesting roles in innovation. There are large communities of non-active or silent users, often referred to as the *invisible participants* or *lurkers*, who are individuals with their own preferences and needs but who don't actively engage in any particular role (Gong et al., 2015). Furthermore, users can have opposing roles against innovative ideas or solutions, refuse to change, or negatively influence processes of innovation, due to their stable cognitive framings of their own routines and consumer behaviour. These types of users are often described as *resistant users* (Oudshoorn and Pinch, 2003). For example, users' knowledge and experience of existing products can interfere with their ability to imagine new user preferences and needs (von Hippel, 1986; Hoffmann, 2007) or to question their assumptions about the alternatives they need (Smith et al., 2015). Transition scholars such as Schot et al. (2016) have further extended user typologies into how they facilitate and actively shape sustainability transitions. They identify roles such as user-producers, user-legitimizers, user-intermediaries, user-citizens and user-consumers (p.4–5). According to them, *user-producers* and *user-legitimizers* create technological and symbolic variety by experimenting with radical technologies and shaping new values or purpose and meaning regarding the significance of innovations. *User-citizens* mobilise against the existing regimes by lobbying for particular change processes and reforms, and *user intermediaries* align various actors together to create momentum by voicing expectations and configuring systems by tinkering with the design of new alternatives, while also shaping user preferences and needs. *User-consumers*, on the other hand, not only buy new and more sustainable products but also embed them in their daily practices, redefining their lifestyles through new usage practices and altering when necessary.

Meanwhile literature discussed above shows how users are involved, what motivates involvement, its effects as well as roles of users throughout innovation processes, it offers limited characterisations of user role variances. Users are treated as either active or non-active; they are involved, i.e. actively co-generating concepts with their commitment, or not involved, i.e. indirectly soliciting information that benefits innovation or with typical characteristics defined by their technology adoption behaviour which exclude the importance of non-early adopters, non-users, and other social groups. Addressing users in their most active roles, as in participatory design or in the democratisation of innovation, has stimulated a plethora of research into methods and tools for engaging and

involving citizens, although not without debate (Kujala, 2003). There are, for example, a few studies which critically discuss the notion of ‘participation’ and ‘user roles’ in terms of who participates and who is represented, and how methods of involvement can influence the process (see Vines et al., 2013; Redström, 2006; Björgvinsson et al., 2010). If involved from principles of democratisation, users need to be given fully active roles, rather than being informants in processes of innovation. At the same time, it is critical to not only focus on lead users or early adopters in design and innovation processes, but to also further explore the living circumstances of large user groups (Björgvinsson et al., 2010).

For sustainable innovations where usage behaviour and consumption patterns are critical, understanding variances in user roles with different characteristics and implications thereof is necessary for improving the ability to manage transitions. Particularly if and when users are considered core stakeholders in innovation, nuances of user groups can be crucial for building momentum for other stakeholders and could lead them to act either in support of alternatives or to go against further uptake and scaling up. In addition, we see user roles as something *assigned* to users, rather than emerging from the mutual initiation of innovation by users and firms or other organisations inducing innovation. There is therefore a need to build further empirical knowledge about the variances in roles that users take when involved, in what ways their roles are manifested and how differences in roles contribute to sustainable innovation transitions; in this case, by looking at the context of a sustainable mobility innovation.

3. Method

3.1. Research setting: KTH mobility pool living lab

KTH Mobility Pool was a product-service system (PSS), herein referred to as mobility system, that was designed and tested as a concept in a multi-stakeholder initiative between 2015 and 2017. The collaboration was initiated by an academic partner building a consortium with a large public organisation (a municipality), a large private organisation (a manufacturing firm), an established car rental agency, an established car manufacturer, a non-profit organisation, an environmental consultancy, a payment service agency and a design consultancy. The project began as the municipality and the manufacturing firm (large workplaces, > 6000 employees) had taken measures to reduce private car use by e.g. providing access to bicycles, but without the measures resulting in the desired changes in their employees’ travel behaviours. The project was initiated with inspiration from a living lab approach (Følstad, 2008; Keyson et al., 2017; Liedtke et al., 2012) by designing and implementing the prototype in real-life environments where users could try it in the context of their workdays, with the purpose of reducing private car trips, the need for parking spaces at work, and carbon emissions from the organisations. The new mobility system was prototyped in the two large workplaces and run in one-year consecutive periods at each workplace serving as a testbed for the solution. One workplace was situated in an urban context with seven vehicles deployed, whereas the other workplace was in a suburban context with three vehicles deployed, which employees from various departments of the organisations had access to free of charge.

