Users and non-users in engineering and feminist participatory research on sustainable aviation[1]

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ABSTRACT

Within engineering, economics, and the natural sciences, sustainable aviation is often configured as an ecological and economic problem, which can be solved through technological innovation. In contrast to this, we set up a research project centering on social innovation, named *Human demands of sustainable aviation*. In the project, we combined theories from Feminist Science and Technology Studies (FSTS) with methods from Participatory Design (PD) and practice-based Ontological Design (OD). In this paper, we use our project as a case study to analyze and discuss how users and non-users are configured within different disciplinary contexts. The findings illustrate that conceptualizations and categorizations of users and non-users are not stable. They denote highly situated phenomena that emerge out of different research approaches and understandings of innovation. Power structures that are entangled with the positions researchers take, including specific theories, methods, and (implicit) values, pervade these contexts and understandings. With this in mind, we advocate for power-critical reflections on the performative effects of knowledge making as processes of world making and for inter- and transdisciplinary research to do justice to the different life worlds we inhabit. We further argue that innovation should be based on collectively negotiated visions of how we want to live in the future, instead of predictions that project our current realities into the *status quo* of tomorrow.

INTRODUCTION

In the face of the global climate crisis and local environmental pollution around airports, including high levels of aircraft noise, aviation researchers strive to make aviation more sustainable. This objective requires more than the improvement or modification of existing technologies. Technological innovation alone will not suffice to eliminate the negative impacts of aviation on the environment in the near future (Åkerman, 2005; Fluglesvedt *et al.,* 2008; Heuwieser, 2017; Lee *et al.*, 2009, 2021; Okonkwo & Smith, 2016; Rothengatter, 2010). Political and social engagement is needed to establish sustainable mobility concepts that take account of people's variable relations with aviation worldwide.

Statistical research provides the following insights: in 2018, only around 11% of the global population travelled by air. Air travelers were mostly high-income people living in North America, Europe, and the Asian-Pacific Region (Gössling & Humpe, 2020). Even in highly industrialized countries, such as the USA, Great Britain, or Germany, over half of the population does not fly (Gössling & Humpe, 2020). Only 1% of the global population, namely frequent flyers, are the cause for more than 50% of emissions from passenger air travel (*ibid.*). At the same time, non-users of aircraft who live in the southern hemisphere are the ones most severely affected by the negative impacts of aviation as a catalyst for the climate crisis (Alston, 2013; Denton, 2002; Gössling & Humpe, 2020; Israel & Sachs, 2013). Despite these insights, many projects from engineering, the natural sciences, and economics focus on technological solutions tailored for sustaining conventional air travel in a more environmentally-friendly way, instead of exploring new holistic concepts for future mobility, which would consider differences in people's living conditions and mobility needs.

We, two feminist researchers at a technical university in Germany, launched a project that provided an alternative approach to making air travel more sustainable. Our project was part of an engineering research cluster[2], which focuses on sustainable and energy-efficient aviation. The objective of our project was to introduce the demands of users and non-users, whose needs are frequently marginalized in projects targeting technological innovation, into the cluster's research. As a complement to our colleagues' quantitative, economically – and technologically-oriented projects –, we applied a qualitative, feminist, participatory research approach to directly integrate and qualitatively investigate passengers and people living near airports regarding their demands for and future visions of sustainable mobility. In this paper, we use our project as a case study to analyze and discuss our findings concerning the performative effects of different disciplinary fields, theories, and approaches on the

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[2] For more information about the research cluster, see: https://www.tu-braunschweig.de/se2a.

configuration of passengers and those living near airports, who represent users and non-users of aviation. Our aim with this paper is to draw attention to the performative power of different research approaches in order to inspire critical reflections on users and non-users as situated and contextual process categories. We then evaluate those categories with regard to their effects on enabling more socially and ecologically sustainable mobility futures.

To begin with, we introduce our project and its institutional framing. Then, we present the results of a literature review and our ethnographic inquiry. The latter was conducted to illustrate the conceptualizations of human demands that emerged when we studied the projects of the research cluster our project was embedded in. Following that, we describe how the concept of human demands transforms when it is grounded in Feminist Science and Technology Studies (FSTS), and Ontological and Participatory Design. This comparison was crucial for our project, because it guided the setup of our participatory research approach. In section three, we discuss the performative effects of our own theoretical and methodological framework as well as the contextual circumstances of our research (for example, the outbreak of the COVID-19 pandemic) on the (re)configuration (Suchman, 2007, 2009) of human mobility demands. We then show how concepts such as users and non-users evolved as situational process categories through the interaction between us as researchers and the participants of the workshops we conducted. After discussing the influence of our own situatedness as researchers on the results, we finally argue for future-oriented inter- and transdisciplinary innovation processes. From our feminist and power-critical point of view, these approaches should allow for collectively created socio-technical visions that take the perspectives of overlooked social groups, specifically non-users, into account, instead of taking past or current usage patterns as unquestioned starting points.
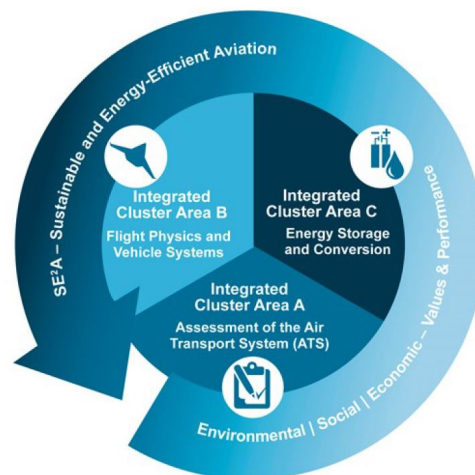
COMPARING CONFIGURATIONS OF HUMAN DEMANDS IN ENGINEERING AND FEMINIST PARTICIPATORY RESEARCH