The product service system integrated light electric vehicles, known as LEVs, which are an emerging vehicle category and were chosen due to their energy efficiency, easy charging infrastructure, and suitable driving range (50–80 km) for short-distance mobility. The vehicles were booked through a web-based system including an app and accessed through an RFID smart card. The service was designed to enhance utility of the vehicles by being offered to so-called *daytime users*, who used the service during the daytime for both business and private errands, and *the caretakers*, who had access to the vehicles after work hours and during weekends for a monthly fee while being responsible for recharging and simple maintenance of the vehicles (see Fig. 1).

3.2. Data collection and analysis

178 employees from both workplaces registered as users for the service during the living lab periods, and more than 500 employees tested driving at least once. For this study, a sample of 51 people were interviewed of which 36 were employees from the manufacturing firm and 15 were from the municipality (see Table 1). The interviews were the main data collected combined with an initial questionnaire conducted prior to the start of the project, as well as with recorded data from vehicles and booking system based on usage activity, tracked by sensor technology.

First, data on user demographics, mobility behaviour and preferences, use of sustainable products and services were collected with the questionnaire which was conducted with all employees eligible for using the system. Then, reports on users’ activity from the tracking of vehicle and booking system usage were analysed during the trial period and this data allowed us to distinguish between users in terms of frequency of service use. The workplaces also provided data on other employees who had not registered for using the service, but who had tested the service once during demo days, and these employees were treated as non-users. Using this classification (see Fig. 2), employees were then invited to an interview at one occasion in addition to other project activities such as workshops and informal meetings, hence 51 from the entire pool of users and non-users responded to the interview. The interviews were focused on individual experiences with the new mobility system since its introduction at the workplace and their engagement. Using Nvivo software and with a code assigned to each user, we combined all individual user data collected from the multiple sources into single user profiles ($n = 51$).

Based on all user profiles, a qualitative data analysis process followed, using coding and categorisation of data (Silverman, 2011). Initially, coding was based on data in which several codes appeared throughout the data set. Then, given that a large number of codes appeared, we drew from literature theoretical conceptualisations on user involvement to further guide the analysis. A number of sources expressing explicit measures on user involvement were applied: user involvement construct (Ives and Olson, 1984), user participation, involvement, and attitude construct (Barki and Hartwich, 1989, 1994; Iddagoda et al., 2016), activities comprising user

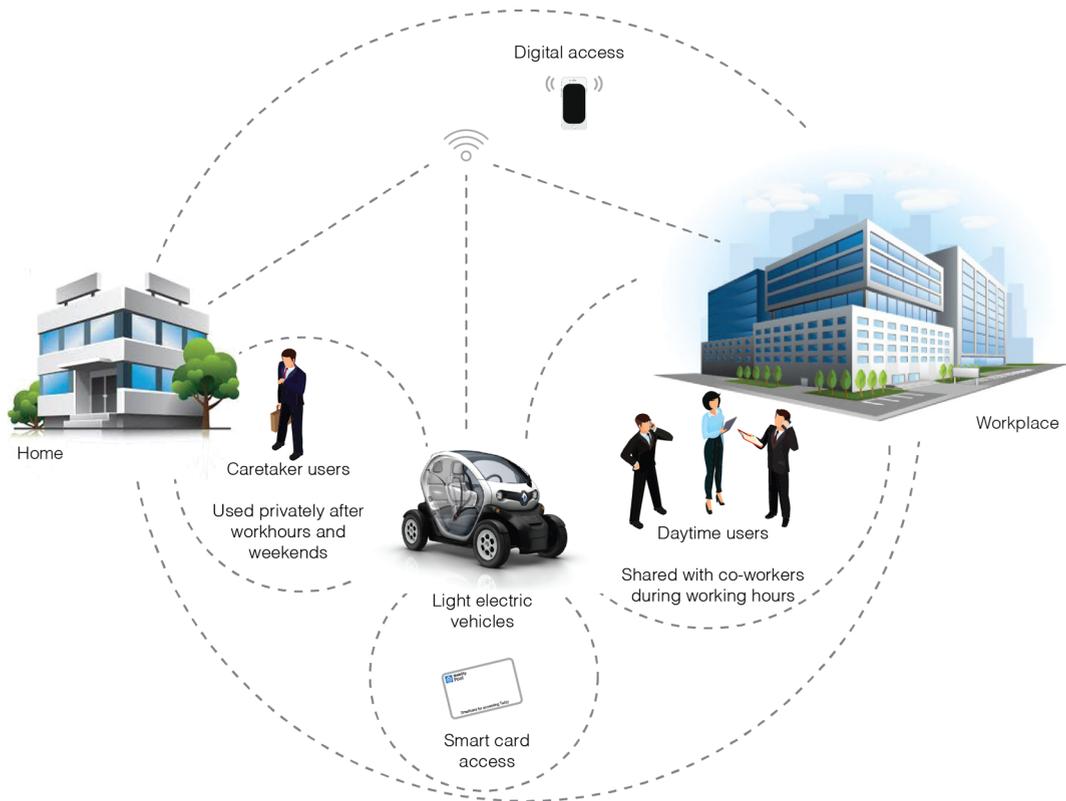


Fig. 1. Illustration of the living labs setup.

Table 1

Respondents characteristics.

Item		No. of participants in the manufacturing firm (n = 36)	No. of participants in the municipality (n = 15)
Gender	Female	11	3
	Male	25	12
Age	20–29	4	/
	30–39	13	5
	40–49	15	10
	50–59	2	2
	60–69	2	/
Education	High School	3	/
	Undergraduate	8	5
	Graduate	18	9
	Post-Graduate (PhD)	3	/
	Trainee/Diploma	2	1
	Not specified	2	/
Family status	Living with partner only	9	2
	Living alone	3	3
	Living with partner and children	20	10
	Living alone with children visiting	4	/
Ownership	Private car ownership	36	15
Travel behavior	Commute to work by private car	25	9
	Commute to work by bicycle	7	/
	Commute to work by public transport	/	6
	Walk to work	4	/

involvement (Baroudi et al., 1986), conceptualisation of user involvement in innovation (Gales and Mansour-Cole, 1995), user activities in processes of innovation and intensity (Alam, 2002), benefits of user involvement (Kujala, 2003), measure of engagement (Kang, 2014), and measure of co-creation (Tommasetti et al., 2017). These were combined into a conceptual framework for data

Classification	Frequency of use	No. of participants from the sample
<i>non-users</i>	not registered, only tested once	8
<i>non-active users</i>	only registered and/or used the service once or twice	8
<i>irregular users</i>	booked and used the service a few times a month	6
<i>active users</i>	booked and used the service few times a week	11
<i>highly active users</i>	booked and used the service every day	18

Fig. 2. Classification of users and non-users (Sensor data).

analysis while also allowing for new categories to emerge which were not found in literature, e.g. reasons, influence on others, values towards the system, (see Table 2: categories). Categories were then further clustered and four themes were defined (see Table 2), revealing the differences between users and the variances in the roles that could be identified among the participants.

4. Findings

4.1. Users' motivation to participate in the new mobility system

The data shows distinct motivations for the different users and whether users had an intrinsic or extrinsic motivation. All 51 interviewees saw the environmental potential of the new mobility service that had become available at their workplace and all 51 were likewise curious about new technologies. An environmental concern drove an intrinsic motivation as 14 of them wanted to change to a more sustainable travel behaviour and 12 were actively looking for a lifestyle change. The other half were more extrinsically motivated, driven by either the convenience of having an extra vehicle available or the wish to try new driveline technology. Thirteen of the participants in the interviews saw the economic benefits through free (or for the caretakers, low-cost) access to a vehicle as their main driver. A clear distinction among users is that of the 51 participants, half of them were engaged because they were contemplating changing their travel behaviour or were already making changes, whereas the rest were either less interested in changing and were seeking functional benefits of the solution, or were sceptical towards change unless the concept proved itself useful and worked in daily life.