By comparing research from engineering, economics, and the natural sciences with our own feminist participatory approach, we show in the following paragraphs how these approaches influence whose demands and interests are considered when it comes to sustainable aviation. From this, we derive conclusions on the varying relevance of the concepts of users and non-users to different notions of innovation.

Conducting feminist participatory research within an engineering research cluster

From October 2019 to April 2021, we conducted a project titled *Human demands of sustainable aviation.* The project was part of an ongoing seven-year interdisciplinary research cluster, funded by the German Research Foundation (DFG).

Fig.1: Organizational structure of the SE²A cluster

Source: Hurtig Design/TU Braunschweig/SE²A.

The cluster, which involves different research institutions from Lower Saxony, Germany, conducts research within three areas of, as its name indicates, "Sustainable and Energy-Efficient Aviation" (SE²A) (Fig. 1). Researchers in the cluster mainly come from engineering, economics, and the natural sciences. In contrast to more technically- and economically-driven engineering research on sustainable aviation, our project centered on social innovation. Our research was guided by theories from FSTS, which explicitly draw attention to marginalized or overlooked perspectives and social groups in technological research and development processes. This theoretical background led to the objective to investigate the demands of passengers and residents living in the vicinity of airports, which, from our point of view, were not appropriately considered within the cluster's research projects. We implemented the project using methods from Ontological and Participatory Design. The following questions structured our research: "How is sustainability defined within the cluster's engineering projects and to what extent are human demands considered within these projects? What (in contrast to the cluster's assumptions) does sustainability mean to passengers and airport residents? What is the role of gender and other aspects of diversity? How do these aspects affect living conditions, and, in consequence, mobility demands as well as exposure to noise emissions?"

Our research process consisted of two main phases:

<u>Phase 1: Literature review and ethnographic inquiry into aviation researchers' ways of thinking and working:</u> In order to understand aviation researchers' notions of

sustainability and which human demands were addressed within their projects, we first conducted an extended review of existing literature on the social and environmental impacts of aviation. The literature review supported us in formulating questions for the ethnographic inquiry. During ethnographic fieldwork, we accompanied some of our colleagues within the cluster to their daily working contexts, conducting participant observation and contextual interviews to gain insights into their research methods and objectives.

Phase 2: Participatory workshops with passengers and people living near airports: For the second phase of the project, we invited participants of diverse ages, genders, living conditions, and relations with and attitudes towards aviation to workshops on sustainable mobility. Within the workshops, we used storytelling and scenario-building methods to inspire the participants to exchange stories about their mobility needs and demands as a basis for the joint development of future mobility scenarios. Originally, the workshops had been planned as face-to-face-events but, due to the COVID-19 pandemic, were reconceived as virtual.

Human demands in engineering research, economics, and the natural sciences

The results of our literature review and our ethnographic inquiry demonstrate that, from an engineering point of view, sustainable aviation is mainly configured as an economic and ecological problem that needs to be solved through technological means. Recent studies show that, over the past decades, air traffic has increased considerably (Lee *et al.*, 2021). Despite a temporary decline due to the COVID-19 pandemic, researchers expect passenger demands and international air traffic to continue to rise in the future (Gössling & Humpe, 2020). At the same time, the climate crisis creates the need to drastically reduce greenhouse gas emissions released by aircraft (Kantenbacher *et al.,* 2018; Terrenoire *et al.,* 2019; Olivier *et al.*, 2020). In addition, local noise emissions at airports impact both humans and animals (WHO, 2018) creating further environmental issues.

In order to deal with those challenges, some research initiatives aim to improve the efficiency of existing technologies, such as the traditional turbofan aircraft, while others target different technological configurations, for example, blended wing bodies (Åkerman, 2005; Okonkwo & Smith, 2016). Moreover, research is investigating solutions for alternative drives, such as electric or hydrogen-based propulsion systems to substitute kerosene as jet fuel (Åkerman, 2005; Lee *et al.*, 2021). Since the 1960s, the efficiency of passenger aircraft transport has increased considerably by approximately the eightfold (Lee *et al.* 2021). Still, fleet turnover is a slow process and technological improvements lag behind the rapid growth of the aviation sector (Whitelegg, 2000; Lee *et al.*, 2021; Walker & Cook, 2009). Moreover, aviation companies, the main stakeholder of aviation research, demand economic feasibility

as well as safety of the technologies researchers and developers envision (Åkerman, 2005; Müller *et al.*, 2018). This is why new aircraft configurations cannot be introduced into the market immediately. Therefore, political actions, like kerosene taxation and fundamental changes in the transport system, are regarded as necessary to mitigate the impacts of air traffic on the environment in the near future (Åkerman, 2005; Fluglesvedt *et al.*, 2008; Lee *et al.*, 2021). Aviation researchers, thus, must serve demands that cannot be easily combined: They have to provide economically feasible and safe technological applications that are affordable for aviation companies, while simultaneously emitting considerably less noise and greenhouse gasses.