4.2. Users' engagement intensity during implementation phase

Based on service usage activity, different patterns of behaviour among users could be identified. The largest groups of users were those who tried the service only once or twice, and those who booked and used the service every day (primarily caretakers). Smaller groups included those using the service a few times a week or just a few times a month. Frequency of bookings differed depending on the number of kilometres driven and this was largely uneven between users, demonstrating that the needs for mobility at each workplace were much more emergent than fixed needs, e.g. meetings, lunchtime errands, emergencies such as a sick child at school, or other unplanned errands. In some ways, the high activity of some users had an influence on the activity of others due to limited availability of vehicles, which was reported by non-active users. Users also engaged differently with their insights and input.

Less active users used the system without necessarily providing any input into its development. Their insights were informative towards system functions and the contextual barriers they experienced, for example contrasting the quality of the vehicle design with other cars or complaining about inconvenient user registration procedures. Meanwhile, one-time users and non-active users only participated in information meetings and test days when the project announced campaigns. These users contributed with feedback and input on barriers and challenges experienced in the use of the service. Active users engaged in workshops and joined group discussions while actively providing feedback and ideas on service improvements and the emerging issues that they experienced. They were engaged in co-creating concepts for mobility system improvements by actively discussing their experiences with the system and any perceived challenges. More active users reflected on how they used the system themselves while also being involved in on how others were using it. Besides participating in research activities, workshops and group discussions, half of active and highly active users also promoted the initiative and made fixes to the system, e.g. maintenance, servicing of the vehicle, and helping others to sign up and learn how to use the system. They were continuously sharing ideas for further system improvements regarding vehicle design, registration procedures and making the system more visible for co-workers, actively evaluating the concept and providing insights on its drawbacks.

4.3. Influence of users on others and on the mobility system

The data shows that among the 51 participants, there were a few users who tried to influence or persuade others both positively and negatively. The one-time users and occasional users were most likely to spread their negative attitudes about the system and talk about how it malfunctioned. This included statements regarding low quality, scepticism about range, experienced bad vehicle comfort, and poorly functioning booking system. A general perception among these users was that the system did not fit their needs. They were eager to discuss the impracticalities and raise their concerns among their peers, including regarding the lack of support they had received on how the system worked. Additionally, they shared strong beliefs that others were not using it due to low functionality regarding both product and services. The more active users were aware of others using the service and were often

Table 2
Data analysis process.

1. Codes	Intrinsic motivations Extrinsic motivations	Reasons for joining the project Reasons for not joining the project	Number of bookings made Number of trips and kilometers driven Self-reported usage	Interaction with researchers in workshops/ interviews Participation in meetings Engagement in campaigns	Consult/ information Feedback Co-creation Initiative taking	Spreading the use to others Informing others Letting others try Engaging in discussions	Attitude toward the PSS Modifications and adjustments made on the PSS Acceptance of the PSS	Emotional experiences Aesthetic experiences	Functional values Emotional values Social impact values	Positive perceptions about sharing alternatives Negative perceptions about sharing alternatives	Positive Negative
2. Categories	Motivations	Reasons	Degree of usage	Participation and Interactions	Degree of participation	Influence on others	Influence on PSS	Experiences	Values towards the PSS	Perceptions on PSS	Perceptions on car ownership
3. Themes	Motivations of users to participate		Users' engagement intensity			Influence of users' engagement		PSS impact on users			

influenced by others but did not try to persuade others or educate them. They listened to other users' concerns during meetings and engaged in discussions, placing emphasis, however, on the challenges for others and not for themselves. For selfish reasons, some of these users did not want to increase the usage of the vehicles, preferring to keep greater availability for themselves. These users were actively adjusting different elements of their everyday life to be able to use the service, e.g. booking a number of trips in advance to secure availability of the vehicle. In order to make the system useful to them, they also made modifications to how they used the system by bending the rules of use, e.g. sharing the vehicle with their partner or booking the service for many days in a row.