The *Flightpath 2050* vision paper issued by the European Commission (2011) serves as a frame of reference for evaluating logistical and technological modifications and innovations in aviation research. The paper's specific objectives are a 75% reduction in CO_2, 90% in NOx and 65% in noise emissions. Economic growth, wealth, and the creation of new jobs are listed as further goals. Technological research and innovation to achieve these goals are named as the "key to maintaining Europe's capacities and competitiveness" (European Commission, 2011) in the aviation sector. With a view to the *Flightpath 2050* objectives, it is remarkable that most CO_2 emissions from international air travel are not covered by political efforts to slow down climate change, such as the *Paris Agreement* of 2015, and that the aviation industry is heavily subsidized by governments (Fichert, 2020; Gössling *et al.*, 2017; Lee *et al.*, 2021). This shows there exist clear political hierarchies between different human demands in relation to aviation. Economic interests and the interests of passengers as aircraft users are considered more important than the interests of human and non-human sufferers from environmental pollution caused by aviation.

For the cluster's research projects, the *Flightpath 2050* vision paper serves as an orientation for long-term research objectives. The researchers we observed and interviewed carry out simulations and create optimization models to assess technological possibilities for making air traffic more sustainable. In addition, production process optimizations and air transport systems logistics are researched from an economic perspective. Research is based on quantitative data sets, largely obtained from international databases. Confirming the literature findings, the researchers we interviewed also mentioned passenger safety as an important research constraint. In our observations, critical reflection on the fact that aircraft passengers only make up a small part of the global population (Gössling & Humpe, 2020) does not take place within the cluster's research projects. Generally speaking, social concerns were only considered in the field of social life cycle assessment, for example to avoid the use of resources using child labor. These insights demonstrate that in the projects we studied, sustainable aviation was predominantly framed as an ecological and economic problem. Innovation was defined in terms of technology

improvement and development, in contrast to social transformation towards more sustainable ways of living, based, for example, on reduced aircraft use.

In the literature, as well as in the projects we studied, human demands play a role in the form of a predicted increase in passenger numbers in the future, which serves as a motivation to make air travel more energy-efficient and ecologically and economically sustainable. Passengers emerge as flight service customers and, therefore, as a quantifiable and relevant economic factor. Technological innovation is considered the main solution to meeting their demands in an environmentally-friendly manner, while also ensuring their safety. In addition, ensuring the continued employment of people in the aviation sector is a further human demand that motivates research on sustainable aviation. Due to the environmental impacts of aviation, those demands need to be met within a framework of political measures, such as the goals set in the *Flightpath 2050* vision paper. Research projects predominantly rely on quantitative data and methods for computational simulation and optimization to enable technological innovation to achieve these goals in the aviation sector. Accordingly, human demands of sustainable aviation are treated in quantitative or statistical terms and are detached from the settings and situations they are embedded in and from which they arise. Due to this approach, human (mobility) demands emerge as decontextualized factors. Within the projects we studied, neither the concept of users nor that of non-users is explicitly reflected upon. Instead, the certain groups of individuals, such as (future) passengers or airport residents, are treated as having the same demands and interests. Consequently, users and non-users are considered in research on sustainable aviation, but without investigating the reasons and motivations that make them users or non-users. In our work, political frameworks and industrial institutions appeared to restrict such a deeper reflection, as the objective of maintaining air travel is prioritized before the goal of making mobility in general more environmentally friendly, not to mention socially just. When aviation research is cut off from specific situational and local contexts, everyone is assumed to be equally affected by the negative as well as positive impacts of the technology, and differences are obscured. Consequently, certain perspectives become marginalized or even invisible in research and development efforts.

Changing perspective: Human demands under the lens of FSTS, OD and PD

In contrast to the projects we studied, we aimed to qualitatively investigate what humans need from sustainable aviation. We focused on passenger and residents living in the vicinity of airports and asked about their needs and desires concerning future mobility. We configured human demands as a set of real people's heterogeneous interests, emerging from dimensions of diversity that include gender, life circumstances, mobility habits, and personal attitudes, all of which need to be

captured in qualitative terms. The focus on passengers and local residents resulted from our objective to close the knowledge gaps in the engineering cluster. As a complement to the investigated projects, we aimed to provide contextualized insights that reveal reasons for the use or non-use of certain means of transportation, including aircraft. For this purpose, we combined of FSTS theories with approaches and methods from Ontological and Participatory Design research. Built on values of social justice and democracy, these theories and approaches share a power-critical view that explicitly focuses on exclusions in knowledge and technology production processes. The field of FSTS provides analytical lenses to reveal power imbalances and raise awareness of the perspectives and interests of affected, but often overlooked and marginalized, social groups in technology and knowledge production. As power-critical methodological complements, Ontological Design (OD) and Participatory Design (PD) offer concrete methods and tools for overcoming these inequalities in favor of more democratic, socially and ecologically fair realities.