A number of highly active users expressed concerns regarding how others were using the mobility system and sometimes reported to the managers. They were open to sharing tips and information with others on how the mobility system worked and demonstrated it to them when they had the opportunity and time to do so. Occasionally, these users shared images and experiences among their social networks. Their attitude towards the mobility system was that it came with a responsibility one must assume as a user of shared alternatives. This gave them the feeling that they needed to take care of other users, too. They were not only more vocal, but they also tried to motivate others to use the service by helping them become members, letting others try the vehicle at work, in the streets, and in their neighbourhood. They answered questions when people approached them with curiosity about the project and shared their experiences with peers, family and friends, while also promoting the initiative as an important step towards sustainability. Surprisingly, non-users also highly supported and promoted the system, despite the fact that they never used the service. This was often because of their mobility needs at work, though, and they saw the initiative as an important change for their workplace.

4.4. Mobility system impact on users

The data shows that the mobility system had several different impacts on the respondents. A general perception was that the mobility system was a good initiative on the part of their employer that contributed to environmental goals and image, and that sharing among co-workers was positive. However, there were contrasting experiences, values, and perceptions among both users and non-users regarding personal benefits of the system, which revealed that preferences for shared mobility were highly varied. Non-users and users who only tried the service once or twice either had no need of a mobility service or were not satisfied with the system and had trouble with different elements of the system, such as the vehicle itself, the smart card, or the booking reservation. These barriers raised insecurity when using the service. For these non-satisfied users, the functionality of the service, e.g. quality of vehicle, was a dominant factor compared to the environmental benefits or service values in terms of potential social impact. They perceived sharing alternatives as inflexible for private reasons but were positive about implementing them at workplaces. They were not willing to replace their personal car with shared mobility solutions due to comfort, flexibility, and freedom. The same issues were experienced by users irregularly accessing the service. However, the acceptance of these issues stood in direct relation to their increased motivation and level of engagement and they experienced satisfaction from contributing to an environmentally better solution. The service practicality in daily life was dominant, e.g. accessibility of vehicles, saving time, costs, and the driving experience.

For those who frequently used the service, experiences were predominantly positive and their perception of contributing to the environment grew positively as they kept using the service. These users valued the overall social impact of more sustainable alternatives relating to sense of self-identity and building a good image for themselves, while enjoying the attention from others when using the light electric vehicle. The frequent users were more willing to compromise when using the service, and thus malfunctions of the system were lower barriers. These users had a positive experience not only from the mobility system but also from how it assisted them in engaging in sustainable behaviour. The environmental potential, including sharing of resources, of the mobility solution was of major value. The fact that they were substituting their car trips made them feel proud and they reflected on the possibility of living car-free. Through trying, these users felt they enhanced their trust in alternatives and became more supportive towards spreading and showing others the possibilities of sharing.

5. A spectrum of user roles in sustainable mobility innovation

The findings reveal four user roles, between which major distinctions can be noticed in the four thematic areas. However, there are also exhibited similarities and sometimes overlaps between them. The roles identified are: *vigilant users* (13), *passive collaborators* (12), *active decision makers* (14), and *ambassadors* (12). Each role is discussed below and summarised in Table 3.

The *vigilant users* are cautious about using and adopting new mobility services despite being aware of their unsustainable travel behaviour. Their motivation to participate depends on the benefits they seek from the service, such as saving on commuting costs or having free access to an extra vehicle. They are least engaged in the process and do not actively contribute to innovation. Due to low activity, both in usage of the service and in the project activities, they are considered as non-users. They are only involved when such action is facilitated by the researchers or providers. They provide feedback and input when asked, such as by participating in interviews and test days, but otherwise stay inactive during the process. Their experiences with the system are often not satisfying due to their expectations that mobility services would offer the same flexibility as a private car, which could be a reason why they did not get involved. For the most part, they perceive the system quality less positively compared to others. They generally lack interest in sharing alternatives, do not need the service, or do not support sharing services due to barriers they experience with system functions relative to the convenience of their private car.

The *passive collaborators* are users who are similar to *vigilant users* but are driven to participate in the trial phase processes of innovation by their needs, such as having an extra vehicle available and seeking economic benefits, though they are not actively seeking to engage in initiatives or commit to them. They are mildly engaged in the process, passively contributing to innovation through usage and sharing their experiences when asked or when participating in different activities. Although not directly engaging,

Table 3
Spectrum of user roles and their characteristics.

	Vigilant users (13)	Passive collaborators (12)	Active decision makers (14)	Ambassadors (12)
Motivations to participate	Save own costs of commuting Free access Try an EV Attractiveness Environmental thinking	Save own costs of commuting Need for extra car Try an EV Attractiveness New technology Environmental thinking	Try alternative means of transport Environmental thinking Curiosity about new things Scepticism toward EVs Desire to change	Ready to change Reduction of environmental impact from travelling Contribution to carsharing development Impact others' behaviors
Engagement intensity	Inactive usage of the PSS Participation in interviews and test days Feedback and input	Irregular usage of the PSS Participation in interviews and test days, survey and promotion activities Consult/provide information	Active usage of the PSS Participation in interviews Present in workshops Co-creation concepts for service improvement	Frequent usage of the PSS Participation in research activities Present in workshops Cocreation of concepts for service improvement Engagement in campaigns Initiative taking Active contribution with ideas
Influence of users	Negative attitude toward the PSS No effort to continue membership Discussion about quality with colleagues Spread info about their negative experiences	Hard to compromise attitude toward the PSS Limited effort to engage others Informed others when asked Did not actively engage in discussions	Positive attitude toward the PSS Made modifications and adjustments to the PSS Accepted the PSS	Positive attitude toward the PSS Made modifications and adjustments to the PSS Accepted the PSS Promoted the alternative Informed others Motivated and persuaded others to try

(continued on next page)

Table 3 (continued)

	Vigilant users (13)	Passive collaborators (12)	Active decision makers (14)	Ambassadors (12)
Impact on users	 <p>Experienced barriers during use</p> <p>Valued functional elements of the PSS</p> <p>Perceived barriers toward using the PSS</p>	<p>Positive experience</p> <p>Valued functional elements of the PSS</p> <p>Valued social impact of the PSS</p> <p>Perceived positive benefits with PSS</p> <p>Preferred to own car</p> <p>Became more positive toward sharing</p>	<p>Positive and impactful experience</p> <p>Valued functional elements of the PSS</p> <p>Valued the social impact of the PSS</p> <p>Perceived PSS as too much hassle</p> <p>Preferred a convenient means of mobility</p> <p>Became more positive toward sharing</p>	<p>Positive and impactful experience</p> <p>Valued the social impact of the PSS</p> <p>Valued functional elements of the PSS</p> <p>Wanted to not drive personal car</p> <p>Became more positive toward sharing</p>

these users have strong opinions on new mobility alternatives. They are generally enthusiastic towards new alternatives and technologies but are not willing to compromise on system functionalities although they appreciate the environmental features. They do not directly engage in discussions with others, though they are willing to educate and help others with practical information when asked. Being part of the initiative made them more positive towards sharing alternatives and electric vehicles.

The **active decision makers** are users who are motivated by their desire to change towards more sustainable means of travelling and expand their environmental choices, but who are rather more sceptical about the daily use of electric vehicles and sharing solutions, and so actively want to push for their continuous development. They are engaged in the innovation process, contributing with their feedback on improvements and positive experiences and participating in different activities and workshops where they engage in co-creation of concepts. They are also observant of how others behave towards the solution and are ready to persuade others to think positively about solutions. These users continuously make decisions about how they use the vehicle and the service while often making modifications, adjustments, and even bending the rules of the system to fit their needs. They openly talk to others about how they made changes to the system and share their experiences. The **active decision makers** share a positive attitude towards new mobility alternatives as they consider them the ‘wave of the future’ and critically evaluate possibilities of shifting to new alternatives. Accordingly, this means they have a say in how their needs can be met and thus enhance their image through the use of more sustainable alternatives.

The **ambassadors** are users who are not only aware of socio-environmental challenges but already make decisions towards environmentally driven solutions while also continuously seeking to change their behaviour. These users are also affiliated with sustainability issues in their daily lives, which motivates them to advocate for new solutions that can contribute to sustainability. They are actively engaged in the innovation process and also take the initiative to spread information and promote the system among their family, friends, and peers. They go beyond sharing experiences by influencing others to make the mobility system work for them as well. These users are ready to compromise on a few flaws of the system and instead focus on making an impact by advocating and raising awareness that users need to contribute to making those services better. **Ambassadors** use the service frequently and engage others by fostering reflection in others as to why such changes are important. **Ambassadors** are enthusiastic about the impact they believe they can make by showing others their own behaviour and helping them understand the potential impact of using more sustainable mobility alternatives. This makes them feel proud and they see their engagement as an opportunity to affect larger societal change.