Ontological Design is based on a critical stance towards dominating capitalist, patriarchal societies, mostly located in the global North. It lays responsibility at designers' feet for their role in this power game, which follows an exploitative and consumerist agenda (Escobar 2018; Law 2015). Such an approach can be considered responsible for current social and ecological crises that severely affect life worlds in southern regions of the globe. Inspired by queer-feminist, decolonial, and indigenous thinking, OD aims to sensitize researchers and designers to marginalized realities and argues for collaborative, local approaches to knowledge and technology development to overcome Western or Eurocentric perspectives and destructive practices. Christian Nold (2018) turns the philosophy of Ontological Design into a practice-based model that uses Participatory Design as a methodical approach to directly integrate disadvantaged or excluded user groups as equal participants in concrete research and development processes (Björgvisson *et al.*, 2010; Robertson & Simonsen, 2013).

Inspired by Nold's model, we conducted participatory workshops to give affected people a direct opportunity to speak for themselves, reflect their mobility preferences and habits, and create their visions for mobility futures. Combining FSTS, OD, and PD can be understood as a way of doing feminist innovation research that can be described as collective accomplishments from the margins (Griffin, 2021; Pecis & Berglund, 2021; Styhre, 2013). Such approaches consciously consider affected social groups, often configured as non-knowers or neglected as non-users. By pointing out the marginalization of certain perspectives in knowledge and technology production, feminist research strives to overcome power structures and inequalities that risk being reproduced in scientific "facts" and technological artifacts (Akrich, 1992; Berg, 1999; Cockburn & Ormrod, 1993; Ehrnberger *et al.*, 2012; Ford & Wajcman, 2017; Hofman,

1999; Suchman, 2007; Wajcman, 1991, 2000, 2010). Based on the insights we gained from the cluster's projects on sustainable aviation, we can validate with empirical observations of FSTS and feminist-inspired critical innovation studies (Benschop & Husu, 2021; Pecis, 2016) that reveal the ways in which research and innovation are strongly associated with technology, men, and masculinity. In this sense, feminist-inspired innovation research promises to provide practices of alternative knowledge- and world-making. These practices approach research activities and development efforts through the lens of social justice and democracy instead of economic productivity and efficiency, and integrate overlooked knowers and users as main change drivers.

In our project, the combination of FSTS with Ontological and Participatory Design guided our reflections on who should be part of research and development activities for sustainable mobility. In political papers or statistics, like the ones we identified as orientation points for the research cluster, human demands appear as decontextualized numbers. Meanwhile, PD and OD turn human demands into the situational, local, and varying interests of both users and non-users. In this sense, our theoretical and methodological approach had a performative effect on our research process and its results. This empirically underpins Karen Barad's argument (2003, 2007) that the outcomes of research processes, as well as the actors involved, emerge within concrete *intra-actions*, which shape and are shaped by power structures, gender relations, and social values. Such perspectives, theories, and approaches helped us to open the 'black box' of human demands for our own project. By, for example, consciously considering and directly inviting both aviation advocates and opponents to our workshops, we hoped to inspire wide-ranging debates or to stimulate what Chantal Mouffe (2000, 2010) calls 'agonistic struggles' on how we want to live in the future and which role aviation should play in future mobility. In Mouffe's perspective, these struggles are a core element of a vivid democracy. Finally, the emergence of human demands within our workshops revealed that users and non-users of flight services have different drives, needs and demands regarding future mobility. Our research results, as we show in the next chapter, are closely related to the situated conditions of our project, including our research interests, the theoretical and methodological approach we followed, as well as the disciplinary and institutional context we were embedded in, with its underlying values.

EMERGING SOCIAL ACTORS IN FEMINIST PARTICIPATORY RESEARCH

In our project, the user and non-user demands considered resulted from our previously described approach to sustainable aviation, which was influenced by our

own being and knowing as feminist researchers within the cluster. In the following, we focus on the second phase of our research: our participatory workshops. We also reflect on the methods we used to design, organize and conduct our workshops regarding the emergence of specific users and non-users of aviation and their visions for the future of mobility.

Participant recruitment and research design

In the course of our project, we conducted three online participatory workshops. The first workshop was part of the conference *Zukunft für alle*[3] (engl. *Future for all*). Originally planned to take place face-to-face, the conference turned virtual due to the COVID-19 pandemic restrictions. The conference aimed to develop ecologically, socially, and economically sustainable future visions for the year 2048 for almost all areas of life, such as education, (care) work, agriculture, housing, migration, mobility, environmental protection, digitalization, the finance system, and global commerce. We considered this an appropriate context for encountering aircraft users and non-users who were interested in the relation between sustainability and mobility. At the conference, we connected with members of *Stay grounded*, a global network of more than 170 organizations, among them local airport opposition and climate justice groups[4], who supported us in the recruitment of further participants after the end of the conference. In accordance with Donna Haraway's concept of 'situated knowledges' (1988), this example demonstrates research as a highly situative and performative practice, in contrast to claims of science as a production site of neutral and objective knowledge. Our project evolved in intra-action with the places and situational circumstances we were embedded in and the personal connections we established. The COVID-19 pandemic in particular had a considerable influence on the ways we organized, designed, and conducted our research.