6. Discussion

The results of this study reveal that users take contrasting roles with varying characteristics in terms of motivation, intensity of engagement, and influence on others and on the system. The identified roles partially confirm existing theory and partially can extend it further, which we discuss below by highlighting the implications of the different role characteristics. The study suggests that both users and non-users are actual co-creators in building momentum for sustainable mobility alternatives, although they vary in how they contribute or act towards new alternatives. The contrasting roles in this spectrum can lead to conflicting outcomes for sustainable innovation but also potentially create a plurality of possibilities that need to be taken into account in sustainability transitions.

The **vigilant users** can both stagnate or enable mainstreaming of sustainable mobility through expecting functional quality before committing, which may relate to the resistant users discussed in the literature (Oudshoorn and Pinch, 2003). In our case, the vigilant users are not necessarily resistant however. Instead, they have different expectations regarding sustainable alternatives and what benefits they seek from them, which differs from how literature conceptualises resistant users. Even though these users do not directly contribute to a process, they can be a source of possible and required improvements for new mobility services. Their experiences provide better insights into why a new mobility system does not suit their needs or is unappealing, which is imperative for developing products and services further (Oudshoorn and Pinch, 2003). Furthermore, they may represent important user groups, potentially mainstream users, who are motivated to use sustainable mobility alternatives such as carsharing but are hesitant due to perceived functional barriers of the system. Sporadic studies have looked at less active user roles. One such study, Gong et al. (2015), argues that these users are also potential customers but have different motivations compared to, for example, more actively involved users. Nevertheless, not accounting for or engaging with this user group may lead to overall misjudgement of population-level interests (Lampe et al., 2010). Vines et al. (2013) reflect on what they refer to as ‘unwitting participation’, whereby users, even if not directly participating, can contribute to the definition or implementation of technology through unwitting actions such as usage data used in design of future services (e.g. Google development of Voice Search). However, they critique how this form of user participation is understood, arguing that this is often much broader in scope than framed. These concerns regarding who participates and who does not are not only ethical, they also reduce the potential of making diverse voices heard, while possibly over-emphasising the voices of those who are heard most often, e.g. the early adopters, user innovators, and technology enthusiasts (von Hippel, 2005) typical in any innovation process. Vigilant users are also critical because they raise questions of representation and shaping of innovation trajectories, thus questioning methods of engagement developed to date. This is especially crucial if sustainability transitions involve a shared responsibility of building expectations about the alternatives.

On the other hand, **passive collaborators** are likely to use mobility services but perceive systems as not yet developed to fit their needs. However, they are vocal in innovation processes through their strong opinions about user preferences and engage in activities to talk about these, which may relate to user-intermediaries developed by Schot et al. (2016). They specifically vocalise large-scale environmental problems and needs for functional quality in sustainable alternatives. Their behaviour contributes to exploring the business opportunity for sharing mobility, as these users may represent a unique user group – those who share environmental values

and who intend to use green services but need more action (Kollmuss and Agyeman, 2002). Understanding this user role provides insights into how to target resistance towards the use of shared mobility services. Lettl (2007, p. 63) refers to this as passive development contribution, which includes the articulation of needs and/or problems and the evaluation of concepts and prototypes. According to him, these users need further motivations in order to be engaged, such as a current perceived problem, an openness to new technologies, or imaginative capabilities.

In contrast, *active decision makers* are much more likely to engage in the making of concepts for improving mobility systems since they are motivated to make changes in their lifestyles. They thus want to bring insights on how new mobility alternatives can be communicated towards those users who are curious but have not yet made the step forward to use mobility as a service due to perceived barriers to trying. In addition, their modifications bring essential knowledge for possible improvements to new mobility systems. Such behaviour is critical for stimulating improvements to the system and embeddedness of services in users' daily lives. This role relates to the role of co-developers (Hoffmann, 2007; Voorberg et al., 2015), and shares characteristics with user-intermediaries and user-consumers (Schot et al., 2016), in that they play a role in tinkering with the design of new technologies and creating interpretations of new technologies through new possible usages. However, the active decision makers identified in this study demonstrate that they are actively evaluating solutions and making adjustments to overcome usage barriers, though they also actively demand better offers when thinking about change. Lettl (2007) for instance, argued that to have active contribution in development, these users need an additional set of characteristics in order to be engaged, such as tolerance of innovation and ambiguity in order to handle the uncertainties of using technology during development phases, which includes openness towards new technologies, willingness to take risks, and willingness to experiment.

Similarly, but more important for sustainability mobility transitions, we argue, is the *ambassador* role. Their engagement in the process can help bridge new linkages between new product service systems and other users since these users are open to stimulate discussions beyond the service and its elements. They reflect on the meaning of such services as well as of broader transformations. Furthermore, their contribution is essential for driving the engagement of other groups, challenging status quos, and thinking beyond the immediate, functional or economic benefits of sustainable mobility services. The user-legitimater as identified by Schot et al. (2016) may correspond with the characteristics of the ambassador role since these express the need for building rationale and meaning of sustainable transitions by anchoring expectations, describing their significance and interacting with other actors. Previous research in innovation also describes numerous roles similar to the *ambassador*. However, the literature primarily refers to different actors in innovation networks or grassroots and political movements, reflecting less on the involvement and roles in sustainable innovation processes. For example, similar roles are framed as *champions*, *gatekeepers*, and promoter roles, such as *orchestrators* (in Nyström et al., 2014), all relating to characteristics of promoting new ideas and engaging in making the conditions for change, while also motivating others to change. Another similar role found in the literature is the *advocate* role, which is described as a distributor of positive information about the innovation (Heikkinen et al., 2007). We argue that the *ambassador* is different as this role represents the actual individual citizens who have used the mobility system in real-world environments without knowing the reasons and motives for e.g. various design decisions or product and service functions, and as these users are not motivated by economic incentives.

7. Conclusion

The study suggests that both users and non-users are actual co-creators in building momentum for sustainable mobility alternatives, although within these two groups, roles vary in how they contribute or act towards new alternatives. Four user roles are distinguished between users and non-users in this paper with defining characteristics: *vigilant users*, *passive collaborators*, *active decision makers* and *ambassadors*.

Environmental motives created conditions for all users to engage, although there were other primary motives, values, and reasons for participating which affected how intensely users were engaged during the process, and thus also the roles they took. In addition, users were more involved when their perceptions, values, and experiences towards the system were positive. Those who were actively involved and had positive experiences were found to be likely to have positively changing attitudes and trust in sustainable alternatives, while also influencing others, whereas those who had experienced barriers tended to show less support of the new solution and were much more likely to spread negative attitudes through their peers. More engaged users can also be said to be more open to the barriers of using the service while at the same time overcoming them with a more positive attitude. However, for those less engaged, there was little change in perceptions of the benefits of the system.

The *vigilant users* and the *ambassadors*, in particular, provided two different extremities in the innovation process, both of which demand attention to achieve sustainable transitions. *Vigilant users* can be said to stagnate transitions although involving them can lead to improved innovation outcomes, e.g. by providing essential insights into how to meet the difficulties in fighting resistance to change that often arise when moving new sustainability solutions into mainstream offers. The *ambassadors*, on the other hand, provide strong support for sustainable alternatives, both in development and in pushing forward transitions with their commitment to changing themselves and influencing others, as these users boost the spread of innovation through information sharing and persuasion.

These nuances of user groups can thus be crucial to building momentum for other stakeholders deciding on innovations. We therefore suggest that a *convergent activation strategy* is needed to involve a full spectrum of users while capturing their insights in ways that positively affect transitions. Such a strategy addresses users and non-users as part of decision making for alternatives and cultivates a culture of user collaboration, while also enabling the plurality of contribution to challenge existing regimes and established practices among individuals. In our case, the living lab setup enabled a process which encouraged involvement while also

affecting the daily life of citizens. The setup provided not only an experimentation space for new solutions but also a commitment-free setting for users to rethink their values as well as their opportunities to make behavioural shifts. However, more strategic approaches are needed in such experimentation zones to better identify and activate different users, to capture the non-open users' insights, and most importantly, to manage the diversity of role contributions.

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Appendix A. Supplementary material

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