In order to attract participants for our following two workshops, we designed a digital postcard (Fig. 2). The image side displayed pictures with provocative captions, hinting at topics related to sustainable mobility and the COVID-19 pandemic to arouse the curiosity of potential participants. On the back side of the postcard, we presented a short invitation text, including information about our research project and expressing our wish to attract participants with diverse mobility demands and varying attitudes towards aviation. We distributed our invitation to flight enthusiasts, including our colleagues, using the cluster's and our institution's e-mail lists, to environmental activist groups, to citizens' initiatives against air traffic and aircraft noise, and finally

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[3] More information on the conference, which took place online from the 25.-28.08.2020, can be obtained on the following website: https://zukunftfueralle.jetzt/.

[4] More information on the network "Stay grounded" can be found here: https://stay-grounded.org/.

to family members, friends, and acquaintances who live near airports (as we do), using instant messengers or social networking sites.

Fig. 2: Postcard for workshop participant recruitment

Source: Technical University of Braunschweig.

Planning and carrying out participant recruitment led us back to Pinch and Bijker's influential approach (1984): the *social construction of technology* (SCOT). The authors elaborate on the role of 'relevant social groups' who share the same notion or a common understanding of a problem that is attached to or supposed to be solved by a certain artifact. Relevant social groups strongly influence an artifact's problem definition, purpose of use, and final design. These groups can comprise producers (e.g. engineers or designers), advocates (e.g. policymakers or lobbyists), users, and bystanders (e.g. neighbors, family members, friends, etc.) as differentiated by Lee Humphreys (2005). Depending on the contexts where research and development processes take place, certain groups are considered relevant and participate in design decisions, while others are neglected or overlooked. The latter groups are not explicitly considered in SCOT, as described in Oudshoorn and Pinch's critique (2003). In accordance with feminist research and innovation approaches, the authors show how users and non-users matter, especially when it comes to gaining insights about the reasons for an artifact's use and non-use.

Guided by this double focus on relevant social groups, on the one hand, and users and non-users, on the other, we considered the interests and demands of users (such as passengers) and those of non-users (such as annoyed residents living near airports) equally relevant in order to complement and contextualize the quantitative data on which the engineering approaches to sustainable aviation were based. We applied Oudshoorn's and Pinch's analytical concept in combination with an

emancipatory mission to make aviation research more socially fair and democratic. To create new and alternative ideas for current and future mobility, we saw participatory workshops as suitable research interventions and "politics by other means" (Harding, 2016, 10) for empowering diverse people to articulate their mobility needs and interests themselves. In the end, we as researchers defined the focus of inquiry, which theories and approaches were applied, which users and non-users were relevant, and, finally, which findings became part of the cluster's knowledge base. These decisions and corresponding actions demonstrate our power position as researchers and the performative effects of our own situatednesss in bringing certain human demands into being. Users and non-users, we conclude, are never just there; they emerge in intra-action and in relation to local and situational circumstances. Moreover, "user" and "non-user" are no stable categories. They are heterogeneous, permeable, and changing according to people's social or professional positions and the transformation of their life circumstances over time, as we will demonstrate in the next section.

The COVID-19 pandemic was another situational aspect that influenced our research approach and the insights we gained. Initially, we considered mobility restrictions and social distancing obstacles that forced us to set up the participatory workshops online[5], instead of conducting them face-to-face. However, in the end, the situation opened up new possibilities for our research in two respects:

- It offered us the opportunity to gather participants from different regions of Germany, overcoming the usual barriers of cost and time imposed by travel.

- We took the pandemic as a real-world experiment and turned the collective experience of (im)mobility into the basis of our participatory research phase.

During the workshops, which we conducted in the summer and autumn of 2020, we asked our participants to imagine themselves back to the beginning of the pandemic in spring and reflect on the disruption of taken-for-granted mobility habits in relation to their (tacit) mobility needs and demands as well as their understanding of sustainability. Based on this, we invited them to create future mobility scenarios. We used storytelling and scenario building as techniques to provoke collective reflections and discussions on the participants' experiences and visions about how we want to travel and live in the future.[6]

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[5] To retain some aspects of the workshop experience we used the conference platform BigBlueButton and the digital whiteboard Miro.

[6] The participants' quotes used to illustrate our findings in the following paragraphs were originally in German. For consistency in language and easier comprehension, we translated them here into English.

Reflecting on our overall research process, the design of our workshops was as situated an approach as the process of participant recruitment. The specific time and place in which they took place impacted the socio-material dimension of our workshops, such as the tools we used to enable an online format, or the knowledge the workshops brought into being.

(Re-)configurations of users and non-users in participatory intra-actions

A total of 17 people, aged from 20 to 54 years, participated in our workshops. In order to get a first impression of our participants' occupations, life circumstances, interests, attitudes, and experiences, we handed out questionnaires some days prior to the workshops. These questionnaires contained open and closed questions covering the aspects named above. In the questionnaires, 11 people referred to themselves by names we interpreted as masculine and six described themselves with names with female connotations. All our participants were either academics or had studied at the university level. All of them lived in larger German cities (Berlin, Braunschweig, Dresden, Essen, Jena, Köln, Leipzig), most of them in a flat. The majority of our participants lived with other people, either with a partner, family, or flatmates. In order to get an overview of the participants' attitudes towards aviation, they were asked to assign themselves to one or more of the following categories: 'frequent flyer', 'aviation enthusiast', 'environmental activist', 'person opposed to flying', 'resident of the vicinity of an airport', 'person affected by aircraft noise' and 'other'. Five participants considered themselves aviation enthusiasts, another five environmental activists, three frequent flyers, and one opposed flying. Seven participants stated that they lived close to an airport. Of these seven, four indicated that they were annoyed by aircraft noise. Four participants described themselves as a combination of aviation enthusiasts, frequent flyers and environmental activists. Of these four, three were aviation engineers.

Most participants use the bicycle as the primary means of transportation in their daily lives, in addition to using public transport or walking. For longer distances, most participants use the train. The choice of these means of transportation, as the workshop revealed, is prompted mainly by environmental consciousness. Additionally, we assumed that since all participants live in larger cities, they have access to bicycle lanes and a well-developed public transport system. The four participants who fly frequently do this for professional reasons. Two of them also use aircraft to visit family members who live abroad. Four participants like to travel by bike during their holidays. Another four own a car, which they use for family vacations and transporting larger items for professional reasons. In two cases, the car was shared with adult members of the family or household. One participant, who used to predominantly travel by public transport and train, reported renting a car more often since the infection rates

of COVID-19 started increasing to reduce the risk of infection. The latter case shows that use and non-use are categories that shift with time. Situational circumstances have a performative effect on who is a user and who is a non-user of a certain technology. The COVID-19 pandemic made us realize this radically once more.

Without us having asked them to do so, our participants explicitly reflected upon how their mobility preferences and behaviours had changed over the course of their lives. Even though all participants had flown at least once during their lifetime, more than half described themselves as trying to avoid flying. One participant, aged 42, explicitly stated: "In the future, I would like to use the plane only in absolutely exceptional cases." Five formerly-frequent flyers had turned into people who avoid flying because of an increasing environmental consciousness. A further reason for travel reduction was parenthood. A male participant, father, and amateur pilot who tries to avoid flying said: "My family and I have so far completely avoided air travel, both for ecological and economic reasons, although, as a hobby pilot, I am an enthusiastic user of small, economical aircraft". The participants who were parents in particular referred to a generational responsibility, which they mentioned as an additional reason for avoiding travelling by air. Another male participant reported his personal mobility turnaround eight years ago. As a software developer dealing with smart meters[7], he reflected ever more on energy consumption and sustainability and eventually decided for a fundamental change. He transformed from a frequent flyer and car driver into a rail traveller and cyclist. Formerly, he visited the USA three times a year and frequently travelled to Spain, Latin America, and Asia. He now explores Europe by train. Use and non-use, we concluded from this, are categories that, in the case of our participants, had changed over their life span and were influenced by personal living circumstances and the attitudes developing in relation to these circumstances.

The younger workshop participants avoided travelling by air mainly for environmental reasons. A female student reported that she liked to travel by train but was sometimes overwhelmed by the cheap flight prices between European cities. Due to her increasing involvement in the *Fridays for Future* movement, she booked a train ticket for her last trip to London. One student, who had written his master's thesis on sustainable mobility and formerly travelled to Asia and South America, now prefers destinations in Germany and Europe. A further student participant rejects short trips and legitimizes travelling by air to distant places if he can extend a trip to several months.

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[7] Smart meters record the energy consumption of e.g., water, electricity, gas and send it periodically to the respective energy suppliers.

Three out of the four participants who were engineers or engineering researchers were also hobby pilots, flying small planes for leisure. During the workshop discussions, it emerged that the aviation researchers suffered from an inner conflict: they were enthusiastic about flying but, at the same time, conscious of the environmental impacts of aviation. One researcher, who also worked as a business consultant, expressed this explicitly:

> (…) by using the current technology, I have got an environmentally harmful hobby – piloting small aircraft and getting to know other cultures. Also due to my profession, business consultant, I travelled by air twice a week before the pandemic started. As I do not want to give up this lifestyle and these hobbies, already during my studies, I began to stand up for new, more environmentally friendly air traffic.

This contradiction was a career choice motivation for many of the participating aviation engineers. One doctoral researcher, whose family lives abroad, expressed his personal motivation as follows: "Immigrants need aviation" – a requirement that results from a globalized world based on the migration of people and the global transportation of goods.

Our workshop participants were highly homogeneous in their attitudes towards aviation, although these attitudes derived from different reasons and life circumstances. They also assigned similar meanings to the concept of sustainability. The participants mainly defined sustainability in ecological terms. Some also mentioned social aspects, like fair working conditions, as a part of the concept. All our participants possessed a critical consciousness of their mobility habits, including flying. Most participants connected their definition of sustainability with the wish to reduce greenhouse gas emissions. According to them, this aspect strongly influenced their mobility behaviours, as described above. Most said that if alternative means of transport to aviation, such as trains, were affordable and comfortably connected across national borders, they would prefer to use those for holiday or business trips, instead of flying. In addition, most participants emphasized that they enjoyed train rides and liked to use trains as a mobile office. For us, this revealed air travel to be a means to necessary ends. It is currently needed for fast travel between different locations, while other means of transportation, such as trains, were associated with a different set of benefits. Accordingly, in most future mobility scenarios the participants developed, public transportation, including e-mobility (in the best case as a free public service), the expansion of bicycle lanes, and railroad networks, including long-distance ones, played central roles. In these future visions, airplanes were depicted as an exception. Some participants even described them as technologies that, in the future, would only be allowed for family visits and humanitarian purposes, such as supply flights for medical care. Most participants

agreed that, in view of their pandemic experiences, short trips by conventional planes, especially for business purposes, will be harder to legitimize in the future.

These insights show that it is problematic to consider current usage patterns the basis for future technology development. Instead, it seems advisable to take into account how people imagine themselves as users or non-users in the future. Acknowledging that use is not stable and might change in the future, alongside other circumstances such as working life, or as an effect of external events or crises, is highly relevant. The mobility scenarios developed showed very clearly that mobility habits, needs, and demands are inseparable from the ways we work and live. In addition, mobility demands are always related to questions of time and financial concerns. One group of participants developed the vision of a post-growth society that offered a completely new idea of how we will live, work, and travel in the future. Due to drastically reduced and flexible working hours, including the possibility of working from home and virtual collaboration between international enterprises and partners, it was envisioned that there would be more time for local engagement in the neighbourhood and slow travelling. Within this scenario, travelling was considered a pleasure in itself, including the appreciation and awareness of distance and different locations. Another scenario involved the possibility of rapid connections between countries and cities through hyperloops[8]. Thus, slow as well as fast travellers were considered. In general, the scenarios included new usage patterns that provided alternatives to the statistical data on increasing flight passenger demands, which we had identified as a phenomenon the aviation research of the cluster was trying to address without questioning it.

DISCUSSION: DOES FEMINIST PARTICIPATORY RESEARCH HAVE THE POWER TO PROVOKE SOCIALLY JUST INNOVATION?

All our workshop participants, whether they were aircraft users or not, can be described as critical urban consumers, highly conscious of ecological sustainability. However, this description is unstable. We observed that some participants assigned themselves labels that seemed mutually incompatible to us, such as 'flight enthusiast' and 'environmental activist'. Some participants switched between perspectives depending on the context and position; professional or private. Others changed their self-labels according to changes in their attitudes or conditions over the course of

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[8] Hyperloops are ground-travelling systems in which passengers travel within a hovering cabin integrated into a vacuum tube. The maximum speed that can be reached with this means of transportation is estimated to be around 1220 km/h. So far, this futuristic transportation concept has not been put into practice. For further information, see, for example: https://www.discovermagazine.com/technology/what-is-hyperloop-and-when-will-it-be-ready [21.02.2022].

their lives. We noticed even our own roles as researchers and workshop organizers changing within the workshops. We sometimes joined the discussions like participants, talking about our own experiences and opinions towards aviation. This dissolved the boundaries and related power structures between researchers and participants. Despite that, we as researchers remained in a superior position. We determined the focus and the questions discussed and our moderation steered the workshop discussions into specific directions. Consequently, our presence had performative effects concerning the knowledge that came into being and the users and non-users that emerged within the workshops. Our feminist research project on sustainable aviation using power critical, democratic approaches, such as OD and PD, was not, therefore, automatically more socially just than technologically-driven innovation processes like the ones we encountered within our colleagues' projects in the research cluster. Feminist participatory research can bring alternative knowledges and worlds into being, but only if the researchers reflect on their powerful positions and the categories they apply, and use their positions actively and consciously to empower marginalized social groups. Our own results demonstrate that we were not successful in this respect.

In analyzing the workshops and reflecting on our research approach, we became aware of the fact that our invitation had reached a very homogeneous group in their education, social class, and living conditions: white, mostly male academics with a respectable income living in larger German cities. Due to their similar life circumstances and social and educational backgrounds, they shared similar (im)mobility experiences, similar attitudes towards sustainability, and had similar experiences in relation to the COVID-19 pandemic. For example, all of our participants were able to work from home. This made us realize that with this particular group of participants we had attracted people whose life circumstances, experiences, and attitudes largely mirrored our own positions and life contexts. Even though we had tried to critically and consciously use our positions of power as researchers to invite people with different educational, social, and economic backgrounds, we lacked non-academic or rural contacts. We were, thus, unable to fully put the feminist mission of empowering marginalized users and non-users into practice. Our own situatedness, our own being, knowing, and the relations that structure our lives affected which users and non-users emerged from our project and whose knowledge was finally transferred back into the research cluster.

Taking the critique of Ontological Design, its anti-western, anti-capitalist stance seriously and referring to the feminist critique of innovation as a technology-driven, male-dominated concept, we would have been required to integrate non-users from other regions of the world into our research design. For example, women from the southern hemisphere, who have been severely impacted by a climate crisis

(Israel & Sachs 2013) to a large degree driven by our transportation system, including air travel, should have a say in innovation for more sustainable mobility. Although the digital format of our workshops would potentially have allowed for international cooperation, we focused on the demands and interests of users and non-users from our own geographic location. The reasons for this were not only our own positions as researchers living in Germany, but also structural constraints, such as the limited duration of the project (one and a half years) and the single PhD position it included. Besides, the digital global society produces its own structures of power and oppression that determine socio-technical participation through the possession of and access to digital communication and information devices as well as hardware infrastructures (Chen & Wellman, 2004; Cruz-Jesus *et al.*, 2018; Huffman, 2018). Only the users of digital technologies and infrastructures have the opportunity to participate in research projects like ours. Different configurations of users and non-users seem to be interwoven and contained within one another. In our case, the users of digital conference tools were also (former) users of aircraft. The reasons for this are their geographic location, socio-economic backgrounds, and levels of education. Including non-users of aviation from other parts of the world into our project would have required a completely different recruitment strategy and research design. The acquisition of participants, thus, was grounded in the theoretical and methodological concerns of the chosen research approach as well as on our local and institutional embeddedness and our professional and personal networks, which partly worked against each other. All these situative aspects ultimately limit a democratic and socially fair research process that would have allowed for joint knowledge-making and world-making with heterogeneous affected users and non-users from around the worlds.

CONCLUSION AND OUTLOOK

Human mobility demands are taken into account in both research approaches we discussed in this paper. But when taking a closer look at what "human demands" mean, different configurations of users and non-users come into being. We showed how these configurations are intertwined with disciplinary conventions, the theories and methods applied, researchers' perspectives and values, as well as situational circumstances and institutional contexts, not to mention funding policies and programs. In the research cluster we studied, human demands are considered in abstract, decontextualized categories, involving statistics and quantifiable metrics. Current usage patterns and the assumed increase of (passenger) air travel in the future are taken as the unquestioned basis for research. The predicted demand for air travel legitimizes research into technological and economic innovation with the goal

of maintaining, if not fostering, the economic growth of the aviation sector. In this context, passengers as (future) users, who only represent a small share of the global population, hold considerably more powerful positions. The research cluster we studied mainly serves their interests. Even though these users do not speak for themselves, their interests are 'heard', although the underlying personal motivations that guide them are not.

Our feminist participatory research approach brought different users and non-users into being and revealed reasons for the use or non-use of aircraft. Despite the environmental consciousness of our participants, our findings show that the use or non-use of a means of transportation is often not a matter of choice. On the contrary, mobility preferences and requirements result from socio-technical conditions that shape certain ways of life. In the case of our project, and this holds true for our participants as well as ourselves, the way we live, work, and travel are expressions of a certain lifestyle practised by people sharing a comparatively high socio-economic and educational status, living in urban areas in one of the most prosperous countries of the Western industrialized world. In comparison, the majority of the world's population are non-users of aircraft or even suffer from aviation's negative impacts on the environment and health.

Our insights demonstrate that the acknowledgement of the dynamic and relational emergence of different users and non-users in reference to disciplinary contexts and situated conditions is highly relevant to implicit local and global power structures and the inequalities they produce. Categories like human demands, users, or non-users are not neutral descriptive labels. They are political, because they mirror and reinforce positions and hierarchies of power that provide advantages to certain realities and social groups, while suppressing and marginalizing others. From a feminist and power-critical point of view, non-users and their personal attitudes and life circumstances play a crucial role in enacting more socially just life worlds, as we argue here.

Feminist innovation research is a collective knowledge- and world-making process that explicitly focuses on the margins. By integrating the perspectives of vulnerable social groups that, in other approaches, are configured as (irrelevant) non-knowers and non-users, feminist innovation research questions and changes power structures, hierarchies, dominant lifestyles, and narratives. It expands the notion of innovation itself, from simply a technological solution to, in line with the Scandinavian Participatory Design tradition, something that involves new social relations. We argue accordingly for research and innovation on sustainable mobility as open inter- and transdisciplinary processes that involve researchers, developers from different disciplines, politicians, and affected non-academic social groups, if necessary, from

different regions of the world. In addition, conducting responsible innovation research for more socially just worlds involves questioning the *status quo* in favour of the desired. Futures are neither predetermined, nor do they represent projections or extrapolations of current developments. Futures are made. Instead of basing research projects on usage patterns projected from past or current realities, we argue for innovation processes that reverse the order of questioning, asking first: How do we want to live in the future? And then: Which role should technology play? No matter how idealistic our sketch of a feminist research and innovation concept sounds, facing the current social and ecological crises, we think that rethinking innovation cannot be idealistic and ambitious enough.

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